

IMPACT OF DRONE TECHNOLOGY ON LABOUR SHORTAGE IN KUTTANAD PADDY FARMING

Sona Mariam Thomas

Research Scholar in Economics

Vels Institute of Science, Technology and Advanced Studies (VISTAS)

Pallavaram, Chennai, Tamil Nadu, India-600117

E-Mail: tsonamariam@gmail.com

Dr. S. Bhuvanewari

Assistant Professor

Department of Economics

Vels Institute of Science, Technology and Advanced Studies (VISTAS)

Pallavaram, Chennai, Tamil Nadu, India-600117

E-Mail: sbhuvanewari.sms@velsuniv.ac.in

Abstract

Kuttanad, known as the rice bowl of Kerala, is located in the Alappuzha district and is widely recognized for its paddy cultivation, fisheries, duck farming, and tourism. Agriculture in this region plays a vital role in ensuring food production in Kerala. Traditionally, farming depended heavily on manual labour, which has recently faced challenges due to labour shortages and rising input costs. This study focuses on the adoption of drone technology as a solution to these issues.

Following the COVID-19 pandemic, significant disruptions in the labour market, particularly among women workers, intensified labour shortages in paddy farming. Many women shifted to alternative employment opportunities such as MNREGA, Kudumbashree, and retail jobs due to health concerns and income stability. As a result, the availability of agricultural labour declined considerably.

This study adopts a mixed-method approach using surveys, interviews, and field observations. Primary data were collected from 64 farmers and 24 drone operators, along with secondary data from institutional sources. A linear regression model was used to analyse the relationship between income and profit before and after the adoption of drone technology. The results indicate a positive relationship, showing that for every ₹1 increase in income, profit increases by ₹0.7075 on average. The findings reveal that drone technology reduces labour dependency, improves efficiency, and increases farmers' profits by approximately ₹4,000 per acre. However, adoption remains limited due to factors such as cost, lack of awareness, and accessibility. The study concludes that drone technology is an effective solution for labour shortages and can enhance productivity with appropriate policy support.

Keywords: COVID-19, Linear Regression Analysis, Paddy Farming, Labour Shortages, Drone Technology

1.0 Introduction

India is primarily an agrarian country. Agriculture in India plays a primary role in food security, Economic security, and rural development. Still, many of the developing and underdeveloped countries rely on agriculture or agriculture-related activities. India is the foremost exporter of tea, spices, rice, and other agricultural products. Kerala plays a unique role in rice cultivation in India because its significance lies in its traditional paddy farming methods, unique below-sea-level farming system, and the preservation of indigenous rice varieties. Kerala has a unique agricultural landscape dominated by plantation crops, spices, and rice cultivation. Presently the state faces challenges like land fragmentation, labour shortages, and climate-related issues. Kuttanad is famous in India for its below-sea-level farming. A complex network of bunds (embankments), canals, and sluice gates is used to regulate water levels. In Kuttanad rice is the primary crop grown it includes both traditional variety and high-yielding varieties of rice. Pokkali is a unique variety of rice that is saline-resistant. More than nine varieties of rice are cultivated in Kuttanad. Presently Kuttanad is facing challenges like labour shortage and this study examines the labour shortage after the Covid pandemic and the role of drone technology as a solution to the labour shortage in Kuttanad farming. Drone technology is a cost-effective method of production as it reduces cost as well as it minimizes chemical usage (over usage of fertilizers).

1.1 Agriculture in Kuttanad

Rice and coconut are the major crops cultivated in Kuttanad. Around 80% of income is derived from the cultivation of these crops. Coconut cultivation in Alappuzha and Kuttanad is declining, as several palms are irreversibly affected by root wilt disease and pests such as the red palm weevil and rhinoceros weevil. Other than these two, duck farming, poultry, rabbit rearing, and fishing play a marginal role in livelihoods. Duck farming is also constrained due to the reduced availability of paddy fields and the prevalence of diseases. Fishing is not very common among the people of Kuttanad; however, some households depend on it for their livelihood. About 13,000 hectares of land are associated with Vembanad Kayal and its connected water bodies, where unique species such as large prawns and pearl spot (Karimeen) are found. However, these species are now becoming endemic due to increasing pollution in the lake, which has adversely affected their breeding.

