Improving Productivity in Agriculture Production in Rain Fed Areas in India – Presentation of a few Case Studies

*Kesava Anirudh.s, ** Udhayakumar.c.s , ***Dr.Kewal Krishan Gupta.

Amrita School of Business, Coimbatore

Amrita Vishwa Vidyapeetham

Amrita University

India

cs_udhay@cb.amrita.edu

Abstract-India is an agrarian economy. Although the contribution of the agriculture in India's GDP is 15%, 67% of the Indian populations are dependent on agriculture as their source of livelihood. There is a vast disparity in per capita income in agriculture profession as compared to industrial and service sectors. The difference in earning is as high as ten times. Agriculture sector has always been second priority of the governments. This is the prime reason why the per capita income of the people living the villages earning their livelihood out of agriculture is so low. This large gap of per capita can only be addressed if the government brings radical changes in the development strategy. More resources and investment are to be made in the agriculture sector.

India has been food deficient country till 1967. It is during the times of Shri Lal Bahadur Shastri and Indira Gandhi, the governments concentrated on increasing the production of food grains by providing high yield seeds, chemical fertilizers and better irrigation facilities. These steps brought green revolution in Punjab, Haryana and western UP. The green revolution increased the overall production of food grains (mainly wheat and rice) from low level of 89 million tons in 1964-65 to a peak production of 152 million tons in 1983-84. The green revolution could not be implemented in rest of India because of lack of irrigation sources. The rest of India is mainly rain fed. The rain fed area contributes to about 44% of the total food grains in India. The main crops which are produced in rain fed areas are coarse cereals(91%), Pulses(91%) oil seeds (80%) cotton(65%). The farmers living in rain fed areas are producing only one crop and therefore are very poor. The main objective of the study is to improve water management in the rain fed areas.

Keywords: Minimum Tillage, Conventional Tillage, Crop Rotation, Inter Cropping, Drip Irrigation, Water harvesting Structures, Mulching, Harrowing.

Introduction

India is an agrarian economy. Although the contribution of the agriculture in India's GDP is 15%, 67% of the Indian populations – who are living in the villages – are dependent on agriculture as their source of livelihood. There is a vast disparity in per capita income of people earning their livelihood based on agriculture as compared to people living in cities and working in industrial and service sectors. Per capita income for the people earning their lively hood on industrial and service sector is about 10 times higher as compared to the people who are earning their livelihood out of agricultural production.

Indian government policies are suited to increase the GDP growth rate from year to year. Various governments have been concentrating on the growth of Industry and service sector. Growth of agriculture sector has always been their second priority. This is the prime reason why the per capita income of the people living in the villages and earning their livelihood out of agriculture is so low.

This large gap of per capita income in agriculture sector and manufacturing and service sector can only be addressed if the government brings radical changes in the development strategy. The priority for government has to be changed. More investment is to be made in the agriculture sector. More funds are needed in carrying out the research how agriculture production can be increased and particularly in rain fed areas. Presently, the buying power of the people living in rural areas is low. So the consumption of goods and services by these people is also low. In case of faster growth of agriculture sector the per capita income of the rural population will improve faster. This will bring more rapid growth of manufacturing and service sector products resulting in higher overall growth of GDP in the entire country.

Green revolution

India has been food deficient country till 1967. The food grains like rice and wheat had to be imported from countries like USA, which was a big drain of foreign exchange. Also, the quality of the food grains which came from abroad was poor. It is during the times of Shri Lal Bahadur Shastri and Indira Gandhi that the governments concentrated on increasing the production of food grains by providing high yield seeds, chemical; fertilizers and better irrigation facilities. These steps brought green revolution to those states of the country where better irrigation facilities were available. These states are namely; Punjab, Haryana and western UP. The implementation of the green revolution could not be implemented in other states because of lack of irrigation facilities.

The green revolution increased the overall production of food grains (mainly wheat and rice) from low level of 89 million tons in 1964-65 to a peak production of 131.8 million tons in 1970-71. The production of the food grains could be further increased to 152 million tons in 1983-84.

