FEASIBILITY OF DRIP IRRIGATION IN THE ORCHARDS OF NORTH EASTERN HILLY STATES

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Abstract

The state of Arunachal Pradesh is reported to have very high potential for growing a large number of horticultural crops due to the remarkable variations in topography and agro climate within a small geographical area. However, the productivity status of various crops is still low as compared to all India level. The purpose of the paper is to examine the physical and economic feasibility of drip irrigation in kiwi crop in hilly tracks of Arunachal Pradesh. First, the paper examines the effect of erratic rainfall on the yield and quality of kiwi fruit. Secondly, it examines the physical feasibility of drip irrigation under the undulating topography and high rainfall. Thirdly, it evaluates the economic viability of drip irrigation in cultivation of kiwi crop.

Dip irrigation can increase yield and quality of kiwi crop under undulating topography and heavy rainfall conditions. Kiwi is an exotic crop, which needs water during its critical stages of growth for obtaining better price in the market. Erratic rainfall causes loss of yield and quality of kiwi frit, which can be corrected with the help of drip irrigation. The cop can be irrigated by drip in a cost effective manner in Arunachal Pradesh because difference in elevation minimizes fuel cost for water supply. However, the cost of drip is insignificant in comparison to total cost of cultivation.

Drip irrigation system is economically viable in kiwi crop in Arunachal Pradesh. The net present value of drip irrigation in kiwi is Rs.87673 and benefit cost ratio (B:C) is 1: 1.18. The pay back period of the system is 6 years. In between farmers can gain some return by intercropping of some annual crops. Lack of proper marketing system is a major draw back among the kiwi growers in the state. Intervention of government agencies and private parties is essential for developing proper marketing channels for the movement of the produce.

1. INTRODUCTION

The northeastern region of India with eight states namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim lies between 21°57' and 29°28' north latitude and 89°40' to 97°50' east longitude. The total geographical area of the region is 2.55 lakh km^2, which is about 8% of the country's total area. The region is divided into three divisions, viz., the northeastern hills, the Brahmaputra valley and Meghalayan Plateau. The NE hills alone accounts for 65% of the total land area while the Brahmaputra valley and the Meghalaya Plateau cover 22% and 13% of the area, respectively.

The region has distinct precipitation and drainage patterns due to its unique location and orography. Empirical Orthogonal Function (EOF) analysis of southwesterly monsoon rainfall over India shows that seasonal rainfall patterns over the northeastern region is different from the rest of the country. In general, north east region is perceived as a higher rainfall area. On an average, the region receives 2070 mm rainfall annually, which is almost double the national average. Nearly 20% of this rainfall comes from thunderstorms that occur during March and May. During the months of June to September, southwesterly monsoons supply 70% of the annual precipitation. Another 8% of rainfall between October and November is associated with northeasterly monsoons. During the southwesterly monsoon season, frequent floods, responsible for both human casualties and property damage, occur as the powerful Brahmaputra River flows are constricted through the narrow Assam valley, which is fed by torrential rains and snowmelt from Himalayan ranges. The rainfall is laden with silt from actively eroding steep headwater slopes.

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The present overall land-man ratio of the region is 0.66ha, more than double the ratio in India as a whole (0.32 ha). In 1991, the ratios were 0.81 and 0.39 for the North-East and all India average respectively. Total cropped area in the region is 5.3 mha and its population is 39 million. The region's total cultivable area is only 25% of its geographical area, compared to the national average of 59%, and its cultivable area utilized is only 59%, compared to the national average of 73%.

The region offers scope for cultivation of a wide variety of horticultural crops such as fruits, vegetables, flowers, tuber and rhizomatous crops and spices because of its diversity in topography, altitude and climatic conditions. A range of fruit crops varying from highly temperate types like walnut and apple to subtropical and tropical grow well in this region. Similarly wide and diverse types of vegetables including indigenous ones are cultivated in the region.

Despite the favorable factors and the scope for cultivation of horticultural crops, the development of horticulture has not picked the desired momentum. The productivity of the horticultural crops is very low in the region because of erratic rainfall. During the summer months, the most needed moisture is not available to the crops. There is also an absence of irrigation infrastructure suitable for hill slopes. The availability of sufficient water for irrigation is also an issue, especially during the summer months.

