***Original Research Article***

**IMPACT OF NICRA PROJECT ON KNOWLEDGE AND ADOPTION OF SUSTAINABLE CABBAGE PRODUCTION TECHNOLOGIES: A STUDY IN SANGSANGYU BLOCK UNDER TUENSANG DISTRICT OF NAGALAND**

**Abstract**

Adoption of sustainable production technology plays a crucial role in enhancing agricultural productivity and resilience, particularly in regions vulnerable to climate change. Present study, was conducted to assess the extent of adoption of climate-resilient cabbage farming practices among beneficiary and non-beneficiary farmers of Sangsangyu block, under Tuensang district, where cabbage cultivation is prominent, with a sample of 150 respondents (75 beneficiaries and 75 non-beneficiaries). The socio-economic analysis revealed that beneficiaries had higher educational qualifications, more farming experience, and better income levels than non-beneficiaries. Most beneficiaries were engaged in agriculture as their primary occupation, whereas non-beneficiaries had a higher proportion of individuals involved in non-agricultural activities. The findings on knowledge levels indicated that beneficiaries had significantly higher awareness of sustainable cabbage production technologies compared to non-beneficiaries. For instance, 73.33% of beneficiaries had high knowledge of sustainable spacing, compared to only 44.00% of non-beneficiaries. A similar pattern was observed in areas such as fertilizer application (58.67% vs. 37.33%), mulching and irrigation (69.33% vs. 49.33%), and integrated pest and disease management (57.33% vs. 30.67%). The statistical analysis confirmed these disparities, with the mean knowledge score of beneficiaries (22.84) significantly higher than that of non-beneficiaries (13.42), supported by a t-value significant at the 1% level. Adoption levels of sustainable technologies were also substantially higher among beneficiaries. The majority of NICRA beneficiaries adopted practices such as transplanting at the right stage (89.33%), proper irrigation during head formation (69.33%), and integrated pest management (72.00%), whereas non-beneficiaries lagged significantly behind. Adoption rates for post-harvest measures were also higher among beneficiaries (69.33%) compared to non-beneficiaries (44.00%), emphasizing the role of NICRA in enhancing climate-smart agricultural practices. Further in context sustainability index, social sustainability contributes the highest of about 58.97 per cent. Overall, the study underscores the positive impact of NICRA interventions in promoting climate-resilient cabbage production technologies. Beneficiaries demonstrated higher knowledge, greater adoption rates, and improved agricultural outcomes compared to non-beneficiaries. However, despite the success of NICRA, a considerable knowledge and adoption gap remains among non-beneficiaries, highlighting the need for broader dissemination of climate-resilient technologies. Expanding outreach and extension efforts could significantly enhance the overall adoption of sustainable farming practices, ensuring greater resilience and productivity in cabbage cultivation.

**Keywords**: Knowledge level, adoption, cabbage growers, NICRA, Sustainability

**I. Introduction**

Agriculture plays a vital role in sustaining livelihoods, particularly in rural areas where the majority of the population depends on farming for income and food security (Rodriguez and Antonio, 2023). However, agricultural productivity is increasingly threatened by climate variability, erratic rainfall, soil degradation, and pest infestations, necessitating the adoption of improved farming practices to ensure sustainability (Zheng et al., 2024). The introduction of climate-resilient technologies and sustainable production practices has become crucial in addressing these challenges, particularly in vulnerable regions like Nagaland, India. One such initiative aimed at enhancing farmers’ adaptive capacity is the National Innovations on Climate Resilient Agriculture (NICRA), launched by the Indian Council of Agricultural Research (ICAR) in 2011. The project focuses on climate-smart agricultural practices to help farmers cope with climate-induced risks (Singh et al., 2024).

