RESEARCH ARTICLE

# Mobile applications in agriculture: An economic analysis on rural farmers in Tamil Nadu

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In today's technological era mobile phones are an important tool that helps farmers to access updated information in the fast and in easiest way. The main objective of this study is to understand India's upcoming mobile application trends, to evaluate the farmer respondents' access to agricultural mobile phones and applications, to examine rural farmers' perceptions and opinions of agricultural mobile apps. These apps help the farmers in delivering information on marketing and marketing cost, market linkage, promotion of rural extension support, farming methods and ideas, etc. Google play store is the largest mobile app store through which many of the apps can be downloaded in the mode of payment or free of cost. Among the network providers, the JIO network has more customers than the other service providers. It is noted that 100 percent of the farmers use mobile phones for receiving calls in both zones. It is revealed from the table that out of the entire sample size of 220 farmers, 60 percent of the farmers are aware of mobile phones and their applications and 40 percent were not aware of the mobile applications. It is also revealed from the survey that the younger generation from the farming community helps the age-old family members in easy handling of mobile phones and their applications. Recently mobile phone usage played a vital role in enhancing the lifestyle of the farmers. Future trend prediction until 2050 shows that there will be a boom in the use of mobile phones and a comparatively reduction in landline connections. It is also revealed from the survey that the younger generation from the farming community helps the age-old family members in easy handling of mobile phones and their applications. In future, mobile server must be updated regularly with reliable information. Knowledge-based technical assistance must be provided by also creating public awareness pointing out the positive impact of mobile culture among the agrarian community also changes in the policy from the government agenda can be made to provide subsidies or to arrange financial support to the farmers to avail smart phones at fair prices. The use of the most recent upgrades for mobile applications can also be encouraged through the provision of training.

**Key Words:** *Cauvery delta zone; Southern zone; Mobile app; BSNL; JIO; Heckman probit model; Selection model; Adopt*

## INTRODUCTION

As agriculture is the prime source for the livelihoods of the Indian population, the Indian food sector performs an active role in establishing the Indian economy [1]. Increasing the productivity of food grains because of the growing population and demand is much emphasized recently. In the production year 2019-2020, It was estimated that food grain production to attain 295.67 MT and in 2020-21 the government of India also targeted to increase the food grain production to reach 298 MT [2]. It is also noted that the sixth-largest food and grocery market in India contributes 70% of the sales in retail. It was also reported in the agriculture and allied industries report, (2020) that 32% of India's total food trade is contributed by the processing industry which is considered to be the biggest food industry in India and ranks 5th in terms of production and consumption to achieve an expected growth rate of an economy. According to the fourth advance estimates for 2021-22, the nation would produce 315.72 million tons of food grains, an increase of 4.98 million tons over the production for the previous year. In order to achieve these goals, various alternative solutions are being discussed among the experts to sustain agriculture [3]. The growth of information and communication technologies creates several opportunities and facilities to boost Indian agriculture in several ways like analyzing market information, weather information, cultivation techniques, etc. and these technical resources are achieved through many software and mobile applications. Recent studies also proved that mobile phones help in reducing poverty in several ways which is a proven fact that the services rendered by mobile phones in agriculture benefit a large number of farmers and consumers as well in their report mentioned that increased growth in the usage of the internet in remote India is a tremendous positive impact where about three hundred million consumers in India use it online. Yogesh Joshi in his report mentioned that mobile applications continue to be used in a wide range of sectors today, including banking, retail, cosmetic products and medical care, to reach a wider audience in a flexible and affordable manner. In order to reach farmers effectively, the agriculture sector is now embracing smartphone apps [4-6]. In the same way, farmers can interact with industry professionals for assistance and receive the most recent information about farming practices, laws and market prices by using agriculture mobile applications. As most of the Indian population are from rural areas focus is given to the use of mobile phones in agriculture to increase production. William Tinzara, in his work mentioned that in today's technological world mobile phones are an important tool that helps farmers to access updated information in the fast and in easiest way. According to the report of the international telecommunication union, mobile phone access in the developing world has reached about 97%, Africa and Sub-Saharan Africa region was estimated at 69% and 52% respectively. According to AMGOO marketing team, 2015 it was also predicted to reach 79%-90% in Sub Saharan African region by the year 2020. A survey report from July and November 2008 in Uttar Pradesh, Rajasthan and Maharashtra, shows, that the farmers were confident in using mobile phones. The report says that the highest usage is from Maharashtra, Rajasthan and UP. The study report from Boston group in 2020 pointed out that in India significantly 315 million rural people are connected to internet service. Nowadays the world is everyone's hand which is more popular among the people simultaneously there is an increase in smartphones even in the village areas which enable the rural farmers to get solved all the farming problems. Matt Hopkins, 2023 in his contribution at international level mentioned that, AGMRI's integration with the John Deere operations center has made it easier for intelinair to collaborate with other industry leaders, like Yara North America and its adapt-N nitrogen management tool. Hyden, in his paper conveys that although on the surface

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it might seem that agriculture and mobile app technology have nothing to do with each other, there is growing evidence that using mobile and cloud-based applications not only helps to solve these sustainability problems but also generates profits for both large agricultural groups and smallholder farmers.

