AGRICULTURAL REVISION IN DROUGHT PRONE ARID REGION OF KUTCH: PEOPLE LED, MARKET ORIENTED GROWTH UNDER ADVERSE CLIMATIC CONDITIONS

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ABSTRACT

Water availability and soil suitability are the primary requirements for stable agricultural production. Due to erratic rainfall and lack of irrigation for agriculture, arid regions suffer from volatile conditions for agriculture. Kutch, the western most district of India in the state of Gujarat is well-known for its arid climate. More than half of its land is either partially inundated by sea water or classified as desert making it unsuitable for agriculture. The remaining land mass experiences low (15 Year Annual Normal = 450 mm) and erratic (45 per cent Coefficient of Variation) rainfall making agriculture in the region, not a very promising occupation. But, in recent years due to access to irrigation through groundwater, the advent of micro irrigation practices and increasing market-oriented crops supported by good rainfall spell for over one decade starting from 2003 have led to significant improvement in agriculture for the District of Kutch. There has been a significant shift towards less water-intensive high-value horticulture crops making it one of the horticulture hot spots in the Gujarat state.

This paper makes a data-based assessment of the agriculture in Kutch to study the transition into different non-traditional high-value crops. It also synthesizes major findings of the field exploration carried out to understand the key success factors in horticulture and the adoption of technology for micro-irrigation creating a higher value chain of the water used. The findings show promising outcomes for less water-intensive farming as well as high-value crops along with highlighting a few hurdles which have to be addressed for smoothly taking up drought resilient and market-oriented agriculture in adverse climatic condition.

Keywords: Adaptation strategies, Agriculture in Adverse climate conditions, Innovative crop water practices, Agriculture in an arid region, Kutch.

1. INTRODUCTION

Agriculture is the major contributor for the livelihood of more than half of the population of India which comprises of diverse landscapes that houses deserts and salt plains in the western part, large flood plains of Ganga and Yamuna rivers in the northern part, dense rainforests and river deltas in the east, hills in the south and semi-arid hard-rock plains in the central and south western plains. Out of all 29 states of India, Gujarat shows the highest orographic gradient. Situated in the western region, Gujarat is geographically classified into 5 regions. 1) South Gujarat (South Gujarat and South Gujarat Hills) 2) Central Gujarat 3) North Gujarat 4) Saurashtra Peninsula (North Saurashtra and South Saurashtra) and 5) Kutch Region. As shown in Figure 1 and Table 1 the climate as well as soil conditions vary within the state to a great extent.

1.1 Kutch: An Oasis in Desert

As shown in the Figure, Kutch is situated in the westernmost part of India and shares its border with Pakistan and Rajasthan State and occupies 25.29 per cent of the total area of the state. Topographically, the region is unique in the way that it is surrounded

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by salt plains, a large area of salt marshes and sea isolating it from the rest of the state and country. The region has been historically valued for being a gateway to the middle-east through ports and still holds dynamic freight activities through four ports Kandla, Mandvi, Jakhau and Mundra. Kutch also got prime focus post the 2001 earthquake rehabilitation phase, when many industries boosted the economy of the region. The government declared the region special economic zone. This fetched very high investments in the manufacturing industry. 72 Large scale and 29 medium scale manufacturing industries are situated in Kutch District, making it one of the leading production hubs in the state. Since 2006, the state Government started focusing on the tourism industry in the region that houses unique crystal white salt planes. “RannUtsav", as it is called is a 3 month long carnival season that fetches very high tourist revenue in the region from all around the world. (GoI, 2016) The aggressive push by the state government for the development of the Kutch region through large scale investments made the region famous for its success stories of production, shipping and tourism industries but it is least known for agriculture and allied activities. Agriculture in Kutch had never been a widely practiced occupation due to low productivity of land, low rainfall and poor availability of water. (Bharwad& Mahajan, 2002)

Table 1: Climate and Soil Types of the Agro-climatic regions of Gujarat

Sub Region	Climate	Soil
Kutch	Arid to semi-arid	Sandy, Saline
North Gujarat	Arid to semi-arid	Loamy, alluvium
Central Gujarat	Semi-arid	Medium black
South Gujarat	Semi-arid to dry sub-humid	Deep black, alluvium
Southern Hills	Semi-arid to dry sub-humid	Deep black, clayey alluvium
North Saurashtra	Dry sub-humid	Shallow, medium black
South Saurashtra	Dry sub-humid	Shallow, medium black, calcareous