Rain fed areas in India

Out of 140 million hectare of cultivated area, 79 million hectare (57%) is rain fed. This rain fed area contributes to about 44% of the total food grains in India. Rain fed agriculture supports nearly 40% of India's population. The main crops which are produced in rain fed areas are coarse cereals(91%), Pulses(91%) oil seeds (80%) and cotton(65%). In the rain fed areas since the agriculture is not spread throughout the year, the farmers are engaged in rearing life stock and other non-forming activities.

Rain fed agriculture suffers from low productivity, high cost of cultivation, poor adoption of modern technology, lack of institutional credit etc. The main objective of the study is to improve the productivity in agriculture production in rain fed areas. This objective is achieved through taking up some case studies.

Review of related Literature

1. Pradhan. A & Roul PK (2016) explained that as per traditional agriculture carried out by the farmers in rain fed areas, the soil fertility will come down over the years. This happens due to erosion of the land, pressures of development and climate change. This type of degradation of agriculture lands can be prevented through practices like crop rotation and inter cropping. In Odisha, the farmers followed a system of crop rotation starting with maize followed by mustard and then a fallow period during dry season. For these crops uncomposted farmyard manures low levels of urea are used as fertilizers. After the Maze harvest, the stover is left in the fields deliberately and used for mulching. Mulching helps in retaining soil moisture , regulate soil temperature and suppress weed growth and soil erosion in fields. For Mustard the stover are not kept in the field, but they are burnt after threshing and taking out the mustard seeds. During the fallow period animals are allowed to freely graze eating any remaining live plant material.

2. KD Sharma (2011) explained that during the rainy season substantial quantity of water flows to nearby rivers and nallas and is not available for irrigation purpose. Out of 4000 billion cubic meters of rainfall annually, nearly 1600 billion cubic meters directly falls on the agriculture land. Balance of 2400 billion cubic meters falls on rest of the land which includes forests, cities, rivers and waste lands etc. It is estimated about 240 million cubic meters can be harvested in tanks and water bodies close to the villages. This harvested water can be used for agriculture purpose during non-rainy season to increase the agriculture production. The author says that this type of water harvesting can increase the agriculture production significantly during dry season.

3. Chilka Sharma, DR. Prasad Thenkabail and JR Sharma (2011) explained that water is primary factor for improving agriculture production in the rain fed areas. Crop production is related to the amount of rainfall but also to the extent of stored water in the ponds and tanks. Agriculture productivity in the rainfed areas can be significantly increased through water harvesting. Water harvesting means storage of rain water in natural or man-made storage structures such as ponds and tanks. After storing the rain water in theses water bodies, the water is used for irrigation and it is a drinking source for animals.

4. B Venkateswarlu (2010) explained that climate change is warming the average temperature in the world as well India. Indian average temperature rose by 0.51 degree centigrade in 100 years i.e. 1901 – 2007. But during the period from 1970 onwards the rise in average temperature took place in accelerated way of 0.21 degree centigrade per every decade. For every 1 degree increase in temperature, the production of wheat, soya bean, mustard, ground nut and potato decrease by 3-7%. Similarly the rice decreases by 6%. In order to keep the plants alive, water requirements also go up.

5. RC Gautama And JV Rao (2007) explained that the land degradation in Rain fed areas is due to land erosion, sand deposition and climatic variation. The pasture lands are degraded due to increase in livestock population and also because of encroachment for cultivation and urbanization.

6. C.K Ganguly (1995) explained that restoration of water harvesting structures in Timbaktu in Anantapur district of Andhra Pradesh, which is a rain shadow area, gave immediate results. Tank desilation was taken up and the excavated silt was applied to agriculture dry lands to the extent of 100 of Acers. The silt improved the fertility of dry lands. The Timbaktu Collective, was given responsibility by district authorities to develop 14 water sheds spread over 14 villages. The villagers were involved into this exercise. Restoration work for 264, tanks and water bodies was taken up, with the help of 210 user groups. Awareness was created for the future maintenance of these water bodies. These restored tanks were the source of drinking water for animals during summer and also source for irrigation for agriculture.

Objectives of the Study

1. To prove that establishment of low cost water harvesting structures around the agriculture village improves the productivity.
2. To prove that traditional crop rotation practices sustain the fertility of the land on continuous basis and also to prove that intercropping enhances the yield to a high level.
3. To prove that drip irrigation decreases the consumption of water and electricity.

