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On August 05, 2021, Mr. Rajesh Patel (54), owner of the Patel Farms, Manavadar [1], India, was once again disappointed as there was no solace from Indra (the Rain God.) This had become a new normal for Mr. Patel, as the monsoon season remained in name only in this region. The rain-fed agriculture was forced to seek alternative water sources. Like many other farmers, Mr. Patel had no choice but to procure water from the outside (transported using vehicles.) Though cultivators in this region had finally adjusted to the situation, the preceding five years (2016-20) were quite challenging because of the continuous rise in the price of water. As a result, several farmers, including Mr. Patel, incurred losses. Mr. Patel had to utilize his savings for interest payments on a working-capital loan. The cash-rich cotton crop was no longer a profitable deal. The losses for four consecutive years (Exhibit 1) forced Mr. Patel to think about possible remedies as his savings were depleting. He discussed this problem with his only son, Rohit Patel, who was a third-year student in the agriculture engineering course at Junagadh Agricultural University (JAU) [2]. Rohit argued for the adoption of a drip irrigation system (DIS) as it was considered beneficial, especially in dry regions. It seemed an attractive proposition but with limited savings on hand, Mr. Patel was debating whether he should adopt his son's idea or if it might prove to be a blunder.

PATEL FARMS: THE BACKGROUND

Mr. Patel experienced the glory days of Patel Farms during the 1980**s**. He learned about the basics of agriculture during that time. Almost every year Patel Farms had a bumper cotton crop. The Patel family was considered one of the wealthiest families with the largest landholding in the region. Due to better quality produce, Patel Farms was able to command a higher price in the market. With the cumulative and sizable surplus, the Patel family even used to provide loans to the peasants during their lean times. Thanks to their generous nature, the Patel Family, earned respect and repute in the community.

Mr. Patel became nostalgic while referring to past days and said:

> *"In those days, I assumed farming to be the most promising profession as the Rain God was on our side (farmers)".*

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Times changed, and the Patel family grew bigger. Differences of opinion among the three brothers created a rift in the family and, in 2005, the land was equally distributed to all three as part of the family resolution. Two of the brothers, Rahul Patel and Ramesh Patel, sold their farms and migrated to the United States of America, while their younger brother, Rajesh Patel, continued with agriculture. After the break-up,. Rajesh Patel had to learn to undertake all the agricultural activities by himself, as some of the activities were earlier being handled by his brothers. But as time progressed, he learned the tricks of the trade and prospered with his abundant cotton crop.

GREEN DAYS TURN RED

For the preceding five years, the overall cost of cultivation had been increasing (Exhibit 1). Mr. Patel had been using a working capital loan from a financial institution that created a fixed interest liability. He had to utilize his savings for working capital liability as unlike earlier years he was unable to pay the interest from his regular farm income. The profitable cotton crop was now a losing proposition for Patel Farms. Commenting on the same Mr. Patel said:

"Cotton is a cash-rich crop but with this water shortage it is difficult to sustain".

Because of the deteriorating financial health of Patel Farms, Mr. Patel, thought of selling his farm. However, before taking that drastic step, he discussed the issue with Rohit. Rohit suggested his father install a DIS on the farm. Though Rohit was confident about the benefits, Mr. Patel wanted to assess this project in detail.

AGRI - COTTON INDUSTRY OF INDIA

India was an agriculture-based transforming country. Though agriculture did not have a major share in the gross domestic product (GDP) growth, it played a vital role in job creation. A large part of the agriculture sector relied on the monsoon season for water for irrigation. The projected total water demand was 1498 billion cubic meters (BCM), but the available supply was only 1121 BCM [3]. Most northern and peninsular regions were already water-stressed and fast becoming water-scarce, both physically and economically. The situation could worsen as climate change presented a major risk and it might have multidimensional debilitating effects on agriculture. The climatic impact could lead to a significant scarcity of freshwater in the country. Rain-fed agriculture, which covered 60% of all the cultivated land in India, could be particularly hard hit. Moreover, the agricultural sector accounted for about 83 percent of all water use, while the remaining usage was by domestic, industrial, energy sectors, and other consumers. Increasing competition with the other water users in the future could limit the water availability for expanding irrigated areas. Hence, the most obvious solution was minimum usage of these scarce resources [4].

The surface irrigation method (furrow irrigation method) [5] resulted in large losses in water conveyance and application. These losses could be considerably reduced by adopting DIS and sprinkler irrigation methods. DIS was developed for field crops in Israel in the early 1960s and in Australia and North America in the late 1960s. The area under drip irrigation in the US was about 1 million hectares, followed by India, Spain, Israel, etc. In India, there had been tremendous growth in the area under drip irrigation during the last 15 years. By 2020,

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around 0.35 million hectares area was under drip irrigation with the efforts of the Government of India (GOI), compared to only 40 hectares in 1960 [6].