The scope of any type of technology or device is judged based mainly on three things – first the actual demand of the element facilitated by the device, second the physical feasibility of the technology under prevailing condition and third is the reliability for economic gain.

The purpose of the paper is to examine the physical and economic feasibility of drip irrigation in kiwi crop in hilly track of Northeastern India. First, the paper examines the effect of the erratic nature of rainfall on the yield and quality of kiwi fruit. Secondly, it examines the physical feasibility of drip irrigation under the undulating topography and high rainfall. Thirdly, it evaluates the economic viability of drip irrigation in cultivation of crop kiwi.

2. DRIP IRRIGATION FOR KIWI ORCHARDS IN ARUNACHAL PRADESH

Arunachal Pradesh is the largest hilly state in the northern hill region, located between 26^{o} 39' N latitude and 91^{o}35' to 97^{o}27' East longitude with elevation ranging from 250-7090 m a.m.s.1. The state has a high potential for horticultural development since topographically and agro climatically there are wide range of variations suitable for growing a large number of horticultural crops. Further, the grain farming is proving un remunerative in comparison to growing of horticultural crops in this hilly undulating area which are devoid of irrigation facilities. The state is as such very rich in biodiversity and biomass. Biodiversity is profuse and generous, catering to the needs of the rural tribal habitants of the state. The dietary components such as herbs and indigenous fruits and vegetable offer self-sufficiency to the people of the state. The total area of fruits during 2000-01 was estimated as 44128 ha with a total production of 93084 metric ton and 9260 ha under spices with 30,017 metric ton production. However, the productivity of various crops is still low in comparison to all India levels.

Kiwi is considered as an exotic fruit in the basket of nutrition. At the global level, production of kiwi is estimated at 908777 metric ton covering an area of 49,322 ha. The countries, which grow kiwi include Italy, New Zealand, Greece, France, Japan and parts of USA. In India kiwi is grown in Himachal Pradesh, Arunachal Pradesh and some part of Nagaland covering around 400 ha of land. The productivity of kiwi in India was 1.2 metric ton/ha during early nineties but it has increased now. The maximum productivity of this crop is 21.5 metric ton/ha, obtained in New Zealand. A ripe fruit has a refreshing delicate flavor with pleasing aroma. Almost all parts of the plant are used in China. The seeds are used in making pastries, fragrant flowers in producing perfumes and leaves as pig feed. Roots can be processed into an effective insecticide against tea caterpillars, aphids and rice borer. In addition, mucilage is used in construction materials for paving roads and wall covering and in preparing wax paper and printing ink and dye.

Farmers in West Kameng district of Arunachal Pradesh started growing this crop during the later part of 19th century. Government of Arunachal Pradesh attempted large-scale cultivation of this crop to promote horticulture in the state. Irrigation of kiwi orchard was introduced in 2001 under the schemes of technology

mission for horticultural crop. Under this mission, the government fully subsidized the drip systems to the kiwi farmers under the projects of the northeast council. The harvesting of fruits from orchards that are under drip systems started in 2004. Drip irrigation of kiwi orchard picked up a little momentum in terms of acreage and production. Presently there is more than 100 ha of kiwi cultivation in this state.

2.1 Objectives of the Study

The primary objective of the study is to assess the viability of drip irrigation for Kiwi orchards in the hilly states of Northeast India having higher rainfall history. The specific objectives are: 1] to assess the need of drip irrigation to compensate for moisture stress experienced by Kiwi crop due to seasonal variation of rainfall in the orchard of hilly state of Arunachal Pradesh; 2] to analyze the impact of drip irrigation on the yield of kiwi crop under the prevailing situation; and 3] to carry out economic evaluation of drip irrigation devices

2.2. Location, Methods and Materials of the Study

Study was conducted in the kiwi orchards of Dirang, Rupa and Bomdila of West Kameng district of Arunachal Pradesh. Kiwi is an emerging crop in Northeastern hilly region. 15 farmers having irrigation system were interviewed during the study. Their crops are in different stages of growth.

Hypothesis was formulated at the beginning of the study that the drip irrigation technology can be a best fit in undulating topography and can increase the yield and quality of horticultural crop kiwi and hence enables high income generation for farmers growing horticultural crop in the hilly areas.