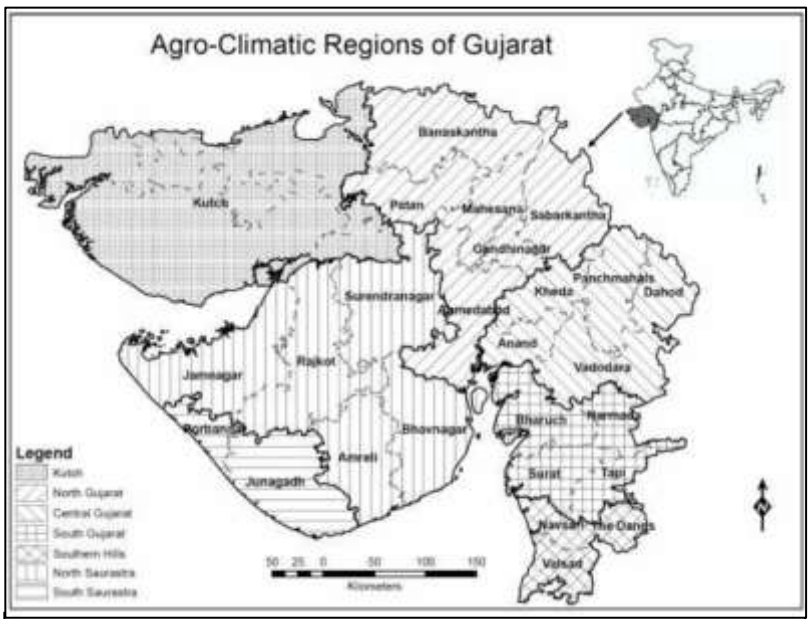

Figure 1: Agroclimatic Regions of Gujarat (Singh & Nair (2012))

Although Kutch has 45,652 sq km of total land mass, most of it is barren or desert land (53 per cent) making only 20.7 per cent of the total land in Kutch available for agriculture after the exclusion of forest, wasteland and grasslands. There is also a lack of irrigation (34 per cent irrigated land as per 2010-11) and erratic rainfall pattern, (45 per cent coefficient of variation). The situation in Kutch has been challenging due to insufficient rainfall for the last 5 years (5-year average = 338 mm as compared to 480 mm). The paper looks into agriculture in Kutch using a broad perspective with a focus on understanding the growth pattern

of high-value agriculture production in recent years. Gujarat as a whole has witnessed sharp increase in agriculture production propelled by expanding irrigation, supportive policies as well as knowledge sharing opportunities for farmers (eg *"Krishimahotsavas*": Dedicated gathering to showcase innovation in agriculture and allied sectors for farmers) over past few decades and this change has brought in many a paradigm shift in cropping patterns as well as water requirements. Availability of water has improvised the cropping intensity and has given a path to more water-intensive cash crops in Gujarat. Kutch which was traditionally confined to a few rain-fed cereal and pulse crops diversified to oilseeds as well as cotton in the early 21st century. Unlike other parts of India, where farm activities are dominated by small and marginal farmers due to land fragmentation, Kutch having large land mass enjoys the benefit of scale. The average land holding for farmers is 3.51 ha (Hectare) as compared to 1.15 ha for India as a whole which makes agriculture in the region dominated by comparatively larger farmers having resources to upgrade and experiment on new crops. There have been stories and case studies highlighted by national media about the innovative agriculture in Kutch led by large scale farmers. This phenomenon of having large farmers take the lead in progressive farming percolates down to encouraging small farmers also to shift to more promising, economically viable and tested agriculture production. The immutable first shift was from traditional crops such as Bajra, Greengram, Jowarand wheat to cash crops having a higher economic value such as Castor, Groundnut, Gowar, Cotton, etc. These water-intensive crops certainly increased water requirements in the water-scarce arid region causing a greater burden on groundwater in absence of any other source of irrigation. (Kumar & Nair, 2012)

Table 2: Changing Cropping Pattern (Bharwad& Mahajan, 2002)

Crop	**Area (Acre)**		**Change (per cent)**
	1958	1992-93	
Bajra	360000	290000	-20
Jowar	174000	350000	+100
Pulses	200000	277500	+38
Cotton	20000	137500	+587
Groundnut	7000	215000	+2970

In the last decade, agriculture in Kutch is again witnessing a paradigm shift in terms of cropping patterns, irrigation as well as crop innovations. The region also provides a unique perspective of the agriculture sector given that the region, unlike other Indian states, has a higher proportion of large and medium farmers who can afford high-cost technology for improving yields. This paper tries to highlight major agricultural improvements in the region with consideration of resource availability and farmers' size group distribution. It also tries to evaluate how market-oriented production of crops is leading to a higher value of output per cubic meter of water used.