Cotton was grown in subtropical and seasonally dry tropical areas and countries such as India, China, the US, Brazil, and Pakistan, which were known as cotton production hubs. Together, these countries accounted for more than three-quarters of global production. Most of the production growth in the coming decade was expected to come from these countries, with India accounting for more than 40 percent of the global increase [7]. As one of the largest cotton producers, India accounted for about 26 percent of the world's cotton production. India had the distinction of having the largest area under cotton cultivation, about 42 percent of the world's area under cotton cultivation between 12.5 million hectares to 13.5 million hectares. However, the country was far behind in productivity. Indian cotton yield was 459 kgs/ ha in 2020, which was significantly lower than the world average yield of about 757 kgs/ ha [8]. Even with a lower yield per hectare, India was likely to maintain the top rank in world cotton production till 2030 [9]

DRIP IRRIGATION - THE RAY OF HOPE

Mr. Patel was considering Rohit's suggestion regarding the installation of a DIS on the farm. JAU regularly conducted workshops on various irrigation techniques. To better understand DIS, Rohit recommended this workshop to his father. Mr. Patel attended a two-day workshop at JAU in order to better understand various dimensions of DIS.

The workshop started with an introductory talk that provided basic knowledge about DIS. Participants also visited the model DIS of the JAU. The university showcased its structure and formation. The detailed networking of different tubes and how they functioned was also explained in great detail. It was emphasized that DIS had proven to be a boon in dry regions as it reduced the exclusive reliance on the monsoon. The DIS worked on the principle of "per drop more crop" hence, with the minimum usage of water, farmers could increase the yield. Moreover, farmers could reduce the irrigation cost, i.e. water and electricity, by at least 65 percent.

The drip irrigation was an almost zero-labor cost system, having an average age of seven years and zero to negligible scarp value. Plant-watering happened automatically, with minimal human intervention. The system had a water control mechanism. Farmers could set the parameters for the required water quantity per the plant's need. Apart from saving water, one could also protect the crop from the overload of water. In the furrow method, excess irrigation resulted in moisture creation. This moisture was a breeding ground for fungus which affected the volume and quality of the crop. Ultimately, farmers had to bear the losses. The runoff water also depleted nutrients in the soil, while with DIS farmers could save those essential elements of the earth. In short, the mechanism helped in decreasing soil erosion and increasing the fertility of the land. The calculated drops of water improved seed germination and increased the efficiency of fertilizers. The unwanted grass (weed) was also a by-product of overwatering. With the controlled irrigation, areas in between the plants could not receive water, so weeds were less likely to grow. Farmers could reduce the expenses of seeds, fertilizers, weeding, and other maintenance by at least 25 percent.

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While discussing the financials, one of the speakers explained that this system required a sizable one-time capital expenditure and regular maintenance costs. However, this cost could be compensated over time as the installation of a DIS could increase the yield by up to 230 percent. Even in average conditions, the farmers could at least expect a rise in yield by 25-50 percent. Moreover, the farmers were incentivized by the GOI to install a DIS and were given a 6 percent annual interest subsidy on borrowed funds (working capital). To evaluate the viability of a DIS an expert suggested that one could assume the cost of capital (CoC)/ discount factor of 15 percent as the thumb rule.

THE ESTIMATION

Mr. Patel thought of doing a cost-benefit analysis with the help of Rohit. Rohit estimated the initial outlay (Rs. 2.42 million), and the first-year operating cost (Rs. 1.02 million) associated with the project (Exhibit 3). He emphasized the fact that the drip mechanism required extra care and it demanded maintenance costs. Rohit stated that the open network of tubes and pipes could be damaged by multiple factors such as scorching sun, excess cold, stray wild animals, and rodents. Explaining it in detail, he said that too much heat could affect the longevity of tubes and could lead to breakage. Moreover, rodents and stray animals could gnaw away at the drip network. The excess cold could create ice in the internal structure resulting in clogging. Additionally, water with impurities could also block the emitters leading to water stoppage. These external factors could reduce the life of drip and might affect the cash flow estimation. Hence, regular care and a vigilant eye was the need of an hour. Any minor problem needed to be solved immediately as otherwise it could disturb the functioning of the entire network. For smooth operation, farmers needed basic technical skills. Methodological know-how could help farmers in the installation of DIS after the period of inactivity also.