Cabbage (Brassica oleracea var. capitata) is an important vegetable crop in India, contributing significantly to the diet and economy of rural farmers (Sureshbhai, 2020). India produced 10049000 tons from an area of 433000 ha in 2023 ranking second in production worldwide next to China (FAOSTAT 2025). In India, the leading producers are West Bengal followed by Odisha, Madhya Pradesh, Gujarat and Assam (NHB, 2023). Nagaland, with its diverse agro-climatic conditions, offers favorable conditions for cabbage cultivation. However, factors such as poor soil fertility, lack of irrigation facilities, and low adoption of improved agricultural practices have hindered productivity in the region (Noopur et al., 2023). The Sangsangyu block in Tuensang district, being one of the major cabbage-growing areas, was chosen for this study to assess the impact of NICRA interventions on farmers’ adoption of sustainable production technologies. Climate change has led to increased frequency of unpredictable rainfall, prolonged dry spells, water scarcity, and pest outbreaks, all of which negatively impact cabbage production. Traditional farming practices, which rely heavily on monsoon patterns, are becoming less effective, necessitating a shift toward climate-smart agriculture. Studies have shown that the adoption of improved agricultural technologies, including integrated pest management, soil moisture conservation, and nutrient management, significantly enhances productivity and resilience in smallholder farming systems (Kmpala and Simatele, 2024). A major challenge faced by non-beneficiaries was limited access to information, financial constraints, and reluctance to change traditional farming methods. These barriers highlight the need for stronger extension efforts, policy support, and farmer education programs to bridge the knowledge gap and improve adoption rates in non-NICRA areas (Khou and Mothilal, 2018). This research contributes to understanding the role of climate-resilient agriculture in enhancing productivity, reducing climate risks, and improving farmer livelihoods. The insights gained from this study will help policymakers, extension agencies, and researchers design more effective agriculture interventions, training programs, and subsidy schemes to encourage widespread adoption of sustainable farming practices. The adoption of improved cabbage production technologies is essential for sustainable farming, particularly in climate-sensitive regions like Nagaland. This study underscores the positive impact of NICRA interventions in enhancing technology adoption among farmers, leading to improved productivity and resilience. However, concerted efforts are required to extend these benefits to non-NICRA farmers, ensuring wider implementation of climate-smart agriculture for long-term sustainability. The primary objective of this study was to assess the adoption level of sustainable cabbage production technologies among farmers in the NICRA project areas compared to non-beneficiaries. The findings from this study indicated a significantly higher adoption rate of improved practices among NICRA beneficiaries as compared to non-beneficiaries. This suggests that NICRA interventions, such as training programs, demonstrations, and input support, played a crucial role in enhancing farmers' awareness and willingness to adopt new technologies. Similar findings have been reported in other regions where extension programs have effectively increased technology adoption.

**II. Methodology**

**Study Area and Sampling Procedure**

The study was conducted in Sangsangyu Block, Tuensang, Nagaland, a region where cabbage is extensively cultivated. This block was selected purposively due to the significant implementation of the National Innovations on Climate Resilient Agriculture (NICRA) Project, which introduced climate-resilient technologies to enhance agricultural productivity and sustainability.

A total of 150 farmers were selected using a stratified random sampling technique, comprising:

* 75 NICRA beneficiaries (farmers who received training and support under the NICRA project).
* 75 Non-beneficiaries (farmers who did not participate in NICRA interventions).

The selection of non-beneficiaries was done from villages where NICRA interventions were not implemented, ensuring a comparative analysis of technology adoption between the two groups.

**Research Design**

A descriptive research design was employed to assess the knowledge level and adoption of sustainable cabbage production technologies among farmers. This design was appropriate for capturing the existing socio-economic profile, knowledge level, and extent of adoption among respondents.

**Data Collection**

Primary data were collected using a structured interview schedule, which was developed based on the objectives of the study. Before final data collection, the interview schedule was pre-tested with a small group of farmers (10 respondents) to ensure clarity and reliability. Necessary modifications were made based on feedback.

The data collection focused on:

1. Socio-economic characteristics (age, education, income, farming experience, and family type).
2. Knowledge levels of sustainable cabbage production technologies among farmers.
3. Extent of adoption of sustainable practices such as land preparation, seed treatment, transplanting, irrigation, pest control, and harvesting.