2. METHODS

In order to take a closer look at the development of the agriculture sector in recent years, this study uses secondary data sets such as horticulture statistics, agriculture production data and development of micro-irrigation in the region to check if there is a significant change in the agricultural practices in the region or not. The data analysis is coupled with on-field exploration where six case studies have been developed to better understand the ground reality related to agriculture within the region. Here it has to be noted that Kutch is a highly drought-prone region and lacks any permanent irrigation source except groundwater. The case studies have been carried out with interest in how farmers are coping with risk in recent years poised by a 5 year long dry spell. They enable the understanding of the emergence and adoption of market-oriented high-value crops and how the farmers are adopting the change. The survey

data compiled helps confirm the estimation of total water usage and estimated income for the farmers from those crops. Traditional farming (cereals and oilseeds irrigated by flood irrigation) is compared with progressive farming (Horticulture crops with water-conserving drip-irrigation technology) to understand the value of output against the water used for irrigation.

3. RESULTS AND DISCUSSION

3.1 Kutch Region Agriculture Data Analysis

3.1.1 Land Distribution by The Size Group Of Holdings

Unlike the general trend in India where more than 85 per cent holdings belong to Small and Marginal farmers, Kutch has approximately 65 per cent of holdings belonging to Medium, Semi-medium and Large Farmers. (Figure 2) The average landholding size of Kutch is 3.51 ha as compared to 1.15 ha for all over India. (MoA, 2015). The land size and productivity of farmers has been a long-debated issue. Fan and Connie (2005) show that to increase labor productivity, and therefore, farmer's income, either land productivity has to increase or land to labor ratio has to improve.

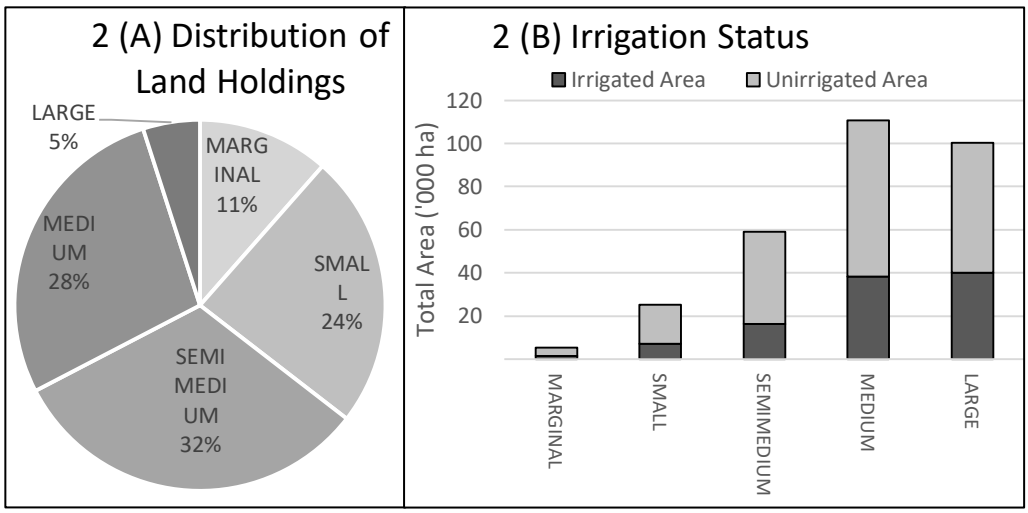

Figure 2 :(A) Distribution of land holdings by the size group of holdings (Marginal < 1 ha, Small :1 - 2 hectare (ha), Semi-medium : 2 - 4 ha, Medium : 4 - 10 ha, Large > 10 ha) (B) Area under different food grain production by size group of holdings and irrigation status