Methodology

Three case studies have been presented in this paper to achieve our objectives. All secondary data has been used which is taken government sources.

Case studies

Case study No.1

Restoration of traditional water harvesting structures at Timbaktu, Anantapur district of Andhra Pradesh

Anantapur is located in the southernmost part of Andhra Pradesh state. It is located in rain shadow area and is drought-stricken. Government of India identified 31 districts as most backward in the year 2006. Anantapur district was one among them. 75% of the population of Anantapur district lives in villages. Their main activity for lively hood is agriculture.

There are no perennial rivers in Anantapur district. Pennar, Jayamangala, Chitravathi and vedavthi are seasonal rivers. Because of this reason, the rulers in the earlier centuries promoted rain water harvesting systems like tanks and water bodies. The whole community of farmers living in a particular village was using water from these water bodies. They also had the responsibility for maintenance and upkeep.

As per record available there were 700 tanks in the district in the beginning of 20th century. Whereas the earlier rulers of Anantapur district promoted the construction of water bodies, the modern governments promoted privately owned irrigated systems like bore wells. This resulted in distruction of water harvesting systems that existed in earlier centuries.

The trend of increase /decrease of source of irrigation facilities from 1961 to 2006 in Anantapur district is given below:

Table 1: Trends of increase/decrease of irrigation facilities from 1961 to 2016 in Anantapur district:

Year	Tanks	Area irrigated by Different Source (ha)				Irrigated area
		Canals	Tube Wells	Other Wells	Other Sources	
1961–62	40344	19238	12	38234	3951	101779
1966–67	32862	21037	0	47688	2505	104091
1971–72	37977	38533	0	52563	4666	133738
1976–77	28676	27460	1	60334	10892	127363
1981–82	23364	37080	197	61923	6924	129488
1986–87	8396	40303	3541	61573	3471	117285
1991–92	9792	38423	12056	78104	3834	142210
1996–97	11992	29076	47025	47472	2934	138499
2001–02	7920	26735	71344	29904	2738	138642
2005–06	3259	23539	60958	28319	397	115035

Source: Government of Andhra Pradesh.

It may be seen from the above table that the area under irrigation through tanks has come down drastically from 40344 hectare in 1961-62 to 3259 hectares in 2005-06 . Whereas the area under tube well irrigation has increased from 12 hectares in 1961-62 to 60958 hectares in 2005-06. This proves our point that over the years the use of tanks have decreased and the use of private tube wells have increased to a very high level.

The Timbaktu collective started restoration of water harvesting structures in 1995 and situation started improving immediately for availability of water for irrigation purpose.

Old tanks were desilted and the silt was applied to the dry fields. Hundreds of acres of land was spread with silt which improved the fertility of land. Recharging of Tanks and application of silt was done in Mushikovela, Kogira and Kambaalapalli villages. The recharged tanks became source of drinking water for animals and also source of water for irrigation during non-rainy season.

Water Shed development:

Seeing the work done by timbaktu collective in the field of restoration of water harvesting structures, the district administration appointed them to develop 14 water sheds in various nearby villages. Each of these water sheds has an area of 500 hectares. After conducting the appraisal, the work of restoration of water bodies started. 264 water bodies were taken up through 210 village user groups. The workers were paid wages for this work by the government. In addition to the afore said, 28721 pits were also dug. These pits provided water for horticulture purpose.

Case Study No:2

Improving agriculture productivity through crop rotation:

The case study pertains to Uplands areas of odisha state. In rain fed areas, the productivity of the agriculture products comes down from year to year because of reduced fertility, erosion of fertile mud through water erosion and climate change. A change of agriculture system in favor of crop rotation helps the farmers to maintain soil quality.

The crop rotation system was introduced in uplands of odisha state during the year 2011-12. The cropping system introduced was maize, mustard and then a fallow period during the dry season. During the monsoon rainy season maze is grown by multiple plowings with a simple plough drawn by bullock. This method of ploughing is called conventional tillage. The plough cuts into the soil and makes a furrow. Uncomposted manure and urea are the fertilizers which are used.