Secondary data were gathered from research journals, ICAR reports, government publications, and agricultural extension records.

**Statistical Analysis**

The collected data were coded, tabulated, and analyzed using SPSS and MS Excel. The statistical tools were used for analysis are frequency, percentage, mean, and standard deviation, t-test, adoption index and Sustainability index.

‘Sustainability’ was measured by developing a sustainability index. First of all, it was divided into three dimensions viz., Environmental sustainability, Economic sustainability as well as Social sustainability. Each of these dimensions was measured on the basis of indicators. Finally sustainability index was calculated using the following formula as follows:



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**Where,**

x1,x2,..xn = Score obtained by individual farmers in economic sustainability

a1,a2,..an = Maximum possible core obtained by individual farmers in economic sustainability

y1,y2,..yn = Score obtained by individual farmers in social sustainability

b1,b2,..bn = Maximum possible core obtained by individual farmers in social sustainability

y1,y2,..yn = Score obtained by individual farmers in environmental sustainability

c1,c2,..cn = Maximum possible core obtained by individual farmers in environmental sustainability

i= Economic sustainability, Social sustainability & Environmental sustainability

j= Total number of farmers in economic sustainability

k= Total number of farmers in social sustainability

l= Total number of farmers in environmental sustainability

**Ethical Considerations**

Farmers participated voluntarily, and informed consent was obtained before data collection. The confidentiality of the respondents was maintained, and the study adhered to ethical research guidelines.

**III. Results and Discussion**

**Table 1.** Socio -economic profile of the cabbage growers (n=150, B=75, NB=75)

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **Category** | **Beneficiaries**  | **Non-beneficiaries** |
| **Frequency**  | **%** | **Frequency**  | **%** |
| **Age**  | Young (Up to 35) | 22 | 29.33 | 27 | 36.00 |
| Medium (36 - 50) | 46 | 61.33 | 36 | 48.00 |
| Old (Above 50) | 7 | 9.33 | 12 | 16.00 |
| **Gender** | Male | 32 | 42.67 | 36 | 48.00 |
| Female | 43 | 57.33 | 39 | 52.00 |
| **Family Size** | Nuclear family (1-4 persons) | 41 | 54.67 | 37 | 49.33 |
| Joint family (> 4 persons) | 34 | 45.33 | 38 | 50.67 |
| **Educational Qualification** | Primary | 12 | 16.00 | 27 | 36.00 |
| Secondary | 19 | 25.33 | 26 | 34.67 |
| Higher Secondary | 28 | 37.33 | 17 | 22.67 |
| Diploma | 7 | 9.33 | 3 | 4.00 |
| Graduation | 9 | 12.00 | 2 | 2.67 |
| **Experience** | 1-5 year | 23 | 30.67 | 41 | 54.67 |
| 5-10 year | 16 | 21.33 | 23 | 30.67 |
| More than 10 years | 36 | 48.00 | 11 | 14.67 |
| **Income**  | ₹0.5- 1 lakh | 8 | 10.67 | 30 | 40 |
| ₹1-2 lakh | 36 | 48.00 | 31 | 41.33 |
| ₹2-5 lakh | 22 | 29.33 | 14 | 18.67 |
| ₹Above 5 lakh | 9 | 12.00 | 0 | 0 |
| **Primary Occupation** | Govt. Job | 2 | 2.67 | 0 | 0 |
| Agriculture | 48 | 64.00 | 34 | 45.33 |
| Business | 21 | 28.00 | 31 | 41.33 |
| Others | 4 | 5.33 | 10 | 13.33 |

The socio-economic characteristics of cabbage growers, categorized into NICRA beneficiaries and non-beneficiaries, are presented in Table 1. The findings highlight variations in demographic, educational, occupational, and income-related aspects between the two groups.

