

International Journal of Agriculture Extension and Social Development

Volume 9; Issue 4; April 2026; Page No. 726-731

Received: 15-02-2026
Accepted: 21-03-2026

Indexed Journal
Peer Reviewed Journal

Analysis of agricultural mechanization, technology adoption, and farm productivity: A case study of Choki (Sorath) Village, Junagadh District

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DOI: <https://www.doi.org/10.33545/26180723.2026.v9.i4i.3541>

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Abstract

A survey was conducted from 2nd to 8th February 2026 in Choki (Sorath) village of Junagadh district, covering approximately 150 farmers. The study collected comprehensive information on socio-economic status, farm size, income, and level of mechanization, including tractor ownership, horsepower, and use of agricultural implements such as cultivators, rotavators, seed drills, sprayers, threshers, and harvesters. It also examined reliance on custom hiring services and shared machinery, along with the adoption of sustainable technologies such as solar systems (at home and farm), greenhouse farming, and biogas plants. Additionally, data on irrigation practices (drip/sprinkler systems), cropping patterns, seasonal production, and yield per bigha were recorded. The survey further assessed farmers' access to government schemes, use of food processing equipment, and awareness of digital tools like Kisan AI and other mobile applications. Overall, the study provides a holistic understanding of agricultural mechanization, technology adoption, and their impact on farm productivity and livelihoods in the village.

Keywords: Agricultural mechanization, micro-irrigation, renewable energy, cropping intensity, farm productivity, digital agriculture, government schemes, rural development

Introduction

Crop cultivation in Junagadh district of Gujarat is largely dependent on monsoon rainfall, which is often inadequate, uncertain, and erratic. These climatic challenges, along with frequent infestation of insect pests and diseases (Zala *et al.*, 2021) ^[6], significantly affect crop productivity and farmers' income. To overcome these constraints and increase crop production, the adoption of improved farm mechanization and scientific management practices is essential. Farm mechanization is a critical input for increasing agricultural productivity. It ensures timeliness of agricultural operations, increases labour efficiency, reduces drudgery, and improves the quality of farm operations. Hence, it plays a vital role in enhancing overall farm output (Mehta *et al.*, 2019) ^[3]. Farm mechanization is recognized as one of the key drivers of agricultural growth and overall national development. Historically, tools and implements have played an essential role in agriculture since the beginning of crop cultivation. With the advancement of knowledge, skills, and technology,

agricultural tools and machinery have evolved over time to improve efficiency and reduce the burden on farm labour (Clarke, 2000) ^[2].

The contribution of mechanization to agricultural production is significant. It includes the use of modern tools and motorized equipment such as ploughs, harrows, and ridgers, along with inputs like improved seeds, fertilizers, herbicides, and insecticides. Mechanization broadly refers to the application of tools, machines, and equipment in agricultural operations (Sarkar and Roy, 2014) ^[4]. Farm power in agriculture is mainly derived from human labour, draught animals, and mechanical sources. However, agricultural productivity in India is relatively low compared to developed countries. A major reason is that about 83% of farmers are small and marginal, cultivating less than two hectares of land.

Thus, there is considerable scope to increase crop production by improving the efficiency of farm inputs and adopting mechanization, particularly for labour-intensive

and time-consuming operations. Mechanization planning involves assessing the mechanization index and its impact on agricultural production, cost of cultivation, and labour utilization (Singh, 2006) [5]. Future trends further highlight the importance of mechanization. According to World Bank estimates, about half of India's population is expected to be urban by 2050. The Indian Economic Survey (2018) also projected that the share of agricultural workers in the total workforce will decline to 25.70% by 2050 from 58.20% in 2001, indicating the growing need for mechanization in agriculture.

Materials and Methods

1. Socio-Economic Profile of Farmers

These primary data were collected from 150 farmers in Choki Village (Sorath), Junagadh District, representing a heterogeneous mix of rural and semi-urban agricultural households with varying socio-economic conditions. The analysis of demographic and economic variables provides crucial insights into the structural characteristics of the farming community. The average family size of the respondents is approximately 5 members. Family size plays a significant role in determining labor availability for farm operations, especially in smallholder farming systems.

The landholding size among farmers shows considerable variation. The average landholding is 14.7 bigha, with a range extending from 2 to 45 bigha. This variation highlights the coexistence of marginal, small, semi-medium and medium farmers within the study area. The majority of respondents fall within the small-to-medium landholding category, which has implications for productivity, investment capacity, and risk-bearing capacity.