Objectives of the study is to:

- Understand India's upcoming mobile application trends.
- Evaluate the farmer respondents' access to agricultural mobile phones and applications.
- Examine rural farmers' perceptions and opinions of agricultural mobile apps.

## MATERIALS AND METHODS

A random sampling technique has been adopted for the study in the region of Southern Zone (SZ) which is considered to be a rainfed area and Cauvery Delta Zone (CDZ) which is called as rice bowl of Tamil Nadu and is considered to be an irrigated area [7]. The primary survey has been conducted in different parts of the selected zones to collect details regarding the usage of mobile phones in agriculture through a questionnaire survey.

A questionnaire survey was conducted among the farmers in the district of Thanjavur representing irrigated region and Madurai district representing the rain fed region. 110 farmers in each zone have been selected for the study and the total sample size was 220. Percentage analysis was worked out to understand the impact of mobile phones among rural farmers.

### Tools of analysis

- Percentage analysis worked out for analyzing primary data.
- Linear forecasting technique for analyzing the secondary data.
- Heckman probit model to assess the adopting technique by the farmers.

### Empirical analysis

**Linear forecasting technique:** It is a method of making predictions about the future using information from the past. To predict future events, an in-depth knowledge of current and previous trends and events is essential. Simple straight-line equations are used to assess the forecasting of future trend.

**Formula:**

Both functions calculate a future y-value by using the linear regression equation:

$y=a+bx$

Where the intercept (a constant) is:

$a=\bar{y}-b\bar{x}$

Additionally, the line's b coefficient is:

$$b = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sum(x-\bar{x})^2}$$

The $\bar{x}$ and $\bar{y}$ values represent the sample means (averages) of the known x and y-values

### Heckman probit model

The Heckman selection model, which was named after James Heckman, a Nobel Prize laureate in 1976, is essentially a technique for estimating regression models with issues of sample selection bias (selectivity bias). When the treated sample is self-selected, calculating treatment effects can be done using the Heckman two-step estimate. The purpose of this study's use of this model was to estimate the factors that influence a particular farmer's decision to choose adoption. STATA was used to estimate.

The first step was to create a model with a group of farmers who were aware of disaster events (selection) and then given that model, the outcome (adoption).

On the following two latent variables, Heckman's sample selectivity Probit model is based: $Y1=b'X+U1$ 1

$Y2=g'Z+U2$ 2

While Y1 indicated the farmers' choice regarding adoption or not, Y2 indicated their level of awareness about the usage of mobile application In the adoption equation, X is a k-vector of predictors; in the awareness equation, Z is an m-vector of predictor; and the error terms U1 and U2 are jointly normally distributed, independently of X and Z, with zero expectations. Size of the adaptable farmers was identified only when a farmer was aware of mobile phones application and their choice to adapt [8]. The size of non-adoption farmers was observed only when farmers were aware of the changes and made the decision not to adapt. To obtain precise forecasts, the model should explicitly take into consideration the non-random aspect of these two selection processes. The following model was established to overcome the issues with multiple sample selection that the magnitude of the adoption equation provides.

Let Y2* indicate the likelihood that a farmer is aware of a smartphone app. As a result, the relationship between the response propensity and the observed outcome Y2 can be calculated as follows:

Y2=1 if Y2*>0, Y2 is a missing value, if Y2*<0 (3)

Let Y1* represent the likelihood to select adaptation measures over non-adaptation measures. When the farmer was aware of the application of mobile phones and choose the value of 1 for adaptation and 0 for non-adaptation, Y2=1 *i.e.,* Y1 is a choice between adaptation and non-adaptation.

Y1=1 if Y1*> 0, Y1 is a missing value, if Y1* 0 (4)

The variables Y (size of adopter farmers) and YN (size of non-adopter farmers) are only seen if Y2=1 and Y1=1 (being aware but not adopted), accordingly.

Even though the first model is what the researchers are most interested in, the latent variable Y1 can only be seen if Y2>0. Consequently, the real dependent variable is:

Y=Y1 if Y2>0, Y is a missing value, if Y2 0 (5)

U2 can therefore be normalized so that its variance equals 1 without losing generality.