According to the State Planning Board, Kuttanad may be declared a Special Agricultural Zone to ensure regular economic assistance from both State and Central Governments, addressing all aspects of conservation, cultivation, consumption, and commerce in a holistic manner. Several recommendations have been made for capacity-building programmes in Kuttanad, especially for women farmers, to enhance group activities. A newly developed integrated farming project, the "one paddy-one fish system," has been introduced after extensive research, identifying suitable fish varieties for polyculture, although certain limitations exist. In a sequential farming system, fish and prawns are cultivated in rice fields after one crop cycle per year. Agricultural waste can be used as input for freshwater aquaculture, while waste from aquaculture can be recycled into the farming system, benefiting paddy cultivation.

Mechanisation is also becoming popular in Kuttanad, as it can replace labour to a certain extent. Electric pumps are used for dewatering, while tillers and tractors are used for land preparation. Power threshers are used for threshing and winnowing. However, some technologies, such as drones, are still not widely adopted.

1.2 Background on Kuttanad Rice Cultivation

Kuttanad is spread over 55,000 hectares across 10 taluks, covering multiple regions in Kerala, including the districts of Alappuzha, Kottayam, and Pathanamthitta (according to Kerala Krishi Bhavan). The Kuttanad region is recognised as a Globally Important Agricultural Heritage System (GIAHS) by the Food and Agriculture Organization (FAO).

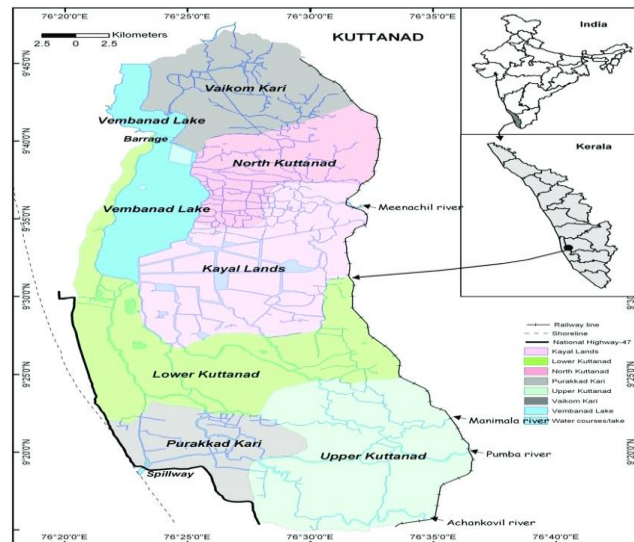
Rice cultivation in Kuttanad takes place 1 to 2 metres below sea level. Five major rivers—Pamba, Achankovil, Meenachil, Manimala, and Muvattupuzha—flow through this region, covering an area of 874 km². In Kerala, paddy cultivation is generally practised under group farming systems known as padashekara samithis. There are around 6,850 such groups, and approximately 600 acres of land are divided with the consent of the concerned samithi.

The division is carried out in such a way that the plots are equal or nearly equal in size, ensuring better logistics and cost optimisation, and should not be less than 150 hectares in Kerala. Apart from paddy cultivation, Kuttanad is also known for duck farming, fish farming, coconut cultivation, and tourism.

Out of the total area, approximately 490 km² lies 1 to 2 metres below sea level and is predominantly used for rice cultivation. Nearly 95% of the farm holdings in Kuttanad are small or marginal. In wetlands, rice is cultivated, while coconut is the major crop in garden lands. Bananas, tubers, vegetables, and tree spices are grown as intercrops.

Kuttanad is divided into six agro-ecological zones based on topography, proximity to saline water intrusion, and flood conditions. These zones are Lower Kuttanad, Upper Kuttanad, North Kuttanad, Kayal lands, Vaikom Kari, and Purakkad Kari. There are three paddy crop seasons: Virippu (autumn), Mundakan (winter), and Puncha, which is considered the third crop of the year.