The tillage can also be made in minimum tillage method. Minimum tillage reduces number of operations by planting directly after harrowing. This ensures a good seed bed for rapid germination and favorable growing condition. The minimum tillage reduces the energy and labor inputs and conserves soil moisture and avoids land erosion. Minimum tillage gives as good or even better yields than conventional tillage method.

The method of agriculture can be either with the same product or intercropped with another variety like maize+cowpea. In most cases intercropping increases the total yield per hectare.

The maize seeding growth period is during the rainy season i.e. from June to September.

After the harvest of maize, the stover is left in the field for mulching purpose. If the soil moisture is sufficient, farmers will till the field again and sow the seeds of local varieties of mustard as a post rainy season's crop i.e. from October to January. The harvesting of mustard seeds is done by threshing. The waste from threshing is burnt.

During the dry season that follows mustard harvesting, fields are left for fallow period. During this period, livestock are generally allowed to freely graze the fields, eating any remaining live plant material.

The following table may be seen.

TABLE 1: The yields of various crops in conventional and minimum tillage methods

Tillage	Cropping System	Residue cover	Average Yield
Conventional Tillage	Maize	Fallow	4777
		Mustard	7168
		Horsegram	6237
	Maize + Cow pea	Fallow	7735
		Mustard	10585
		Horsegram	9882
Minimum Tillage	Maize	Fallow	4260
		Mustard	6461
		Horsegram	5776
	Maize + Cowpea	Fallow	7739
		Mustard	10731
		Horsegram	9726

Source: Government of Andhra Pradesh.

It may be seen from the above table that total yield increases significantly with intercropping. Also, in minimum tillage method the yield will maintain or increases as compared to conventional tillage method.

Case study No 3

Improving Agriculture productivity through use of drip irrigation:

Location: Ahemednagar and Pune, Maharashtra state.
Maharashtra state has been chosen because it is one of the water scarce states in India. The area under irrigation in Maharashtra is quite low. It is about 17% as against 42% figure of national average. Traditionally, in spite of the water scarcity for irrigation purpose, flood method of irrigation for agriculture was used over the ages. From 1986-87 on wards the Maharashtra state government has been encouraging the use of drip irrigation in production of various crops. The districts selected for the case study are Ahemednagar and Pune. In these districts main crops are sugarcane, Grape and Banana.

Table 1: State wise progress of drip irrigation in India

States	Area under drip Irrigation							% progress under drip irrigation.
	Cultivated Area	2001-02	2002-03	2003-04	2004-05	2005-06	Total Area covered	
Andhra Pradesh	10410	5900	7139	21487	24905	51811	111242	1.100
Andaman & Nicobar	746	0	7	0	0	0	7	0.001
Assam	7850	0	0	0	116	0	116	0.001
Bihar	5664	0	0	0	392	0	392	0.010
Chhattisgarh	4800	0	0	0	11	6	17	0.000
Goa	141	6	23	0	0	16	46	0.030
Gujarat	9622	0	1374	0	304	16000	17678	0.180
Haryana	3566	226	175	0	115	0	516	0.014
Himachal Pradesh	4543	68	77	43	0	0	188	0.004
Karnataka	10031	0	6366	11093	6408	129	23996	0.239
Kerala	2191	0	154	0	297	0	451	0.020
Madhya Pradesh	14859	727	844	0	289	0	1900	0.012
Maharashtra	17619	7100	44082	0	36957	23857	111996	0.640
Mizoram	2085	0	50	20	2	0	72	0.003

Odisha	5845	0	185	0	0	0	185	0.003
Punjab	4250	0	0	0	279	560	839	0.019
Rajasthan	16765	703	444	668	1134	0	2949	0.017
Sikkim	672	0	0	0	0	50	50	0.007
Tamil Nadu	5172	16067	9674	0	9988	0	35728	0.690
Uttar Pradesh	16812	477	276	184	50	0	988	0.050
West Bengal	5522	0	0	0	110	0	110	0.010
Total	**149165**	**31274**	**70910**	**33496**	**81357**	**92429**	**309466**	**0.210**

Source: Rajya Sabha Unstarred Question No.437, dated 02.03.2007.

On close examination of the above table, it is clear that three states namely; Andhra Pradesh, Maharashtra and Tamil Nadu have done significant progress in changing over the method of irrigation from flood irrigation to drip irrigation.