With this information and understanding, Mr. Patel and Rohit did a back-of-the-envelope calculation. Due to significant project costs, Mr. Patel decided to apply for a bank loan. The remaining gap needed to be covered from residual savings (Exhibit 4). The father-son duo estimated revenue and expenditure under three different scenarios namely Pessimistic (25 percent increase in yield), Average (40 percent increase in yield), and Optimistic (50 percent increase in yield) (Exhibit 2). While justifying the situational analysis Mr. Patel said, *"I always believe in preparing for the worst-case scenario".*

THE DECISION POINT

It was August 2021, when Mr. Rajesh Patel was considering whether to install DIS or drop the idea altogether. Though the idea seemed an attractive proposition, it required sizable capital investment. With strained finances on hand, he was grappling with the following issues: In how much time he could recover the initial investment? What if he were to have the least increase in yield? What would be the fixed financial liability? Could he service the loan with inflow? And most importantly was the installation of a DIS a viable idea?

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EXHIBITS

ome & Expenditure of Patel Farms

1) Acres under cultivation	(2) Total Average total cost per Acre /Acre Rs.	(3) Cost of Water / Acre Rs.	(4) Total Cost Rs. (1*2)	(5) Cost of Water % of total cost (3/4)	(6) Yield per Acre (Quintal)	(7) Total Yield (Quintal) (1*6)	(8) Price/ Quintal (Rs.)	(9) Gross Income from Farming Rs. (7*8)	(10) Net Income from Farming Rs. (9-4)	(11) Working Capital Loan Rs.	(12) Effect Intere on worki capita Loan after intere subsi Rs. (11*0
48	28800	7500	1382400	26.04	6.50	312	4790	1494480	112080	1000000	60000
48	29750	8580	1428000	28.84	6.35	305	4680	1426464	-1536	1100000	66000
48	31800	9650	1526400	30.35	6.50	312	4700	1466400	-60000	1200000	72000
48	32590	10490	1564320	32.19	6.40	307	4750	1459200	-105120	1200000	72000
48	33800	12200	1622400	36.09	6.80	326	4625	1509600	-112800	1200000	72000

ed by authors using data provided by Rajesh Patel. Total cost of per acre included Cultivation, seeds, fertilizers, weeding, m
r, Electricity etc.

ultivated Summer /Long Duration cotton every year

l 75% - 80% working capital loan on total working capital requirement, Amount was rounded off

12% interest on Term Loan & Working Capital Loan. 6% interest subsidy receivable at the end of every year from Governm
orking capital)

ual to 100 kg

Exhibit 2: Expected Cost Benefit scenario estimation/ analysis for 2022

Particular	Estimation under Furrow System for the year 2021	Drip Irrigation		
		Pessimistic: Yield increase by 25%	Average: Yield increase by 40%	Optimistic: Yield increase by 50%
Acres under cultivation	48	48	48	48
Average cotton Yield per Acre (Quintal)	6.5	8.125	9.1	9.75
Total expected Yield	312	390	436.8	468
Average cotton Price (Rs.) Per Quintal	4700	4700	4700	4700

Total Revenue/ Operating Revenue	**1466400**	**1833000**	**2052960**	**2199600**
Recurring Cost				
a. Cost of Water per acre	12250	4288	4288	4288
b. Other expenses: Cultivation, seeds, fertilizers, weeding, maintenance, Labour, Water, Electricity etc. per acre	22750	17062	17062	17062
Total (a+b): Average total cost per Acre (Rs.)	35000	21350	21350	21350
Working Capital Requirement/ Operating Expense	**1680000**	**1024800**	**1024800**	**1024800**
Source: Created by authors using data provided by Rohit Patel & Rajesh Patel				
The estimated numbers for year 2021 under existing furrow system were given by Rohit Patel & Rajesh Patel based on actual cost incurred till July 2021.				
It was expected that installation of drip irrigation system could reduce the irrigation (water + electricity) by 65% and could reduce the other costs (cultivation, seeds, fertilizers, weeding etc.) by 25%. Reduction in the cost had been estimated on the basis of expected cost for 2022 in furrow irrigation system				
Working capital requirement was expected to increase 5% every year. Additional working capital needed to be financed through equity.				
Average Cotton Yield per acre in furrow system was estimated using average yield of last five years (exhibit 1)				

Exhibit 3: Cost for Drip Irrigation system	
Particulars	**Amount (Rs.)**
Acres under cultivation	48
a) Head Unit Components: Filters, inlet and outlet, pressure gauze, control valve, butterfly valve, air release valve, bypass GI fitting	8500
b) Field Unit components: Main line, sub-main and laterals-PVC pipes, PVC ball valve, PVC flush valve, LLDPE plain lateral, emitters, and PVC fittings and accessories	42000
Total Capital Cost (Fixed Assets) Per Acre (a+b)*	50500
Total Capital cost (Fixed asset) Investments	**2424000**
Irrigation Cost	4288