Among the beneficiaries, the majority (61.33%) belonged to the middle-aged category (36-50 years), followed by young farmers (29.33%), and only 9.33% were above 50 years. Similarly, among non-beneficiaries, 48.00% were middle-aged, while a higher proportion (36.00%) were young farmers, and 16.00% belonged to the older age group. The gender distribution showed that among beneficiaries, 42.67% were male, while 57.33% were female. In contrast, among non-beneficiaries, the proportion of males was slightly higher at 48.00%, whereas females accounted for 52.00%. The family structure analysis indicated that 54.67% of beneficiaries lived in nuclear families, whereas 45.33% belonged to joint families. Among non-beneficiaries, a slightly lower proportion (49.33%) had nuclear families, while 50.67% were part of joint families. A significant difference was observed in the education levels of the two groups. Among beneficiaries, 37.33% had higher secondary education, followed by 25.33% with secondary education and 16.00% with primary education. In contrast, non-beneficiaries had a higher proportion of farmers with primary (36.00%) and secondary education (34.67%), while only 22.67% had completed higher secondary education. A small percentage pursued a diploma (9.33% beneficiaries vs. 4.00% non-beneficiaries) and graduation (12.00% beneficiaries vs. 2.67% non-beneficiaries). Similar results also identified by Sultana et al., 2020 and Thakor and Joshi, 2022.

The farming experience of the beneficiaries showed that 48.00% had over 10 years of experience, while 30.67% had 1-5 years of experience, and 21.33% had 5-10 years of experience. In contrast, a higher percentage of non-beneficiaries (54.67%) had 1-5 years of experience, whereas only 14.67% had more than 10 years of experience. In terms of income distribution, among beneficiaries, 48.00% had an annual income between ₹1-2 lakh, 29.33% earned between ₹2-5 lakh, while 12.00% earned above ₹5 lakh, and 10.67% fell in the ₹0.5-1 lakh category. In contrast, the majority of non-beneficiaries (41.33%) earned ₹1-2 lakh, followed by 40.00% in the ₹0.5-1 lakh category, while only 18.67% earned ₹2-5 lakh, and none had an income exceeding ₹5 lakh. Agriculture was the dominant occupation among beneficiaries (64.00%), followed by business (28.00%), government jobs (2.67%), and other occupations (5.33%). Among non-beneficiaries, only 45.33% were primarily engaged in agriculture, while a higher percentage (41.33%) were involved in business, and 13.33% had other occupations, with no one engaged in government jobs (Kumawant et al., 2024).

Table 2: Distribution of NICRA beneficiaries and non-beneficiaries according to their Knowledge of sustainable production technology of cabbage (n=150, B=75, NB=75)

|  |  |  |  |
| --- | --- | --- | --- |
| Sl | Practices | Beneficiaries (%) | Non-beneficiaries (%) |
| H | M | L | H | M | L |
| 1 | Land preparation  | 62.67 | 30.67 | 6.66 | 45.33 | 28.00 | 26.67 |
| 2 | Seed rate  | 68.00 | 30.67 | 1.33 | 41.33 | 25.33 | 33.33 |
| 3 | Recommended spacing  | 73.33 | 22.67 | 4.00 | 44.00 | 30.67 | 25.33 |
| 4 | Seed treatment  | 53.33 | 32.00 | 14.67 | 32.00 | 14.67 | 53.33 |
| 5 | Transplanting at the right stage | 64.00 | 20.00 | 16 | 46.67 | 29.33 | 24.00 |
| 6 | Application of recommended fertilizer dose  | 58.67 | 24.00 | 17.33 | 37.33 | 32.00 | 30.67 |
| 7 | Use of mulching and proper irrigation methods | 69.33 | 22.67 | 8.00 | 49.33 | 21.33 | 29.33 |
| 8 | Integrated pest and disease management practices followed | 57.33 | 28.00 | 14.67 | 30.67 | 25.33 | 44.00 |
| 9 | Irrigation during head formation and pre-harvest stage | 54.67 | 26.67 | 18.67 | 25.33 | 33.33 | 41.33 |
| 10 | Recommended weed control measures | 58.67 | 34.67 | 6.66 | 34.67 | 33.33 | 32.00 |
| 11 | Harvesting and yield | 49.33 | 33.33 | 17.33 | 33.33 | 30.67 | 36.00 |
| 12 | Post harvesting measures | 46.67 | 38.67 | 14.66 | 38.67 | 14.67 | 46.67 |
|  | **Respondents** | **Mean** | **sd** | **t value** |
|  | ***Beneficiaries*** | 22.84 | 8.65 | 1.653\*\* |
|  | ***Non-beneficiaries*** | 13.42 | 6.71 | 1.529\*\* |