Table 2: Area under drip irrigation in Maharashtra

Year	Area under drip irrigation(Ha)
2009-10	81,660
2010-11	1,27,967
2011-12	1,50,995
2012-13	1,62,100
2013-14	81,008

Source: Commissionerate of Agriculture, GoM

It may be seen from the above table that, due to importance given by the Maharashtra government for promoting drip irrigation, the areas under drip irrigation has been increasing over the years.

Table 3: Compassion of HP and Electricity in Drip and flood Irrigation

Crop	Type	HP per ha	Electricity per ha
Sugarcane	Drip	3.45	15.96
	Flood	3.65	35.16
Grapes	Drip	4.98	6.95
	Flood	8.94	18.89
Banana	Drip	9.82	5.33
	Flood	10.82	16.44

Source:http://www.iwmi.cgiar.org/EWMA/files/papers/Drip-energy-AN-paper%20%282%29.pdf?galog=no

After close examination of the above table, it is seen that Drip irrigation is more cost effective.

Table 4: Saving in water consumption in Drip irrigation

Crop	Saving In water	
Sugarcane	Quantity	1412
	Percentage	44
Grapes	Quantity	1968
	Percentage	37
Banana	Quantity	3245
	Percentage	29

Source:http://www.iwmi.cgiar.org/EWMA/files/papers/Drip-energy-AN-paper%20%282%29.pdf?galog=no

The figures in the above table reveal that there is significant saving in water consumption in drip irrigation compared to flood irrigation.

Table 5: Comparison of yield in Drip and flood irrigated crops

Particulars	Method	Sugarcane	Grapes	Banana
Yield (Quintal/ha)	Drip	1383.60	243.25	679.54
	Flood	1124.40	204.29	526.35

Source:http://www.iwmi.cgiar.org/EWMA/files/papers/Drip-energy-AN-paper%20%282%29.pdf?galog=no

It may be seen from the above table that the yield of all the three crops is significantly higher in case of drip method.

Findings:

1. In Timbaktu example, Timbaktu Collective promoted regeneration of the conventional water bodies which increased availability of water during non-rainy seasons. The fertility of the lands also improved by putting the silt in fields which was dug from age old defunct tanks. Through this case study our objective number 1: "**To prove that establishment of low cost water harvesting structures around the agriculture village improves the productivity**" has been established.
2. We have seen in our odisha example that the crop rotation is done by sowing maize-Mustard- Fallow period. The tillage can be "conventional tillage" or "Minimum tillage". The minimum tillage method is less costly and sustains the productivity level or sometimes even increases the productivity level. Productivity can also be increased by intercropping system of agriculture. Again in our odisha example, we have seen that there is a very high level of increase of yields in case of maize + cowpeas. This case study establishes our objective number 2: "**To prove that traditional crop rotation practices sustain the fertility of the land on continuous basis and also to prove that intercropping enhances the yield to a high level**."
3. We have seen in our Maharashtra state example (**Ahemednagar and Pune**) that for various performance parameters like: water consumption, electricity consumption and yield are significantly better when drip method is used. In the rain fed areas, the water is not be available in the non-rainy seasons. By digging/regenerating water bodies, the rain water may be stored near the village and used for second cropping by drip irrigation. This will provide additional work and income to

the farmers. This case study establishes our objective number 3: "**To prove that drip irrigation decreases the consumption of water and electricity.**

Conclusion:

In the earlier generations, the rulers had made **community water bodies** in each village where the water used to get stored during the rainy season. This water was useful for irrigation purpose during non-rainy season periods and also served as a source for drinking water for animals. In the modern times, the importance of these community tanks was forgotten and the government encouraged privately owned tube wells. In rain fed areas, the practice of digging private tube wells is having lot of uncertainty element and if water is not found after digging, the farmer comes under acute pressure and even may commit suicide. We have seen that Timbaktu Collective promoted regeneration of the conventional water bodies which increased the availability of water during non-rainy seasons. The fertility of the lands was also improved by putting the silt in fields which was dug from age old defunct tanks.

Another method of improving the productivity of crops in the rain fed areas is by way of **crop rotation.** The system of crop rotation is not new and was practiced by earlier generations of farmers for hundreds of years. The crop rotation helps to maintain the fertility of the land from year to year.