Table 2: Average yield of major crops for Kutch and rest of Gujarat state from 2007-2012 (AID, 2019)

Crop Name	Season	Average Yield (Kutch)	Average Yield (Rest of Gujarat)
Castor Seed	Kharif	1.83	2.03
Moong(Green Gram)	Kharif	0.43	0.48
Cotton(lint)	Kharif	4.43	3.09
Groundnut	Kharif	1.60	1.36
Guar seed	Whole Year	0.49	0.57
Bajra	Kharif	1.01	1.08
Sesamum	Kharif	0.43	0.40
Wheat	Rabi	2.87	2.89
Moth	Kharif	0.37	0.47
Rapeseed &Mustard	Rabi	1.68	1.51

Given the consensus that smaller farms have a lower land-labor ratio than large farms, Dyer (1997) and Havnevik and Skarstein (1997) consider that smaller farms enjoy higher land productivity in the short term, but over the long-term when a change in technology comes into the picture, land productivity tends to drop.(Chand & Prasanna, 2011) They argue that this long-term drop in land productivity results from over intensive cultivation of the land in order to maintain labor productivity, when more and more people need to survive on the same small area of farmland, and as the smaller farms are resource-poor to invest in preserving soil fertility, soil productivity eventually becomes exhausted and land productivity drops. This is supported by data as although having a large land size and less suitable soil conditions, the average crop productivity for major crops is comparable for Kutch with the rest of Gujarat as given in Table 2.

3.1.2 Cropping Pattern: An Adaptive Occurrence

Traditional agriculture was food-crop-oriented since it was meant for subsistence, but in modern agriculture, cash crop cultivation has increased rapidly. The new adoption of high-value crops is frequently highlighted.(Rahman, 2017) The area under cotton has increased by seven-fold and that under groundnut by 30 times from 1958 to 1993. The comparative increase in food crops has been much lower, and the production of Bajra, the staple diet of local people, has fallen over time as evident from Table 2. Apart from this, recent agriculture census reports show a further decline in cereals production. Figure 3 shows the change in area under different types of crops. It is evident that the area under cash crop and fodder is rising over the years. This suggests an inclination towards crops with higher economic values. Here, fodder production can be used as a proxy for milk production. Increasing milk production also indicates an increase in value based crop production. Another paradigm shift in agriculture, which is visible now is increasing horticulture farming. Apart from the increase in cash crop production, in recent years Kutch has witnessed a sharp rise in very high-value horticulture crops. Given the utility available with relatively large farmers, the growth in horticulture crops which require heavy pre investments, in terms of securing round the year irrigation as well as the care required for plants during the initial gestation period, can be afforded by well off farmers as compared to marginal or small farmers. It is important in case of Kutch to look at the land size given that field exploration suggests most of the innovative initiatives such as horticulture crops, drip irrigation, sand filtration etc are adopted by farmers with limited or no incentives from government policies.

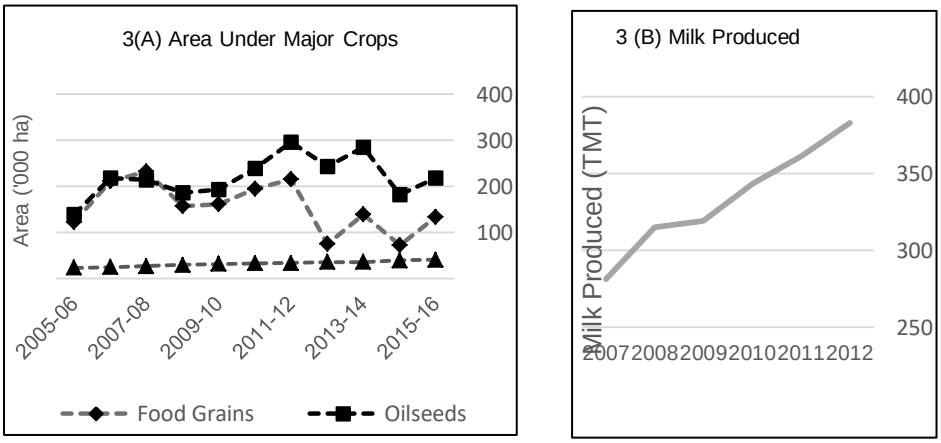

Figure 3: (A) Area under different types of crops. (AID, 2019)(B) District milk production TMT (Thousand Metric Tonnes) (NDDB, 2013)