*N.b: H=High, M= Medium, L=Low; all datas are in %. \*\*= significant at 1%*

The knowledge level of NICRA beneficiaries and non-beneficiaries regarding the adoption of sustainable production technologies for cabbage is presented in Table 2. The findings indicate that a higher proportion of beneficiaries possessed high knowledge levels across most recommended practices compared to non-beneficiaries. Regarding land preparation, 62.67% of beneficiaries had high knowledge, while only 45.33% of non-beneficiaries fell into the same category. Similarly, for seed rate, 68.00% of beneficiaries exhibited high knowledge, in contrast to 41.33% of non-beneficiaries. A significant difference was also observed in awareness of recommended spacing, where 73.33% of beneficiaries had high knowledge compared to 44.00% of non-beneficiaries.

Seed treatment knowledge was relatively lower among both groups, with 53.33% of beneficiaries and only 32.00% of non-beneficiaries having a high level of understanding. For transplanting at the right stage, 64.00% of beneficiaries had high knowledge, whereas 46.67% of non-beneficiaries were aware of the correct stage for transplanting. A notable difference was seen in the application of recommended fertilizer doses, with 58.67% of beneficiaries having high knowledge compared to 37.33% of non-beneficiaries. Similarly, in the case of mulching and proper irrigation methods, 69.33% of beneficiaries exhibited high knowledge, while only 49.33% of non-beneficiaries were well-informed (Tiwari et al., 2024).

Regarding integrated pest and disease management practices, 57.33% of beneficiaries had high knowledge, whereas the percentage was significantly lower among non-beneficiaries (30.67%). The knowledge gap was also evident in irrigation during head formation and pre-harvest stages, where only 25.33% of non-beneficiaries had high knowledge compared to 54.67% of beneficiaries. For weed control measures, 58.67% of beneficiaries had high knowledge, while only 34.67% of non-beneficiaries were aware of the recommended methods. A similar pattern was observed in harvesting and yield management, with 49.33% of beneficiaries exhibiting high knowledge as compared to 33.33% of non-beneficiaries. The difference was also significant in terms of post-harvesting measures, where 46.67% of beneficiaries had high knowledge, whereas 38.67% of non-beneficiaries were aware of the correct practices (Singh et al., 2022).

The statistical analysis further confirms these differences, with the mean knowledge score of beneficiaries (22.84) being significantly higher than that of non-beneficiaries (13.42). The computed t-value (1.653) was significant at the 1% level, indicating a statistically significant difference in the knowledge levels of beneficiaries and non-beneficiaries. This suggests that participation in the NICRA project had a positive impact on farmers' awareness and adoption of sustainable cabbage production technologies. These findings highlight the effectiveness of NICRA interventions in enhancing farmers' knowledge of climate-resilient agricultural practices. The results emphasize the need for wider dissemination of such initiatives among non-beneficiaries to bridge the knowledge gap and improve overall adoption rates of sustainable production technologies (Lenka et al., 2023).