To support and justify the hypothesis, the following are discussed: erratic nature of rain fall in the region and its affect on yield and quality of the crops, the physical feasibility of MI in terms of conditions prevailed in the region and the calculation and comparison of incremental return from using Micro irrigation and other irrigation system in the region.

The following approach was used to test the hypothesis: field visits to capture, comments and opinions of the farmers growing the crops both under irrigated and rain fed conditions; study of physical attributes, relationship of crop physiology and data on existing physical conditions like weather, rainfall etc., from research stations and review of literature (papers and research documents).

An outsider's perception of the region is that it is a water-surplus region with higher annual rainfall and high range of topographical variation. The mechanization of farming and infrastructural amenities is also not at par with the more developed states of the country. The use of ground water in agriculture is also very low as compared to rest of the country, except the valley portion of Assam and Tripura, which are using ground water to some extent to irrigate some of their crops. The farming community of the region is always skeptical about the use of modern, precision irrigation devices like drips. The concept of productivity of water is still new to the people of the region, whereas productivity of land use is a common concept. The traditional practice of agriculture like Jhum still prevails in a substantial acreage among the tribal people in the hilly states.

This study is tying to address the issue of improving the productivity of the available water in fruit production through efficient use with the help of drip irrigation. In this study, efforts are made to assess whether crops like kiwi and orange actually need irrigation for better performance in high rainfall conditions. Arunachal Pradesh is perceived as a higher rainfall zone but the distribution of the precipitation is erratic with low precipitation during the winter months of December, January and February.

2.3. Water Requirement of Kiwi and Rainfall Pattern of the Region

Inadequate soil moisture during dry season adversely affects the fruit size, yield and crop return as the water requirement of this fruit is very high because of vigorous vegetative growth and larger leaf area. Irrigation of matured vine is essential when the average annual rainfall is below 1000mm and water holding capacity of soil is low. Fully grown vines require 80-100 lt of water for total daily transpiration from 16-17m^2 canopy area during summer.

- Moisture deficiency results in foliage dropping of the vines during the early stages of growth (first 2-3 years).

- If plants suffer from moisture stress during the period of rapid growth, it will wilt and leaves turn brown. (Chauhan, Chandel, Negi).
- Water stress during the flowering and bearing stage results in lesser yield in terms of number of fruit per vine and size of the fruit.
- Poor management of the vines along with water stress during the dormant stage of the crop results in lesser bearing in the next season.

Young trees should be irrigated at an interval of 2-3 days, while fruit-bearing trees need irrigation at an interval of 5-7 days, with 20% depletion of soil moisture from field capacity during summer to get better size of fruits. It is very important to meet the water requirement of the vines during the first two years after plantation for successful production of kiwi orchard (Awasthi and Badyal, 2005).

Kiwi fruit requires a well distributed rainfall and high humidity. Application of drip is recommended, which should be operated for two hours everyday.

According to Chandel et al., (2004), the vines irrigated at 100% ETc with drip method registered 39 and 43% increase in shoot growth and trunk girth, respectively, over traditional basin method of irrigation. Water use efficiency was found to be highest (2.91 q/ha-cm) with drip irrigation at 100% ETc and lowest (1.84 q/ha-cm) with basin irrigation at 15 days interval. Besides saving 22% of irrigation water, drip irrigation at 100% ETc yielded 19.4% more fruits compared with basin irrigation, and also produced fruits of better size and quality.

Irrigation in different stages of growth in crucial for kiwi, as the crop has large canopy and vigorous growth. The physiology of the crop reveals that there are a few critical stages in the life cycle of kiwi crop where providing sufficient water to the roots is very important for a good crop harvest and sometimes even for the survival of crop itself. These stages coincide with the dry spell of the region.

The critical stages of bearing plants of kiwi are bud formation from the month of February to March; flowering from the month of April to June; fruit growing stage from September to October; and, fruit maturity stage from November to December. Besides these, the young plants need water for entire year to attain vigorous canopy growth. The first 2 years of growth are important for better bearing of the plant. The water requirement in this period of time is high and subsequently foliage covering the entire area acts as mulch and reduces the frequency of irrigation.

2.4 Fuel-free Drip Irrigation in Kiwi Vineyards of Arunachal Pradesh

Commercial cultivation of fruits like apple and kiwi and vegetable like tomato and flower like orchid has started in the state very recently. The drip irrigation systems used in kiwi vineyards in the study area are gravity operated.