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Cultivation, seeds, fertilizers, maintenance cost etc.	17062
Average Total cost per Acre (Rs.)	21350
Working Capital Requirement	**1024800**
Source: Created by authors using data provided by Rohit Patel & Rajesh Patel	
The age of DIS was seven years with zero scrap value.	
Working capital requirement was expected to increase 5% every year. Additional working capital needed to be financed through equity.	
* Cost calculated using MAFW (2017), "Indicative cost of Drip Irrigation System for calculation of subsidy", part of Operational Guidelines of Per Drop More Crop (Micro Irrigation) Component of Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), Ministry of Agriculture & Farmers Welfare (MAFW), available on https://pmksy.gov.in/microirrigation/Archive/GuidelinesMIRevised250817.pdf, accessed on September 01, 2021	

Exhibit 4: Means of Finance	
Particulars	**Drip Irrigation**
Investment in Fixed Assets	2424000
Maximum possible loan @ 75%	1818000
Loan Amount planning to apply	1800000
Own Contribution	624000
Working Capital Requirement	1024800
Maximum Working Capital Loan @75%	768600
Loan Amount planning to apply	760000
Own Contribution	264800
Source: Created by authors using data provided by Rohit Patel & Mr. Rajesh Patel	
Banks generally gave 75% total project requirement, Amount was rounded off	
Bank charged 12% interest on term loan and working capital loan	
Government of India (GOI) given 6% interest subsidy on working capital loan to all the farmers, receivable at the end of respective year	
Term loan to be repaid in seven equal annual installments	
The Discount Rate/ Cost of Capital to be taken as 15% for calculation purpose as suggested in JAU workshop	
Agriculture business in India did not attract any income tax so effect of depreciation was nullified	

Exhibit 5: Assumptions to be used in the case	
1	Bank charged 12% interest on Term Loan & Working Capital Loan. Government of India (GOI) given 6% interest subsidy on working capital loan to all the farmers, receivable at the end of respective year

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2	The Discount Rate/ Cost of Capital to be taken as 15% for calculation purpose as suggested by Mr. Rohit Patel
3	Term loan to be repaid in seven equal annual installments
4	Agriculture income in India does not attract any income tax so effect of depreciation was nullified
5	Cost includes the transportation cost and applicable taxes and is net of all the capital subsidies applicable
6	Working capital requirement was expected to increase 5% every year, repayable at the end of seventh year.
Source: Created by authors using data provided by Rohit Patel & Mr. Rajesh Patel	

1 Manavadar is a small village in the district of Junagadh, Gujarat State, India

2 Junagadh Agricultural University (JAU) is one of the largest Agricultural Universities in the state of Gujarat, India. JAU is based in the city of Junagadh - headquarter of the Junagadh district. JAU offers higher education in the faculties of Agriculture, Agricultural Engineering & Technology, Fisheries Science, Veterinary & Animal Husbandry, and Horticulture. University imparts training to farmers and other stakeholders. Please refer http://www.jau.in/

3 "Charting Our Water Future: Economic frameworks to inform decision-making", McKinsey & Company, accessed July 18, 2021, https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/sustainability/pdfs/charting%20our%20water%20future/charting_our_water_future_full_report_.ashx

4 "Vision 2050", Indian Council of Agricultural Research, July 2015, accessed July 18, 2021, https://icar.org.in/files/Vision-2050-ICAR.pdf

5 Furrow irrigation was one of the oldest methods of irrigating fields. It was also known as flood or surface irrigation. In this method, farmers flow water down small trenches running through their crops. It was still used throughout the world, especially in less-developed areas where mechanical techniques were not available. It was not the most efficient irrigation method, but it was cheap and low-tech. Source: Water Science School, "Irrigation Methods: Furrow or Flood Irrigation", June 13, 2018, https://www.usgs.gov/special-topics/water-science-school/science/irrigation-methods-furrow-or-flood-irrigation

6 "Drip Irrigation Technology to save Water and Enhance Crop Yields", Indian Agricultural Research Institute (IARI), accessed July 18, 2021, https://www.iari.res.in/index.php?option=com_content&view=article&id=88&Itemid=312

7 "OECD-FAO Agricultural Outlook 2021-2030", OECD-FAO, July 05, 2021, http://www.fao.org/3/cb5332en/cb5332en.pdf, accessed on September 01, 2021

8 "National cotton scenario" The cotton corporation of India Ltd., accessed July 18, 2021, https://cotcorp.org.in/national_cotton.aspx

9 G. Chandrashekhar, "India to maintain top rank in world cotton production till 2030", the hindu businessline, August 03, 2021, https://www.thehindubusinessline.com/markets/commodities/india-to-maintain-top-rank-in-world-cotton-production-till-2030/article35699684.ece