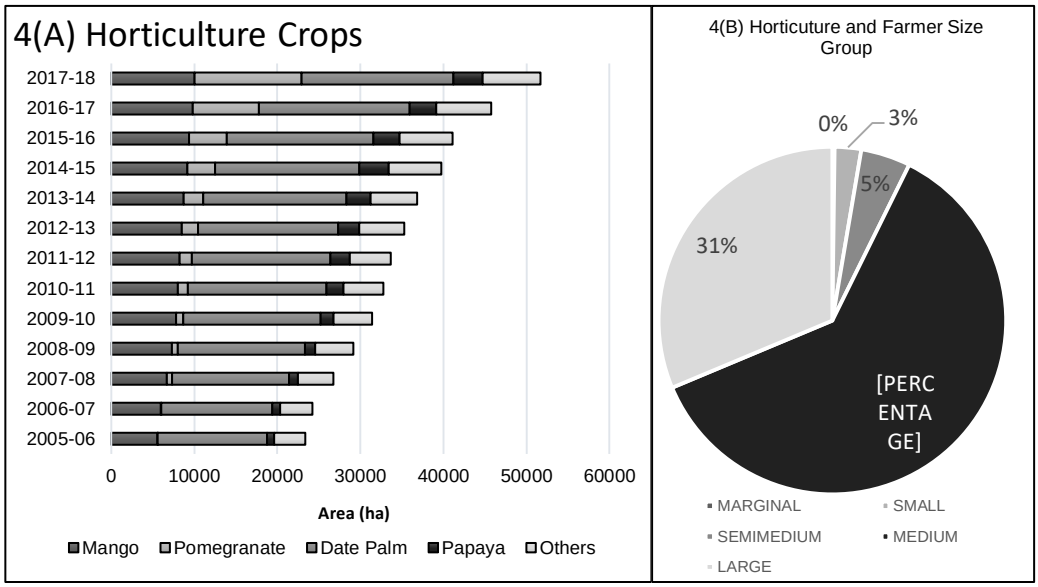

Figure 4: (A) Area under different Horticulture Crops (DoH, 2019). (B)Distribution of Horticulture crops by size group for the year 2010-11 (MoA, 2015

3.1.3 Contemporary Development in Irrigation and Groundwater Condition

Kutch has a high variation in rainfall (50 per cent). Such high variation causes uncertainty in agricultural production in the absence of alternative sources of water. Isolated by salt planes and the sea from the mainland, major parts of Kutch lack perennial sources of irrigation. This has been the major cause of stagnant agricultural growth in the region.

With increasing access to cheap boring and almost free farm power supply, Kutch has been witnessing rapid growth in the area under irrigation. As of 2010-11, a total of 37 per cent area is under irrigation as compared to 24 per cent in 2000-01 (MoA 2015). The improvement in irrigation is entirely due to groundwater as surface water resources are scarce in the region. There has been further development but the scarcity of data prevents further estimation of area under irrigation post-2010.

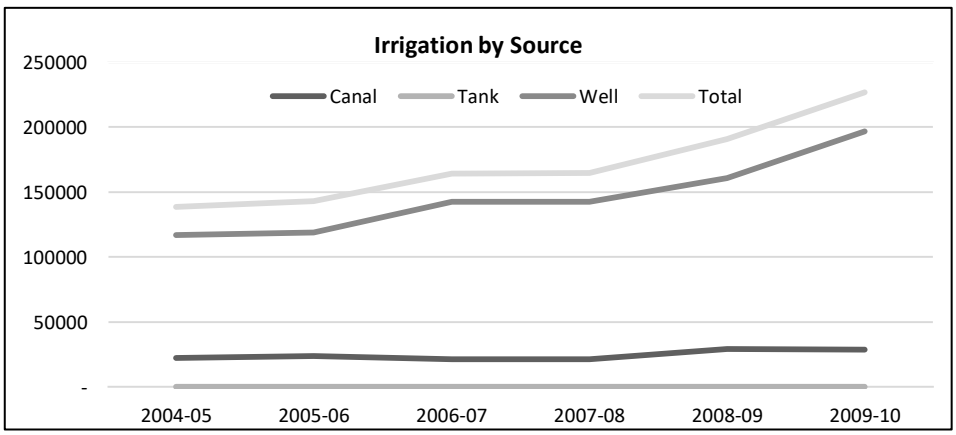

Figure 5: Irrigation by Source in the district of Kutch (Land use statistics)