There are plenty of surface streams in undulating slopes in the state, which are a primary source of water in the area. They are mainly perennial and flow from very high altitudes thereby providing elevation difference. Government departments like public health engineering department and department of horticulture construct community tanks at the foothills, collect the water and send to supply tanks constructed in the valley. The high pressure gradient of the streams because of the steepness and difference in altitude provides the required pressure for drips. Water is distributes water with the help of hosepipes. Government departments maintain the community tanks. Farmers may sometimes govern the tanks made for agricultural activities.

The study area has a very large stream, which supplies water to the population within 20 km range under the range of elevation difference of 700 ft to 1500 ft. The farmers have to pay a minimal monthly charge and some deposit to PHE department against the water supply to their residences and fields. In some of the fields, the farmers have constructed storage tanks in the field for operating drip systems. Farmers do not use pump set. Since most of the orchards are on the location of the hill, water flowing from the tank over the hill does not require additional pressure. However, many times the pressure become higher than required. In such cases, farmers use additional check valves and other ways to bypass the additional water and control the water pressure. Farmers thus enjoy fuel or power free drip irrigation systems.

2.5. Impact of Irrigation on the Yield of Kiwi

To understand the economic viability of the system in terms of certain parameters like yield and quality impact and comparing the incremental income from the crops under drip irrigated and rain fed cultivation we conducted a primary survey of villages using drip irrigation for cultivation. In Arunachal Pradesh, the kiwi growers of West Kameng district responded positively towards water requirement of the crop. The 100% of the farmers interviewed during the study responded that drip irrigation increases the yield of the crop.

First, 5 factors were identified as affecting the yield of kiwi in the region. They are: altitude of the vineyard, management practices, air temperature and type of soil, and variety of crop. The farmers were them asked to rank the factors affecting the yield and quality of kiwi production, in the order of importance, majority of the farmers ranked irrigation as top followed by management practices and variety.

2.6 Impact of Drip Irrigation in the Production of Kiwi and Fruit Quality

The determinants of better quality fruit for obtaining better price in the market are size of the fruit, juice content, flavor and some oregano type of taste like sweetness. The size of a best quality fruit ranges from 100-130gm. Weight of medium quality fruit size ranges from 60-100gm and weight below that constitutes average quality.

In the study area the average size of the fruits are not uniform. The average size of the fruit under irrigated condition is 60gm per fruit and fruit grown under rain fed condition is 40gm. Table 1 shows the criteria for fruit quality and how it changes depending on water source. As a part of post harvesting activities, the fruits are sorted according to the size. Farmers in study area reported that irrigated farms harvested better quality fruits/plant as compared to rain fed farms. Subsequently, irrigated farms got a better price realization from the crops.

Table 1: Change in Fruit Quality due to Irrigation

Fruit Quality Criteria	Irrigated Kiwi	Rain fed
Average (less than 40gm)	10%	40%
Better (40-70gm)	60%	50%
Best (more than 70gm)	30%	10%

Yield impact: Farmers of study area responded that there is more gain in fruits per pant of kiwi under irrigated condition irrespective of variety as compared to rain fed cultivation. Kiwi is a very high yielding crop under favorable growth conditions. A matured kiwi crop can yield up to 800 fruit/bearing. In study area, the average number of fruits per plant is not very high ranging from 50-700 during different years of production. The bearing of fruit also depends on the variety of fruit. Table 2 shows the yield impact of rain fed farming vs.

Table 2 : Yield Impact of Rain fed Farming vs. Irrigated Farming.

Variety wise Yield	Number of fruit per plant under irrigated condition			Number of fruits per plant under Non irrigated		
	Allison	Haward	Monty	Allison	Haward	Monty
4th year	100-150	90-200	100-150	60-100	50-80	65-90
5th year	250-450	200-400	200-400	150-200	100-250	100-200
6th year	500-600	500-700	450-550	300-500	200- 450	300-400

The Haward variety under irrigated condition bears highest number of fruits during the sixth year of growth. Farmers are expecting more yields in the coming year.