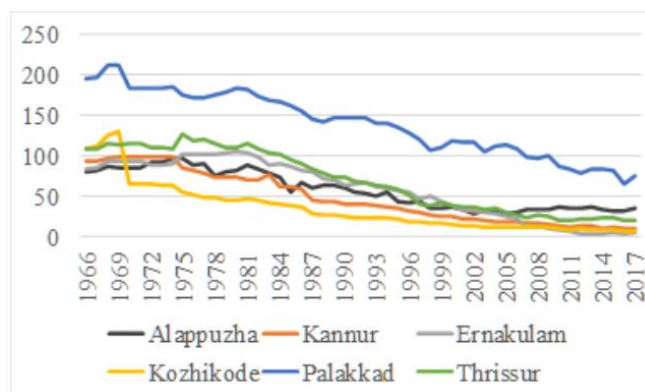
Figure 1



Six agro-ecological zones in Kuttanad source:(Kerala State Planning Board)

1.3 Overview of paddy farming in Kerala:

Figure 2



Source : State planning Board 2022

Kerala is known for cultivating a variety of cash crops and spices that contribute significantly to its economy. After the colonialization, there was a drastic shift from food crops to cash crops in India especially in Kerala. Kerala has a unique agricultural sector shaped by its unique tropical climate. As the state is very small it faces some challenges shrinking farmland, Labour shortage, and climate change. In Kerala, most of the farmers own small plots of land due to the land reform practices. Kerala agriculture is completely dependent on the season, The state receives complete monsoons so they reduce dependence on irrigation for agricultural purposes. But if its heavy rain makes the crops vulnerable to flood. Unlike other Indian states where food crops dominate, Kerala primarily grows cash crops like rubber, coconut, spices, and tea. Nowadays due to urbanization and globalization migration is increasing so the younger generation is shifting away from agriculture to non-agricultural activities. Another challenge Kerala agriculture is facing is land conversion for non-agricultural purposes have reduced cultivable land. According to the Kerala State Planning Board, the area under cultivation of rice has shown a decline over the last several decades. Since 2007-2008 there was a decline in the trend of agriculture around 2.29 lakh ha in 2007-08. In the year of 2018-19, the area was only 2.06 lakh hectares. The total production of agriculture decreased to 5.78 lakh tonnes. Agriculture in Kerala shows a negative growth with -2.38 percent and -6.62 percent in 2018-19 and 2019-20 respectively. The fishing and forestry sectors showed a positive growth rate of 6.55 percent and 0.54 percent respectively, in 2018-19.

1.4 Table:1 Import Trends in Kerala

Inward Movement of Agricultural Commodities to Kerala in tonnes, 2019-20

Products	Inward
Rice not in the husk (inc. Rice Flour)	601023.3
Wheat	405402.9
Other Grain	2376
Oil Cakes	155505.3
Spices	256

Source: Kerala State Planning Board 2022

According to the Kerala State Planning Board, during the fiscal year 2019-20, Kerala imported substantial quantities of staple foods from other states rice including rice flour of 601023.3 tonnes this shows a dependence on neighboring states for staple food. The major states supplying staple food to Kerala are Tamil Nadu, Karnataka, Madhya Pradesh, and Telangana (This is according to the report Kerala State Logistics Action Plan).

1.5 Table 2 : Export Trends of Kerala

Product Champions	No products under HS 6 digit	US\$ million in exports in 2018
Fruits and nuts	2	331.67
Essential oils	3	247.36
Tea and spices	5	197.95
Rice	1	42.52
Edible food preparations	2	30.75
Vegetables	1	28.49
Preparation from fruits and nuts	1	28.40
Cashews	1	14.62
Coconut and coconut products	2	29.95

Source: Kerala State Planning Board

The shows the export trends of Kerala during the year 2018. Kerala predominately produces cash crops and Kerala is the best exporter of cash crops. Followed by fruits, Spices, Tea, and Rubber. Kerala produces specialty rice varieties, but its export volume remains low. Similarly, cashew exports lag despite Kerala being a major processing center but the major issue they are facing with the production and export of cashew nuts is due to the increase in the cost of production. Rubber exporting shows a larger share with 63.6 percent in India's total exports during 2018-19 (EXIM Bank, 2020). Kerala has a significant share in exports of products such as floor coverings at 56.9 percent, vegetable oil at 15.5 percent, spices at 13.4 percent, and tea at 13 percent (EXIM Bank, 2020).