In terms of economic status, the average annual income is ₹2.67 lakh, but with a wide range from ₹25,000 to ₹10 lakh, indicating significant disparities among farmers. Such variation reflects differences in resource endowment, access to irrigation, mechanization, crop choices, and market linkages.

The findings suggest that landholding size is a critical determinant of economic well-being. Farmers with larger landholdings tend to have higher incomes due to economies of scale, better access to resources, and the ability to diversify crops. Conversely, smallholders often face constraints such as limited capital, lower productivity, and higher vulnerability to risks. The observed income inequality underscores the need for targeted interventions to support marginal and small farmers.

2. Mechanization Status

Mechanization is a key driver of agricultural efficiency and productivity. The dataset reveals that 63% of farmers own tractors (average 38 hp), indicating a relatively high level of mechanization compared to traditional farming systems. However, the remaining 37% of farmers do not own tractors and rely on alternative arrangements such as custom hiring services & Shared machinery within the community. The commonly used agricultural implements include cultivators, blade harrows, rotavators, seed drills, sprayers, threshers, harvesters, other. Approximately 70% farmers are adopting custom hiring or community shared practices of tractors, thresher, harvester, rotavator and other machinery.

The data clearly show that agricultural mechanization is

well established but still unevenly distributed among farmers. While a majority (63%) own tractors—indicating strong progress toward mechanized farming, over one-third of farmers depend on external access to machinery. The widespread adoption of custom hiring services and shared machinery (used by about 70% of farmers) highlights their critical role in bridging this ownership gap.

Overall, this suggests that although individual ownership of machinery is growing, collective access systems such as custom hiring and community sharing are essential for ensuring inclusivity, improving operational efficiency, and enabling small and marginal farmers to benefit from mechanization. Moreover, farmers can use the electric tractors or electric drives for agricultural work, as it provides benefit in saving operational costs and hence increase the income of the farmers (Agravat *et al.*, 2023) [1]. Strengthening these services can further enhance productivity and promote equitable agricultural development.

3. Adoption of Renewable Energy

The adoption of renewable energy technologies remains limited among the sampled farmers. Only 25% of households have installed solar systems at home with an average 2.7 KW capacity, while a mere 11% have adopted solar solutions at the farm level with an average 5.5 KW capacity. Some farmers were aware of the PM Surya Ghar Yojna for solar at home and the PM Kusum Yojna for solar at the farm.

The low adoption of solar energy, particularly in agricultural operations, highlights several barriers such as high initial installation costs, limited awareness of long-term benefits, low risk capacity and inadequate access or awareness to government subsidies or financing mechanisms. Despite these challenges, solar energy presents a significant opportunity, especially for powering irrigation systems. Increased adoption could reduce dependency on conventional energy sources, lower operational costs, and promote environmentally sustainable farming practices.

4. Irrigation Practices

Irrigation is a critical factor influencing agricultural productivity. The data indicates that 68% of farmers have adopted modern irrigation methods such as drip and sprinkler systems, with drip irrigation being the most prevalent. The average irrigated area by modern irrigation methods is approximately 12 bigha, suggesting that a substantial portion of cultivated land is supported by irrigation infrastructure.

The high adoption rate of micro-irrigation systems reflects growing awareness of water conservation and efficient resource utilization. It also indicates the positive impact of government initiatives such as the Pradhan Mantri Krishi Sinchai Yojana (PMKSY). However, nearly 32% of farmers still depend on traditional irrigation methods, which are often less efficient and more water-intensive. This highlights the need for continued efforts to promote modern irrigation technologies.

5. Crop Patterns and Cropping Intensity

The cropping pattern in the study area is characterized by a mix of commercial and staple crops. The most commonly

cultivated crops include groundnut, soybean, wheat, sesame, vegetable, cotton, etc. The average cropping intensity is around 2 seasons per year, with some farmers cultivating up to three crops annually.

The moderate cropping intensity indicates that farmers are utilizing their land efficiently, particularly those with access to irrigation. Crop diversification helps in risk mitigation, especially against market and climatic uncertainties. However, diversification may also limit specialization and economies of scale in certain crops. Farmers with better irrigation and mechanization tend to achieve higher cropping intensity.