It is more important to look at the development of water-efficient irrigation practices in the case of Kutch which has been facing acute water shortage in recent years due to below normal rainfall and high groundwater extraction. To expand the area under water efficient micro-irrigation practices, the Government of Gujarat formed Gujarat Green Revolution Company (GGRC) which has been mandated to promote and implement micro-irrigation schemes in the state of Gujarat. The government also provides subsidies (70 per cent) to promote micro-irrigation technologies such as drip

irrigation. Figure 6 shows year on year addition of area under new micro-irrigation schemes as well as estimated total area under micro-irrigation. It is evident from comparing Figure 6 with Figure 4(A) that the increase in new Pomegranate cultivation and additional development in micro-irrigation are contemporaneous. Most of the new pomegranate cultivators had to start adopting micro irrigation practices for better water efficiency.

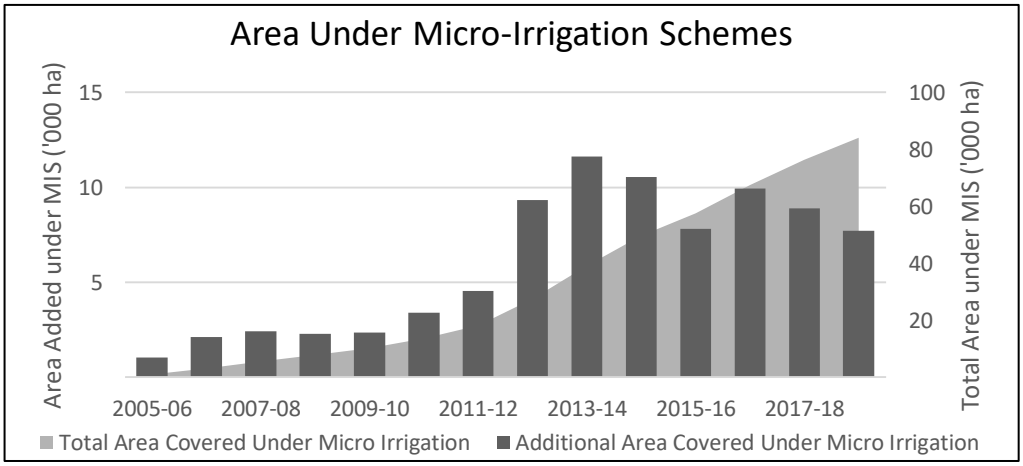

Figure 6: Area undermicro-irrigation schemes implemented by GGRC (GGRC, 2019)

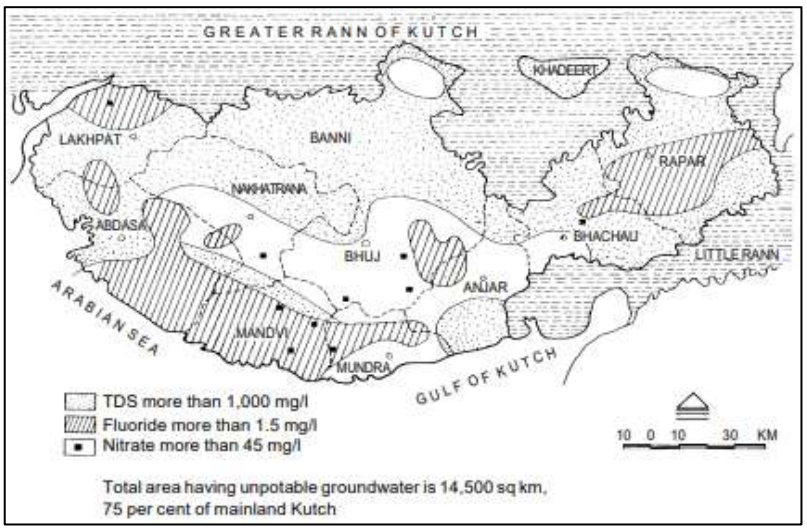

Figure 7: Ground Water Condition in Mainland Kutch (Greater Rann of Kutch and Little Rann of Kutch are partially desert and partially salt planes that are inhospitable) *Source: Patel, PP, (1995)*