1.6 Modern Technology in Kuttanad Paddy Farming: To overcome the challenge of labor shortage and to improve the efficiency of cultivation various technical methods were adopted. To reduce labour dependency machines are used for the seedling transplantation of paddy plants uniformly. Combine Harvesters are used for harvesting and threshing which save time and effort. For land preparation and plowing in the waterlogged fields tillers and tractors are used. More than this high-yielding varieties of seeds are used for cultivation which are resistant to waterlogging. For promoting soil health biofertilizers and organic farming methodology is adopted. The Kerala government supports machinery and other modern technology through different subsidies. Nowadays drone technology is used for monitoring crops and spraying fertilizers.

1.7 Labour shortage in paddy farming: Migration to other jobs is the primary reason for the labour shortage in paddy farming. This is happening especially after the COVID-19 pandemic due to the health risks and also employment in paddy farms is not continuous it is seasonal. In the present era younger generation prefers to move to urban areas for employment, this less interest in paddy farming is another reason for labour shortages in paddy farming. Most of the paddy farmers are small-scale farmers and some are renting out the farmland and doing the farming thus rising labour costs make farming less profitable.

1.8 Drone technology in paddy farming: Drone technology plays a significant role in precision farming it helps farmers in many ways like monitoring crops, spraying fertilizers and managing water resources. So it can reduce manual costs in less time. It helps farmers to assess the moisture content in soil to improve the cultivation. This study found that within 2 hours drones can spray fertilizers minimum of 10 acres of land without any human stamping on crops. It reduces the health risk from paddy dust and other harsh work done by farmers in waterlogged areas. The precise application reduces the overuse of fertilizers and it can reduce environmental pollution.

2.0 Review of literature

It is necessary to review the previous studies to have a clear perception of the present study. It will help in proper framing and useful analysis of the study.

Prof. Thomas KC (2020) explained the trends in the area, production, and productivity of paddy cultivation in India, Kerala, and the Kuttanad region from the period of 2009-10 to 2018-19. The study that there was a slight recovery in absolute values compared to the past during 2018-19 Kuttanad recorded a peak level of production (2920 kg/hectare) beating the national average (2659 kg/hectare). He found that factors like high labour costs, and climate uncertainties are some of the challenges faced in Kerala paddy farming. The study pointed out the importance of paddy cultivation in food security, rural livelihoods, and economic development.

Dave et al.,(2024) revealed their research work by knowledge level are same for all age categories of farmers on the different schemes and subsidies practices and all the farmers are aware of the popular funding schemes like Kisan credit card, Pradhan Mantri Samman Nidhi but they are unaware about the scheme related to mechanization and these familiar schemes are not supporting for mechanization.

Muralidharan et al.,(2015) observed in their study that the drums seedling method of paddy farming is better than the traditional method of broadcasting paddy farming. Because the broadcasting method requires more seed and makes the crop more vulnerable to pests and disease. The drum seeding method is more efficient and has better profitability and the yield is higher compared to other methods of production. The study recommended replacing broadcasting with a drum-seeding method. Annie et al.,(2023) examined the paddy cultivation in Kainakary in Kuttanad facing a challenge of labour shortage as the study found that many workers shifted from farming activities to MNREGA. While the younger generation prefers only non-agricultural jobs. The study recommends addressing labour shortages by promoting agriculture as a career, providing subsidies, improving credit access, enhancing marketing/storage facilities, and resolving payment delays through better banking supports

3.0 scope of the study

The present study examines the economic impact of drone usage in paddy farming in Kuttanad. It analyses the extent to which drone technology has helped farmers increase their profits. The study also examines the inconsistency in labour availability before and after the COVID-19 pandemic. Furthermore, it provides an understanding of the improvement in profit and efficiency in paddy farming following the adoption of drone technology.

3.1 Objectives of the study

1. To examine the inconsistency in the number of paddy farmers before and after covid 19
2. To analyze the impact of drone usage as a solution for labor shortage
3. To analyze the relationship between farmer's profits before and after the adoption of drone technology

3.2 Importance of the study: Kuttanad’s agriculture has traditionally relied on manual labor, but labor shortages have intensified in recent years due to migration to other sectors and rising wages. Studying drone adoption technology in agriculture in Kuttanad is essential for developing strategies that enhance productivity, sustainability, and economic viability and help to tackle the problem of labour shortages in agriculture.

4.0 Methodology

The study makes use of both primary and secondary data. Primary data were collected through a survey conducted by the researcher. A random sampling technique using the lottery method was adopted for this study. The questionnaire included questions related to the socio-economic background of farmers, changes in their income before and after the adoption of drone technology, constraints in using drone technology, and labour availability.