2.7 Economic Benefit in terms of Labor Saving

Weed is a major constraint in cultivation of most of the crops grown in the region because of vigorous vegetation growth. Weeding is a cost intensive operation for widely spaced crop like kiwi. Drip irrigation restricts weed growth because of less availability of soil moisture for their growth. So, man days required for weeding are reduced. The cost of weeding is higher in hilly areas because of higher labor charge at the cost of Rs.70/man day. According to farmers in the study area, in drip irrigated plots the weed growth is less compared to rain fed plots.

2.8 Checking of Soil Erosion

The top soil is always susceptible to erosion when the land is sloppy. Drip irrigation checks the vulnerability of the soil towards erosion because of moisture availability in the root zone of the plants. The fruits being perennial, help in checking soil erosion and provide high density green cover to the soil.

3. ECONOMIC BENEFITS FROM DRIP IRRIGATED KIWI

3.1 Net Present Worth of Return from Drip Irrigation in Kiwi Crop

Drip irrigation system is an investment, which is able to give returns over time and the cash flows can also change in due course of time. Since this system involves fixed capital, it is necessary to take into account the income streams for the whole life span of drip investment. The economic feasibility of drip is determined by calculating the B: C ratio as well as the NPV over a period of 6 years. In kiwi crop, the initial investment is high. The operational cost of drip is low because of fuel free irrigation (due to gravity flow caused by difference in elevation). The operational cost occurs in terms of man days for weeding as well as some physical maintenance of the system.

Table 3: Benefit Cost Analysis of micro irrigation.

Year	Investment Cost (Rs)	O & M Cost (Rs)	Total Cost (Rs)	Benefit (Rs)	Net benefit (Rs)		Discount Coefficient	Net present Worth (Rs)	
					- ve	+ ve	12%	-ve	+ve
1	5,00,000	20,000	52,0000		5,2,0000		0.8929	4,64,308	
2		20,000	20,000	6,000	14,000		0.7972	11,161	
3		20,000	20,000	6,000	14,000		0.7118	9,965	
4		20,000	20,000	6,000	14,000		0.6355	8,897	
5		20,000	20,000	2,50,000		3,40,000	0.5674		1,92,916
6		20,000	20,000	6,40,000		7,68,000	0.5066		3,89,088
							49,4331	5,82,004	

The benefit cost ratio (B-C ratio) is 1:1.18. The NPV of the returns from drip irrigated Kiwi orchard is Rs. 87673 (Rs. 582004-Rs. 494331). The pay back period is 6 years. The NPV is satisfactory and the B:C ratio is greater than unity. This implies that drip irrigation in kiwi crop is economically viable.

3.2 Findings

Dip irrigation can increase yield and quality of kiwi crop under undulating topography in heavy rainfall zones. Kiwi is an exotic crop, which needs water during its critical stages of growth for obtaining better price in the market. The erratic nature of rainfall causes loss to the yield and quality of kiwi frit which can be corrected with the help of drip irrigation. The cop can be irrigated by drip in a cost effective manner because of fuel free water supply in the state due to difference in elevation. The cost of drip is insignificant in comparison to total cost of cultivation.

Drip irrigation system is economically viable in kiwi crop in Arunachal Pradesh. The net present value of drip irrigation in kiwi is Rs.87673 and benefit cost ratio is 1: 1.18. The pay back period of the system is 6 years. In between farmers can gain some return by intercropping some annual crops. Thus, investment on drip irrigation is sound and economically viable. Therefore, the cultivators are advised to make use of drip sets.
The stream water is plenty in the state now and is used extensively in all type of activities, which may lead to severe depletion during the course of time with increasing population. Deforestation is causing depletion of rainfall, which adversely affects the availability of water in the streams. Proper practices for conserving streams should be launched for sustainability of agriculture in the state.

4. CONSTRAINTS FOR KIWI CULTIVATION IN ARUNACHAL PRADESH

4.1 Non-Availability of Quality Planting Materials

Good quality material is key to the success of any fruit crop. Fruit crops are generally perennial in nature and bad effect of inferior planting materials is only visible after several years of efforts made by growers and when the trees have come to the stage of bearing fruits. The cost of planting material in case of kiwi is high. The grafted panting material is about Rs. 85 in study area, which is a major item in calculating cost of production of the crop.