6. Crop-wise Productivity Analysis

a. Wheat

Wheat is the most widely grown and best-performing crop in this village. The yield range of the wheat crop is 12 to 25 man per bigha, with an average of 20 man per bigha. Wheat shows consistently high productivity, with most farmers achieving yields between 18 and 22 man per bigha. A few farmers reaching 24–25 man per bigha indicate advanced farming practices, such as proper irrigation, improved seed varieties, and balanced fertilizer use. Wheat is a stable, high-yield crop and reflects better access to agricultural resources.

b. Groundnut

Groundnut is the second most common crop with stable performance. The yield range of the groundnut crop is 12 to 20 man per bigha, with an average of 17 man per bigha. The yields are relatively consistent across farmers, mostly between 15 and 20 man per bigha. This indicates that groundnut performs well under moderate input conditions but does not reach very high yields like wheat. A reliable and stable crop, but productivity can improve with better soil and nutrient management.

c. Soybean

Soybeans show moderate but uniform productivity. The yield range of the soybean crop is 12 to 16 man per bigha, with an average of 14 man per bigha. The narrow yield range suggests low variation among farmers, possibly due to similar farming practices or environmental conditions. However, yields are lower compared to wheat and groundnut. A moderately productive crop with scope for improvement through better inputs and technology.

d. Cotton

Cotton provides moderate returns with reasonable consistency. The yield range of the cotton crop is 15 to 22 man per bigha, with an average of 18 man per bigha. Cotton yields are fairly stable but depend heavily on pest control, irrigation, and input use. Variability is moderate compared to other crops. A commercial crop with steady productivity, but sensitive to management practices.

e. Maize

Maize has relatively low productivity. The yield range of the maize crop is 10 to 12 man per bigha, with an average of 11 man per bigha. The low yield levels suggest that maize is likely grown under low-input or rain-fed conditions. There is little variation, indicating uniform but limited

productivity. A low-yield crop requires improved practices for better performance.

f. Pearl Millet (Bajra)

Pearl millet is a low-yielding but resilient crop. The yield range of Pearl Millet crop is 8 to 12 man per bigha, with an average of 10 man per bigha. Typically cultivated in dry and less fertile areas, pearl millet shows low productivity but is valued for its drought resistance. A survival crop rather than a high-income crop.

g. Vegetables (Chilli)

Vegetable crops show high variability in yield. The yield range of the vegetable (chilli) is 4 to 10 man per bigha, with an average of 7 man per bigha. Chilli shows very low yield in some cases (as low as 4 Man/Bigha), while mixed cropping (Chilli & Tomato) reaches about 10 Man/Bigha. This variability is due to pest and disease attacks, high water requirements and intensive management needs. High-risk, high-variation crops that require careful management.

h. Pulses and Other Crops

Pigeon Pea: The average yield of pigeon pea is 18 man per bigha. It has a good yield compared to other pulses; relatively stable.

Cumin: The average yield of cumin is 15 man per bigha. It has moderate productivity; sensitive to climate and soil.

Castor: The average yield of castor is 17 man per bigha. It performs moderately well; suitable for dry regions.

7. Allied Infrastructure

The adoption of allied agricultural infrastructure remains relatively low. The adoption of greenhouses, biogas plants and food processing units are 11%, 7% and 10%, respectively. The limited adoption of these technologies suggests that farmers are primarily engaged in conventional farming practices with minimal diversification into allied sectors. This represents a missed opportunity for value addition, income diversification, and sustainable resource utilization (e.g., biogas from farm waste). Promoting these technologies could significantly enhance farm income and resilience.

8. Government Scheme Utilization

The analysis shows that 41% of farmers do not benefit from any government schemes, while the remaining farmers (59%) utilize various programs such as Subsidies for irrigation and farm equipment, such as i-kehdut, crop insurance schemes, including kisan credit card, and financial assistance programs such as PM Kisan Samman Nidhi Scheme, PM Kusum Yojna, PM Surya Ghar Yojna, PM Fasal Bima Yojna, National Agri Infra Financing Facility, etc. Although government schemes are available, their reach is not universal. The limited participation may be due to a lack of awareness, complex administrative and documentation procedures, a lack of a comprehensive tool and limited accessibility. Improving awareness and simplifying procedures can enhance participation and maximize the impact of various government schemes. There are various government financial schemes available for farmers and entrepreneurs. Hence, we intend to develop a comprehensive platform. Farmers and entrepreneurs can

access this platform to improve their farming practices and livelihood. Also, entrepreneurs can grow their business by utilizing various government funding schemes from this platform.