Primary data were collected from 52 farmers and 24 drone operators and dealers from Kuttanad. Secondary data were collected from government reports, Kerala Agricultural University, NABARD, and Kerala Krishi Bhavan.

A linear regression model was used to estimate the cause-and-effect relationship between dependent and independent variables.

4.1 Drone Pilot Training Hub at Kerala Agricultural University (KAU)

In January 2025, Kerala Agricultural University (KAU) and the National Bank for Agriculture and Rural Development (NABARD) signed a Memorandum of Understanding (MoU) to establish a Drone Pilot Training Hub at KAU's Vellanikkara campus in Kerala. This initiative aims to improve the agricultural practices in Kerala. This initiative, titled "Empowering Agriculture Through Innovation: Establishing a Drone Pilot Training Hub at Kerala Agricultural University offers capacity-building programmes for farmers and gives Drone pilot licencing

4.2 Additional Skill Acquisition Programme (ASAP)

It is a 7-day program for farmers to build additional skills for farmers. It offers an agricultural drone pilot training programme. It is a small-category course focusing on basic principles of flight and drone equipment maintenance. This helps farmers to operate small drones effectively.

4.3 Namu Drone Didi Scheme

On November 30, 2023, Prime Minister Narendra Modi launched this scheme. The scheme was launched to empower rural women by integrating drone technology into agriculture. It is a central government initiative with a budget of Rs. 1261 core. The scheme aims to provide 15,000 drones to selected Women's Self-Help Groups (SHGs) between the fiscal years 2024-25 and 2025-26. It enhances the income of women. The Fertilisers and Chemicals Travancore Limited (FACT) in Kerala serves as a nodal agency and provides proper training relating to drones and facilitating drone distribution.

Table 3 . The profile of workers population in Kerala

Particulars	1981	1991	2001	2011
No. of main workers (MW)	67,90,060	82,99,377	82,37,008	82,36,741
Percentage of total population (%)	26.68	28.53	25.87	24.67
No. of cultivators	8,87,461	10,15,844	5,86,475	7,40,403
Percentage to main workers (%)	13.07	12.24	7.12	7.2
Agricultural labour	19,16,834	21,19,661	10,21,389	16,53,601
Percentage to main workers (%)	28.23	25.54	12.40	16.1

Source: *Economic Review, Government of Kerala (various issues)*

The table shows data on the workforce in Kerala over four decades 1981, 1991, and 2001,2011 During 1991 the number of main workers increased from 67.9 lakhs to 82.99 lakh. After 1991 the employment growth was stagnant it remained stable at 82.37 lakh and in 2011 it was 82.36 lakh. Among workers, the percentage of cultivators declined from 13.07% in 1981 to 7.2% in 2011. This shows a decline in agricultural occupations, the major reason might be due to urbanization and shifts to other industries. Among the main workers, the percentage of agricultural laborers declined from **28.23% in 1981 to 16.1% in 2011**. This is because of movement away from agriculture due to reasons like industrial growth, Migration, or other better job opportunities. The number of cultivators and agricultural laborers fell significantly after 1991, reflecting a shift away from agriculture. The data revealed that the employment structure in Kerala has likely undergone structural shifts towards non-agricultural sectors.

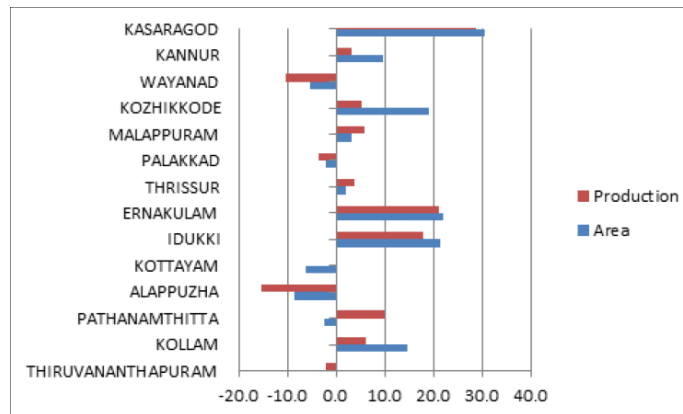
Table: 4 Area under and production of Rice in the districts under Kuttanad and kerala in 1982-83 and 2013-2014