Table 3: Level of adoption of sustainable production technology of cabbage (n=150, B=75, NB=75)

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| --- | --- | --- | --- |
| Sl. | **Sustainable cabbage production technology** | **Beneficiaries (%)** | **Non-beneficiaries (%)** |
| **Adopted** | **Not adopted** | **Adopted** | **Not adopted** |
| 1 | Land preparation  | 73.33 | 26.67 | 46.67 | 53.33 |
| 2 | Seed rate  | 81.33 | 18.67 | 40.00 | 60.00 |
| 3 | Recommended spacing  | 77.33 | 22.67 | 44.00 | 56.00 |
| 4 | Seed treatment  | 68.00 | 32.00 | 32.00 | 68.00 |
| 5 | Transplanting at the right stage | 89.33 | 10.67 | 42.67 | 57.33 |
| 6 | Application of recommended fertilizer dose  | 77.33 | 22.67 | 37.33 | 62.67 |
| 7 | Use of mulching and proper irrigation methods | 86.67 | 13.33 | 46.67 | 53.33 |
| 8 | Integrated pest and disease management practices followed | 72.00 | 28.00 | 28.00 | 72.00 |
| 9 | Irrigation during head formation and pre-harvest stage | 69.33 | 30.67 | 29.33 | 70.67 |
| 10 | Recommended weed control measures | 72.00 | 28.00 | 37.33 | 62.67 |
| 11 | Harvesting and yield | 74.67 | 25.33 | 34.67 | 65.33 |
| 12 | Post harvesting measures | 69.33 | 30.67 | 44.00 | 56.00 |

The level of adoption of various sustainable cabbage production technologies among NICRA beneficiaries and non-beneficiaries is presented in Table 3. The findings reveal a significantly higher adoption rate among beneficiaries compared to non-beneficiaries, indicating the positive impact of NICRA interventions. In terms of land preparation, 73.33% of beneficiaries adopted the recommended practices, whereas only 46.67% of non-beneficiaries followed the same, with more than half (53.33%) not adopting the correct method. A similar trend was observed for the recommended seed rate, where 81.33% of beneficiaries adhered to the guidelines, while only 40.00% of non-beneficiaries adopted the practice (Khati, 2020).

The adoption rate of recommended spacing was also higher among beneficiaries (77.33%) compared to non-beneficiaries (44.00%). Seed treatment, a crucial step in preventing early-stage diseases, was adopted by 68.00% of beneficiaries, whereas only 32.00% of non-beneficiaries followed this practice, with 68.00% neglecting it. A remarkable difference was found in transplanting at the right stage, where 89.33% of beneficiaries adopted the recommended practice, while only 42.67% of non-beneficiaries adhered to the correct timing. Similarly, application of the recommended fertilizer dose was significantly higher among beneficiaries (77.33%) compared to non-beneficiaries (37.33%) (Sodhi et al., 2023).

The use of mulching and proper irrigation methods showed an adoption rate of 86.67% among beneficiaries, whereas only 46.67% of non-beneficiaries followed this approach. The gap was also evident in the adoption of integrated pest and disease managementpractices, with 72.00% of beneficiaries implementing the recommended measures, while only 28.00% of non-beneficiaries followed them. For irrigation during the head formation and pre-harvest stage, only 29.33% of non-beneficiaries adopted the practice, compared to 69.33% of beneficiaries. Weed control measures were adopted by 72.00% of beneficiaries, whereas only 37.33% of non-beneficiaries followed the correct techniques.

The adoption rate for harvesting and yield management was 74.67% among beneficiaries, whereas only 34.67% of non-beneficiaries adhered to the recommended methods. Similarly, post-harvest measures were adopted by 69.33% of beneficiaries, compared to 44.00% of non-beneficiaries. Overall, the findings clearly indicate that NICRA beneficiaries had significantly higher adoption levels of recommended cabbage production technologies compared to non-beneficiaries. This suggests that NICRA interventions played a crucial role in promoting the adoption of improved agricultural practices, emphasizing the need for further extension efforts to bridge the gap among non-beneficiaries.