There are about 31,344 operational schemes for minor irrigation distributed among ten blocks of Kutch district, out of which about 92% of schemes are groundwater based. Of these, 31 per cent are dug wells, 22.5 per cent shallow tubewells and 46.5 per cent deep tubewells. (CGWB, 2015)

Groundwater-based irrigation is sustainable if the annual extraction is less than renewable groundwater recharge. In the case of Kutch, the recharge is very less due to the erratic rainfall as well as aquifer characteristics having low permeability for most of the region. (CGWB 2015)

3.2 Field Observations

Section 3.1 provides a bird's eye view regarding the agriculture and irrigation shift whereas in section 3.2, the focus is on the study outcomes of field exploration carried out by the researcher with the help of local farmers in Kutch. This section synthesizes the major takeaways regarding improving irrigation through groundwater as well as increasing horticulture.

3.2.1 Why Horticulture Over Traditional Crops?

Analyzing the horticulture data shows us that the increase in area under horticulture crop can be attributed to the introduction and rapid adoption of Pomegranate cultivation around 2010. It started with few large scale farmers who experimented with the crop and found good economic returns. Quick adoption by other farmers can be broadly attributed to two reasons:

1) *High Economic Value*: Table 3 gives a comparative analysis of the value of output per Acre for major crops grown by farmers in the region. Agriculture production prices are susceptible to market dynamics thus the average expected value of the crop in normal season is considered. For a given year, using different possible combinations of crops a traditional farmer can earn up to Rs 80,000 to Rs 90,000 per hectare (ha). In the same region farmers with pomegranates or mangoes can earn approximately Rs 300,000 to 400,000 per hectare depending on the market prices as well as yield. (We are not considering date palms as they need specific soil conditions which may not be available for most of the region of central Kutch. Also as seen in Figure 4 (a), mango and pomegranate are the crops that have seen a major improvement in recent years). This suggests greater earning opportunity for farmers. This caused many of the Medium and Large farmers to shift to horticulture in a phase-wise manner. Typically, unlike other horticulture crops such as Mangoes and Date palms (3-4 Years), Pomegranates (15-18 Months) provide an advantage due to shorter gestation period. This made the transition less detrimental to farmers' income and encouraged others to take up the same.

2) *Depleting Groundwater*: The agricultural growth of the region is entirely dependent on groundwater resources for fulfilling water requirements during non-monsoon months as well as during erratic rainfall season. Field studies highlight that all the places examined have witnessed depletion of groundwater by approximately 30 m in the last 10-15 years. With high depletion, the groundwater extracted has higher salt content. Most parts of Kutch now face groundwater Total Diluted Salts (TDS) as high as 1500 to 3000 mg/l. (As per World Health Organisation (WHO) standards TDS higher than 600 mg/l is considered poor and higher than 1200 mg/l is unacceptable) (WHO). Under these conditions, many crops are not able to sustain without fresh irrigation water. Pomegranates are gaining acceptance due to its TDS tolerant properties. The plant can survive with irrigation water having TDS around 3000 mg/l. Also, the water requirement for the plants when fulfilled using drip irrigation helps reduce total water requirement to a great extent.

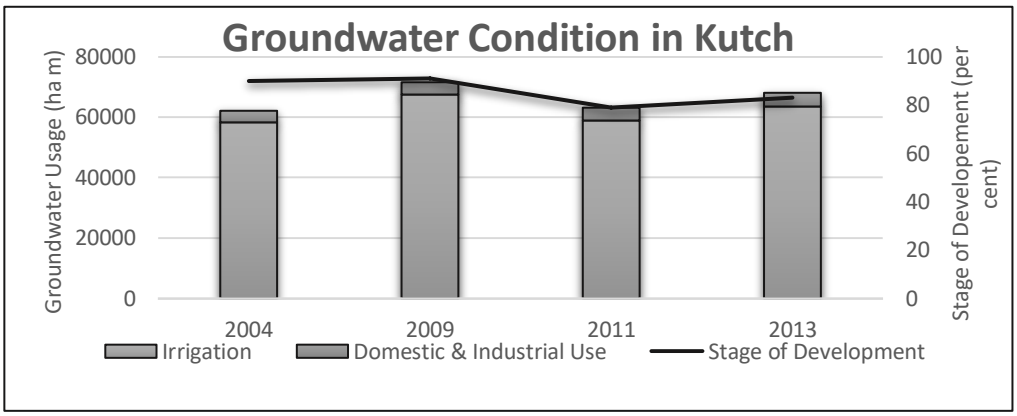

Figure 8: Total Groundwater daft for Irrigation, Domestic & Industrial uses and Stage of Development in hectare meter (ha m). Stage of Development (per cent) above 70 per cent is considered unsafe. (CGWB 2006, 2011, 2014, 2017)