	Year	Area (hectare)	Percentage change	Production(Metric Tonne)	Percentage change
Alappuzha	1982-83	83862	-	149769	-
	2013-14	37402	-55.4	106866	-28.6
Kottayam	1982-83	34596	-	50729	-39.3
	2013-14	15746	-54.5	-	-
Pathanamthitta	1982-83	-	-	-	-
	2013-14	2468	-	7554	-
Kerala	1982-83	778490	-	1306197	-
	2013-14	199611	-74.4	564325	-56.8

Source: *Economic Review, State Planning Board, Thiruvananthapuram Kerala, Various issue*

This table shows data on rice cultivation and rice production in the districts of Kottayam, Alappuzha, and Pathanamthitta from the **period (1982-83 to 2013-14)**. The data revealed that overall agriculture in Kerala declined from **778,490 hectares to 199,611 hectares**. That is a 74.4 Percent reduction. Alappuzha district declined its production from **83,862 hectares (1982-83) to 37,402 hectares (2013-14)** which is 55.4 %. In Kottayam district it is from **34,596 hectares to 15,746 hectares** decline in production. This data reflects a shift away from agriculture to other job industries this would impact the food security and agricultural stability in Kerala.

Table 5: Percentage change in area and production of rice in major districts of Kerala during 2015-16 over 2014-15, in percent



Source: Directorate of Economics and Statistics, Govt. of Kerala

The figure shows a declining trend in agriculture in Kerala. The main reason for this decline in production is due to high input prices and high labour wages. Other crops like Banana and coconut give more returns than paddy cultivation. The reason is that the unstable market prices for paddy. Many of the wetlands have been converted to commercial lands and residential lands.

5.1 Result and Discussion

The study analysed a change in profit as the income increased after using the drone technology. The higher value of R² shows that other than income factors like resource utilization, cost, Time, etc contribute to the profit additionally.

Table: 6: Consolidated Income Ranges and Frequency

Increase in Income	Number of occurrences
5,000 - 10,000	4
10,001-20,000	12
20,001-30,000	18
30,001-40,000	6
40,001-50,000	4

The primary source of data 2025

Table : 7 A consolidated change in profit

Profit before(Range)	Profit After (Range)	Average change in profit
2000 - 7000	5000 - 20000	8000
8000 - 12000	13000 - 28000	12000
14000 - 17000	20000 - 37000	11000
Above 19600	32000 - 47000	25000

Primary Source of Data 2025

The researcher attempts to find out the relationship between changes in income after the usage of drone technology here from the data it is evident that there is a positive shift in income around 24,000 rupees increase. There is a drastic change in profit, some of the profits are doubled it is according to the usage of drones and the type of land they used for cultivating the paddy. The profit and income increase drastically due to the main reason for the decrease in the labor wage before it was 800 rupees to 1000 rupees additionally for food need to pay and they needed more than 5 laborers per day from morning till evening but after the usage of drones 10 hectare of land can be sprayed in 2 hours and the rent is only around 500 rupees to 700 rupees.

Table: 8 Regression Statistics

Regression Statistics	
Multiple R	0.889783548
R Square	0.791714762
Adjusted R Square	0.787283161
Standard Error	3740.724302
Observations	52

Table 9 : ANNOVA

ANOVA	df	SS	MS	F	Significance F
Regression	1	2499882017	2499882017	178.6520937	1.26029E-17
Residual	52	657671860.4	13993018.31		
Total	52	3157553878			

Table 10 Coefficients of regression

Standard Error	t Stat	P-value	Slope
1350.394473	-3.583637846	0.000802266	0.707514731964071
0.0529336	13.36607997	1.26029E-17	

5.2 Regression Statistics: The regression statistics show a positive correlation between the increase in income and profit Multiple R is 0.8897 and the variation in change in profit is explained by an increase in income the value of R square is 0.7971 which shows a strong explanatory power thus the model is a good fit. F statistic 178.65 shows the model is statically significant. Slope (0.7075): For every ₹1 increase in income, the profit increases by ₹0.7075 on average. There is a Strong Positive Relationship Since the coefficient (0.7075) is positive and highly significant, it confirms that increasing income leads to an increase in profit. The low p-value shows that the model is statistically significant. For every ₹1000 increase in income, profit increases by ₹707.5 on average.