Table 4: Distribution of respondents based on sustainability of cabbage farming practised by NICRA farmers of Sangsangyu block N=75(Beneficiary)

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| --- | --- | --- | --- | --- | --- | --- |
| **Sr. no.** | **Dimensions of sustainability** | **Level** | **%** | **Mean****score** | **Sd** | **Sustainability index** |
| 1 | Economic sustainability | Low (<4)Medium (4-5)High (>5) | 5.3394.670.00 | 4.65 | 0.67 | 10.74 |
| 2 | Social sustainability | Low (<22)Medium (22-27)High (>27) | 4.0081.3314.67 | 24.67 | 2.61 | 58.97 |
| 3 | Environmental sustainability | Low (<11)Medium (11-14)High (>14) | 8.0078.6713.33 | 12.30 | 1.29 | 30.29 |

Table 4 represents the distribution of respondent based on sustainability of cabbage farming practised by farmers of Nagaland. It was observed that majority 94.67 per cent of the respondents had medium level of Economic sustainability and remaining 5.33 per cent of them had low level economic sustainability. Further it was found that majority (81.33%) of the respondents had medium level of Social sustainability followed by 14.67 per cent of them having high level of social sustainability and 4.00 per cent of them had low level of social sustainability. It was also found that majority (78.67%) of the respondents had medium level of environmental sustainability, followed by 13.33 per cent of the respondents who had high level of environmental sustainability and 8.00 per cent of the respondents having low level of environmental sustainability respectively. Among the three dimensions, the mean score (24.67) of social sustainability was the highest.

Fig 1: **Contribution of different dimensions of sustainability on overall Sustainability index (%) for the cabbage growers**

Figure 1 concludes that in case of overall sustainability index for the cabbage growers of Sangsangyu block under Tuensang district of Nagaland state, social sustainability contributed the highest (58.97%) among the three dimensions of sustainability, followed by 30.29 per cent by environmental sustainability and remaining 10.74 per cent by economic sustainability.

**IV. Conclusion**

The study highlights the significant socio-economic and technological differences between NICRA beneficiaries and non-beneficiaries in cabbage production. Beneficiaries exhibited higher educational levels, greater farming experience, and better economic status, with a larger proportion engaged in agriculture as their primary occupation. In contrast, non-beneficiaries had a higher representation of younger farmers with limited farming experience and lower income levels, indicating restricted access to improved agricultural resources. The analysis of knowledge levels revealed that beneficiaries possessed significantly higher awareness of recommended production technologies compared to non-beneficiaries. For instance, 73.33% of beneficiaries had high knowledge of recommended spacing, whereas only 44.00% of non-beneficiaries were aware of it. A similar trend was observed across all key production practices, including seed rate, fertilizer application, and pest management, confirming that NICRA interventions had a positive influence on knowledge dissemination. The statistical analysis further validated these differences, with beneficiaries achieving a significantly higher mean knowledge score (22.84) compared to non-beneficiaries (13.42), with a t-value significant at the 1% level.

The adoption of recommended practices followed a similar pattern, with beneficiaries demonstrating higher levels of implementation across all aspects of cabbage cultivation. Notably, 89.33% of beneficiaries adopted the recommended transplanting stage, compared to only 42.67% of non-beneficiaries. Likewise, the use of mulching and proper irrigation methods was significantly higher among beneficiaries (86.67% vs. 46.67%), emphasizing the impact of NICRA interventions in promoting climate-resilient farming techniques. Integrated pest and disease management practices were followed by 72.00% of beneficiaries but only 28.00% of non-beneficiaries, highlighting the need for further dissemination efforts among non-beneficiaries. Further, in case of sustainability index, Social sustainability contributes the highest of about 58.97 per cent. Overall, the findings indicate that NICRA interventions have significantly improved farmers' knowledge and adoption of recommended cabbage production technologies, leading to better socio-economic outcomes. The program has played a crucial role in bridging the knowledge gap and enhancing sustainable farming practices. However, efforts must continue to extend these benefits to non-beneficiaries, ensuring wider adoption of climate-resilient technologies and improved agricultural productivity.

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