We have seen in our odisha example that the crop rotation is done by sowing maize-mustard- fallow period. The tillage can be "conventional tillage" or "minimum tillage". The Minimum tillage method is less costly and sustains the productivity level or sometimes even increases the productivity level.

The productivity can also be increased by intercropping system of agriculture. Again in our odisha example, we have seen that there is a very high level of increase of yields in case of maize + cowpeas.

In Rain fed areas where availability of water is scarce, **Drip Irrigation** is very effective way of improving the productivity of the agriculture products. We have seen in our Maharashtra state example (**Ahemednagar and Pune**) that for various performance parameters like: water consumption, electricity consumption and yield are significantly better when drip method is used. In the rain fed areas the water is not available in the non-rainy seasons. By digging/ regenerating water bodies, the rain water may be stored near the village and used for second cropping by drip irrigation. This will provide additional work and income to the farmers.

About the authors

*****kesava Anirudh.s

Final year MBA student

Amrita School of Business,

Amrita Vishwa Vidyapeetham University,

Coimbatore- 641112.

** Udhayakumar.c.s

Faculty

Amrita School of Business,

Amrita Vishwa Vidyapeetham University,

Coimbatore- 641112.

*** Dr.Kewal Krishan Gupta

Visiting Faculty

Amrita School of Business,

Amrita Vishwa Vidyapeetham University,

Coimbatore- 641112.

References

1. Pradhan. A & Roul PK,"Conservation Agriculture Practices in Rain Fed Uplands of India " , "http://www.ncbi.nlm.nin.gov/pubmed/27471508", dated 2016.
2. Alison Collier, Mark Poggio and Eamon Holligan, "A case study in use of legume crop rotations in sugarcane" ,"http://era.daf.qld.gov.au/3127/1/Legume_Crop_Rotation_In_Sugar.pdf", dated 2015.
3. Mirza.B.Baig, Shabbir A Shahid & Gray S,"Making rain fed agriculture through environmental friendly technologies in Pakistan: A review" , "International Soil and Water Conservation Research" ,volume 1,issue 2, September 2013.
4. Brenda Bateman, Racquel Rancier, "Case Studies in Integrated Water Resource Management from Local Stewardship to national Vision" , "AWRA", dated, November 2012.
5. KD Sharma, "Rain fed agriculture could meet the challenges of food security in India", "CURRENT SCIENCE, VOL.100, No.11", dated10th June, 2011.
6. Chilka Sharma, DR. Prasad Thenkabail JR Sharma, "Earth Observing Data and Methods for Advancing Water Harvesting Technologies in the Semi-arid Rain-fed Environments of India" ,"USGS",dated 2011.
7. B Venkateswarlu, "Lecture delivered at Birsa agricultural university Ranchi, "organized by BAU and Ranchi chapter of Indian society of soil science", 25th September 2010.
8. R.Rukmani & Manjula.M, "Designing Rural Technology Delivery Systems for Mitigating Agricultural Distress: A Study on Anantapur District", "MS Swaminathan Research Foundation Chennai, publication", dated November 2009.

9. Gautam, R.C Rao,J V Pal and Dr.Mahendra , ”Concepts of Rain fed Agriculture”, “Niscair”, dated 10th March, 2008.
10. Gavino Isagani, ”Conventional vs. Conservation Tillage”, ”the conservationist “, dated 2006.
11. Mark Rosegrant, Ximing Cai , Sarah Cline and Naoko Nakagawa,”The Role of Rainfed Agriculture in the Future of Global food Production ” ,“International Food Policy Research Institute, publication” ,dated February 2002.
12. C.KGanguly, ”Timbaktu Collective” , ”http.www.timbaktu.org/our-programs/timbaktu/water conservation”, dated 1995.
13. Greg W.Roth, ”Crop Rotation and Conservation Tillage”,“PENNSTATE”, dated 1996.
14. N.S.Jodha & R.P Singh, ”Crop Rotation in Traditional Farming System in Selected Areas of India” “ICRISAT publications”, dated 1989.
15. B M BHATIA, “Indian Agriculture A Policy Perspective”, “SAGE PUBLICATIONS”, dated 1988.