Regression Equation: The relationship between Change in Profit (Y) and Increase in Income (X) is given by:

$$Y = -4839.32 + 0.7075X$$

5.3 Neo-Classical Theory of labour migration

The neo-classical labor migration theory explains migration patterns based on wage differentials and regional employment opportunities. The neo-classical theory of labor migration suggests that most workers migrate from rural to urban with the aim of high wages and better economic and job opportunities. Migration occurs as a result of rational decisions because when the laborer feels that the working conditions are not enough and the wage he is earning is not enough they will find out-migration as a solution for that. This can happen due to the reason of population rate or globalization, Imitation of other cultures, etc. In the context of Kuttanad, the theory can applied and the theory is valid because it is found from the study that higher wages in non-agricultural sectors like in the fields of construction, Tourism, and urban employment. If we see the financial incentives for farmers are very limited and as farming is a seasonal job they will shift from job in which they can get more constable income. Neo-classical theory of labor migration explains the shift of agricultural workers in Kuttanad to other sectors, leading to severe labor shortages in paddy farming. In response, technological adoption presents a practical and necessary solution to sustain agricultural productivity. Studying the adoption of modern farming technologies is crucial for understanding its impact, overcoming challenges, and formulating policies that promote efficient, cost-effective, and sustainable agriculture in the region.

6.0 Major Findings

The present study provides a detailed investigation into drone technology in Kuttanad, Kerala. The research was conducted using a linear regression model, and it was found that there is a positive relationship between increases in income and profit after the adoption of drone technology to address the major problem of agricultural labour shortages in Kuttanad. Most of the people engaged in agriculture belong to the age group of 40–60, which indicates that the younger generation is shifting away from agriculture to other employment opportunities. After the COVID-19 pandemic, the younger generation in Kerala started migrating, and women marginal labourers in paddy fields shifted to other jobs such as MNREGA, sales jobs in shops, and small-scale jobs in self-help groups. There are two major reasons for this shift among women labourers. First, many women working in paddy fields are affected by health issues such as allergies, back pain, and joint pain. Second, since agriculture is a seasonal occupation, wages are unstable, which attracts them to jobs that provide a steady income. Among men, the major reason for labour shortages is the attraction of the younger generation towards white-collar and other skilled jobs. The study found that most farmers do not own drones; instead, they rely on rented drones. Only a few farmers have started using drones in recent years, and very few own drones. Since Kuttanad follows a group farming system (padashekara samithi), each group rents a drone for the entire group for a day during the season for spraying and other purposes.

7.0 Recommendations of this study

The following recommendations are made on a pragmatic basis with a view to providing a new baseline for action:

1. There is a need to provide subsidies to increase the use of drones, making them more accessible to farmers and reducing dependence on rented drones.
2. There is a need to provide training for farmers to operate drones, so they do not have to rely on drone operators.
3. The government can allocate one drone for each paddy field group (padashekara samithi).
4. There is a need to increase awareness of new technological innovations, as farmers are currently more aware of popular schemes such as the Kisan Credit Card.
5. Banks should provide loans for the purchase of drones.
6. Government departments should make budgetary allocations for training farmers in drone operations.
7. There is a need to establish more agricultural universities and increase research and development programmes for the younger generation.
8. Media involvement should be encouraged to improve awareness of technological innovations among farmers.
9. Providing drone operation training to self-help groups can increase the participation of women in agriculture.

8.0 Conclusion

The major reason for labour shortages in Kuttanad is urbanization. The younger generation shows less interest in farming practices, and the ageing farming population is another contributing factor. Labour shortages in agriculture increase dependence on technological innovations. Technological advancements such as mechanized transplantation, combine harvesters, automated irrigation systems, and drone usage have played a crucial role in mitigating the impact of labour shortages. Drone usage in agriculture reduces labour dependency, lowers labour costs, and saves time, thereby improving efficiency. It also prevents crop damage caused by human trampling. Drone technology is an efficient and cost-effective method; however, certain challenges still exist, such as high training costs, lack of awareness, and limited subsidies. To ensure sustainable farming in Kuttanad, providing subsidies for drones and other machinery will improve productivity and support farmers. While technological innovations are essential for overcoming labour shortages, a balanced approach that includes skill development and financial support is necessary to ensure long-term agricultural sustainability.

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