4.2 Lack of Marketing Facilities

Major issue facing kiwi growers is the marketing of the fruit. There is strong need for an organized marketing system for kiwi in Arunachal Pradesh. Intervention of government agencies and private parties is essential in developing proper marketing channels for the movement of the produce. The cost of marketing is very high because of higher transportation cost. At present farmers are marketing their products through middle men, and often sell it in the local market. Recently APEDA (Agricultural Processed Fruit Export Development Authority) purchased a few tons of kiwi, but was not able to buy the whole lot, which was produced. Horticultural crops being perishable require proper handling and distribution within a limited period. But, due to lack of marketing infrastructure, farmers are forced to sell their produce at a very low price. To achieve better realization to the growers, therefore, there is need to establish marketing systems with forward and backward linkages. By this, farmers can get remunerative price for their produce and would further generate employment opportunities for the people of the state.

4.3 Lack of Processing Industry

There is no processing industry that can utilize the excess produce and protect the growers' interest. Better quality juice, jam, jelly and canned slices of fruit can be made from kiwi, which have very much remuneration in metros and cities. Processing units, which are in the proximity of the fruit-growing area, can be more efficient because of the poor transport facilities available in the state. Until today, there are hardly any cold storage facilities available in the state. A few processing units exist but are not functioning to the desired capacity.

Table 4: Costs of production of kiwi fruit crop grown under rain fed and drip irrigation system

Sr. No.	Attributes	Under Drip Irrigation	Under Rainfed Condition
1.	Average size of land under cultivation (ha)	1.2	1.5
2.	Average annual cost of cultivation (Rs) of Kiwi	500000	4,40000
3.	Operational Cost	20000	25000
4.	Average Yield	260	175
5.	Annual Gross Returns	15,60000	7,00,000

Table 5: Break up of cost of production of kiwi in Arunachal Pradesh (Rs. / ha)

Sr. No.	Activity	Under drip irrigation	Under rainfed
1.	Planting Material	14,000	14,000
2.	Cleaning Forests	10,500	10,500
3.	Digging	7,000	7000
4.	Cost of T bar	3,20,000	3,20,000
5.	Fertilizer	5,000	5,000
6.	Land preparation	7,000	7,000
7.	Fencing	50,000	50,000
8.	Irrigation	30,000	Nil
9.	Harvesting	20,000	10,000
10.	Marketing	30,000	15,000
11.	Total	4,93,500	4,38,500
12.	Operational Cost	20,000	25,000

The operational cost includes cost of man days for weeding and the maintenance of drip system. Till date, no pest and disease are reported by farmers in kiwi cultivation. This reduces the input cost.

Table 6: Area and Prodcution of Various Fruits (2004-05)

Name of Crop	Area (ha)	Production (‘00 ton)
Apple	8403	9474
Citrus	23360	27251
Banana	4914	14817
Pineapple	7913	36310
Kiwi	190	62
Walnut	3516	58
Others	5916	15262
Total fruits	54213	103234
Large cardamom	4142	572
Black Pepper	1612	133
Ginger	7618	36666
Total spices	13372	37371
Grand Total	67584	140605

Source: Annual Report 2004-05, Dept. of Horticulture, Govt. of Arunachal Pradesh

Table 7: Minimum Annual Rainfall in Arunachal Pradesh & Assam (2004-05)

Station	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	MAR	Driest Month
Bomdila	20	20	15	73	118	243	239	159	116	103	29	8	1143	Dec
Dening	73	132	250	460	589	1461	1017	871	588	204	67	46	5758	Dec
Gerukamukh	35	151	89	465	130	270	580	58	55	51	51	8	1942	Nov
Kimin	34	37	54	232	396	513	961	542	590	143	51	27	3579	Dec
Pasighat	47	97	140	248	407	890	1053	751	574	222	31	26	4484	Dec
Sunpura	38	76	145	255	308	449	488	325	337	133	37	25	2616	Dec
Yazali	18	27	57	102	156	313	194	136	125	58	24	15	1224	Dec
Ziro	39	59	78	152	194	239	253	177	153	69	50	47	1510	Dec
Assam														
Gohpur	40	33	58	141	336	444	432	372	236	133	34	19	2277	Dec

ACKNOWLEDGEMENT

The author is thankful to IWMI-TATA Water Policy Program, International Water Management Institute for the support to carry out this study.

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