3.2.2 Water Demand Estimation

Water is the most precious resource for *Kutchis*(People from Kutch). It is of utmost importance to understand the additional value addition done by the water used. Horticulture is known for having a high value per m^3 of water used. (Malhotra & Das, 2016) Given the scarce water resources in Kutch, it is also important to check whether horticulture crops also substantially reduce the total consumption of water as compared to other traditional crops. Horticulture crops are mostly grown with drip irrigation technology that helps in the reduction of water required as compared to flood irrigation. Drip irrigation does not put a huge monetary burden on farmers as the state government is subsidizing it by almost 70 per cent. (GGRC, 2019)
Water requirements are estimated as follows:

Total Water Required: $\boldsymbol{TWR = N * t * D}$
N = Average Number of Irrigations Required
t = Time required to irrigate 1 Acre of Land (hr)
D = Water Discharged in Unit Time (m^3/hr)

Based on the calculations, Table 3 shows the approximate value of production per cubic meter (m^3) of water used for traditional Flood Irrigated Crops as well as Horticulture crops irrigated using the drip irrigation method

Crop Name	Gestation Period	Gross Income	Net Income	No of Irrigation	Water Usage	Gross Income per m3	Net Income per m3
	(Months)	('000 Rs /Acre)	('000 Rs /Acre)		(m3)	(Rs /Acre / m3)	(Rs /Acre / m3)
Cotton	4-8	60-65	35-40	30-50	900-2000	17.5-44.4	30.0-72.2
Wheat	3	35-40	20-25	20-25	600-1000	20.0-41.7	35.0-66.6
Ground-nut	3-4	45-50	28-32	20-30	600-1200	23.3-53.3	37.5-83.3
Rajko	2.5	20-24	12-15	15-20	450-800	15.0-33.3	25.0-53.3
Mustard	4	30-35	20-25	25-30	750-1200	16.7-33.3	25.0-46.6
Castor	8	70-75	50-55	50-60	1500-2400	20.8-36.7	29.1-50.0
Mango**	30-36	300-450	200-250	120-150	600-900	222.2-416.7	333.3-750.0
Pome-granate**	15-18	250- 450	200-300	120-150	600-900	222.2-500.0	277.8-750.0

Table 3: Expected crop production and value of output for major crops in the region. (*1 Mann = 40 kg, ** Mango and Pomegranate are horticulture crops and income from their production is for 12 months once they are fully grown and use Drip Irrigation)

4. CONCLUSIONS AND WAY FORWARD

It is very evident from Table 4 that the horticulture crops are grown using drip irrigation improve upon the water productivity by more than 10-15 times, clearly indicating the high water productivity of crops in the region. Apart from the higher value, horticulture crops also help in reducing the multiple sowing and cultivation cycles hence reducing the efforts required for maintenance of the field. Another salient feature of the agricultural practice in Kutch is the relatively higher wage rates for farm-labor. An average farm laborer earns Rs 300-350 for 8 hr of work as compared to Rs 120-150 in Central and South Gujarat. This is partly because of the following reasons. 1) High Industrial Labour Demand: As mentioned earlier, Kutch has been a budding industrial hub for the manufacturing, shipping as well as the tourism industry. The advent of alternative sources of employment has reduced the labor supply for agriculture. 2) Relatively Skilled Labour Required: For horticulture production, farm laborers need better punitive skills as compared to traditional farming. 3) Increased Landlord Income: Relatively well-off landlords do not hesitate in spending more on labor to get higher efficiency.

Agriculture in Kutch under erratic rainfall and scarce water resources helps us understand how farmers can be more climate resilient with use of progressive technology and suitable cropping pattern which in turn improve their water productivity.

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