9. Awareness of Agricultural Technology (Kissan AI)

The study reveals that 92% of farmers are unaware of advanced digital agricultural technologies such as Kissan AI, while only a minority (approx. 8%) have some level of awareness. This indicates a significant digital divide in the

agricultural sector. Limited awareness of AI-based advisory systems restricts farmers from accessing real-time information on weather, crop management, and market trends. Bridging this gap through training programs and digital extension services is essential for modernizing agriculture.

Photographs of the survey undertaken at Choki Village of Junagadh District



Results and Discussion

The data present an overview of a rural farming community characterized by moderate landholdings and a family-based agricultural system. It reflects a steady level of income supported by diversified crop cultivation and seasonal farming practices. The community shows significant adoption of mechanization and modern irrigation

techniques. Renewable energy and government scheme participation are gradually increasing among farmers. However, the use of advanced agricultural technologies and sustainable practices remains at an early stage. The average and summarized findings of the conducted survey are presented in Table 1.

Table 1: Data Summary of the Survey at Choki Village, Junagadh District (No. of Respondents: 150)

Sr. No.	Survey Type	Result
1	Average family size	5 Members
2	Average landholding size	14.7 Bigha
3	Average annual income	₹2.67 lakh
4	Tractor owned (Mini and big)	67%
5	Average hp of the tractor	38 hp
6	Adoption of custom hiring or community shared practices for tractor and agricultural machinery and equipment	70%
7	Adoption of solar systems at home	25%
8	Average capacity solar systems at home	2.7 KW
9	Adoption of solar systems on farms	11%
10	Average capacity solar systems at the farm	5.5 KW
11	Adoption of drip and sprinkler irrigation systems	68%
12	Average irrigated area by modern irrigation methods	12
13	Most cultivated crops	Groundnut, Soybean, Wheat, Sesame, Vegetable, Cotton, etc.
14	Average cropping intensity	2 seasons per year
15	Average yield of wheat crop	20 man/bigha
16	Average yield of groundnut crop	17 man/bigha
17	Average yield of soyabean crop	14 man/bigha
18	Average yield of cotton crop	18 man/bigha
19	Average yield of maize crop	11 man/bigha
20	Average yield of pearl millet crop	10 man/bigha
21	Average yield of wheat crop	20 man/bigha
22	Average yield of vegetable (chilli)	7 man/bigha
23	Average yield of pigeon Pea	18 man/bigha
24	Average yield of cumin crop	15 man/bigha
25	Average yield of castor	17 man/bigha
26	Adoption of greenhouses	11%
27	Adoption of biogas plants	7%
28	Adoption of food processing units	10%
29	Adoption of utilization of government schemes	59%
30	Name of government schemes	i-khedut, PM Kisan Samman Nidhi Scheme, Kisan credit card, PM Surya Ghar Yojna, PM Kusum Yojna, PM Fasal Bima Yojana, etc.
31	Adoption of digital agricultural technologies	8%

SWOT Analysis

A comprehensive SWOT analysis of the survey has been conducted to evaluate its key aspects in detail. This analysis systematically examines the strengths, weaknesses, opportunities, and threats associated with the survey, providing a well-rounded understanding of its overall effectiveness and areas for improvement. The findings derived from this evaluation have been carefully reviewed and are summarized below in a structured and concise manner for better clarity and interpretation.

Strengths

- Moderate level of mechanization
- High adoption of micro-irrigation systems
- Crop diversification and multiple cropping
- Partial utilization of government support schemes

Weaknesses

- Low adoption of renewable energy technologies
- Limited value addition and allied infrastructure
- Significant income disparities
- Low awareness of advanced digital tools

Opportunities

- Expansion of solar-powered irrigation systems
- Promotion of AI-based agricultural advisory services
- Development of food processing and value addition

units

- Strengthening custom hiring centers for mechanization access
- Development of a comprehensive digital platform for farmers and entrepreneurs to spread awareness of several government benefits

Threats

- Climate variability and unpredictable rainfall
- Water scarcity
- Increasing input costs
- Slow adoption of modern technologies
- Low risk-taking ability and dependency on others

Conclusion

The analysis clearly indicates that the farming community is undergoing a transition from traditional to semi-modern agriculture. While progress has been made in areas such as irrigation and mechanization, substantial gaps remain in renewable energy adoption, digital awareness, and value-added agricultural practices. To ensure sustainable agricultural development, a holistic approach is required. This should include promoting modern technologies, improving access to government schemes, strengthening extension and digital services, and encouraging diversification and value addition. Such measures will not only enhance productivity but also improve economic

resilience and livelihood.

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