The Ordinary Least Squares (OLS) estimate of b will be biased if the sample selection problem is disregarded and Y is regressed on X using only the observed Y's.

$$E[Y1|Y2>0,X,Z] = b'X + rsf\frac{g'Z}{F}(g'Z) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots,(6)$$

where F is the standard normal distribution's cumulative distribution function, f is its associated density's' is the variance of U1 and 'r' is the correlation between U1 and U2. Hence,

$E[Y1|Y2>0,X]=b'X+rs\,E[f(g'Z)/F(g'Z)|X]$ (7)

If r is non-zero, the latter term leads to bias in sample selection. The model parameters are estimated using the maximum likelihood method to produce asymptotically efficient estimators and avoid the sample selection problem.

The first stage of the Heckman's sample selection model is the perceptions of changes to technology and this is the selection model (equation 4). The second stage, which is the outcome model (equation 5), is whether the people adapted to technology change conditional on the first stage that she/he perceived a change in the situation.

RESULTS AND DISCUSSION

## Number of telephone connections in India

According to telecom regulatory authority of India 2023, a total of 1,170.75 million telephone consumers in India at the end of January 2023 as compared to 1,170.38 million at the end of December 2022, indicating a monthly growth rate of 0.03 percent.

Figure 1 shows there will be an increasing trend of mobile phone connections in India. It has been predicted that 2157 million mobile telephone connections will be made by the end of 2030. As mobile phones are easy to access and can be taken anywhere, mobile phone users are increasing tremendously day by day and it reaches even a remote distance people.

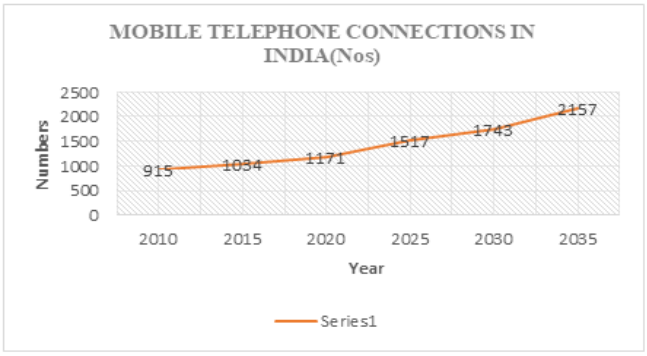


**Figure 1)** *Future trend of mobile telephone connections in India (Millions)*

Figure 2 shows that there is a boom in mobile phone connections than landline phone connections [9]. People prefer to use more advanced technology in the future than the fixed source of connections to cope up with the moving world. Moreover, improvised mobile phones are day by day emerging in the market with the latest technological features.

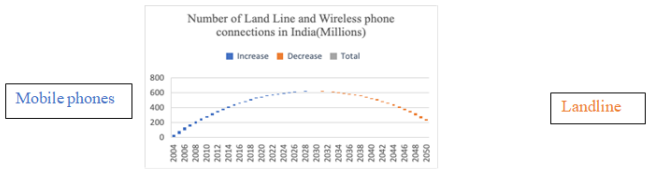


**Figure 2)** *The trend in landline and wireless phone connections in India (Millions)*

## Mobile application in India

In recent days increase in the usage of mobile applications enabled farmers to get easy information on agriculture. Mobile applications are software that can be downloaded on mobile phones from an online application store. Farmers also expect trusted information in depends on their current requirements. Many mobile applications that provide the recent agronomic information like climate trends, types of machinery and equipment, latest innovated technologies, prevailing latest methods being used, assist in identifying pests and diseases, disaster warnings, prevailing local markets which offer the best prices for the raw materials etc. Besides, cultivators can also get guidance from agriculture professionals throughout the nation using the mobile apps. Extension digest, in their report mentioned that these mobile apps deliver market knowledge, facilitate market connections, help to access extension facilities, farm-related news, etc. to the cultivators. Aker, also in his study analyzed that the involvement of IT in agriculture has also helped the farmers to collect information on market price situation, weather data to take over cropping, transport facilities available and the latest agricultural techniques available in order to improve Indian agriculture.

Mittal and Tripathi in their study identified that there is a positive sign of using mobile phones which in turn develops agriculture in many different regions. His findings also underlined the usage of mobile-enabled agriculture information services in remote areas where the markets are far away from the farmlands [10].

Although there are almost 170 numbers of mobile applications were framed for farmers, the most used mobile application by farmers in India are listed in Table 1.

TABLE 1
**List of popular mobile application software in India**

| **Commonly used mobile apps in India** | | | | | | | |
|---|---|---|---|---|---|---|---|
| My Agri Gu | Agriplex | Indian satellite weather | Kisan Space | Mandi Central | Uzhavan (Tamil App) | Kisan Suvidha | |
| Iffco Kisan | Market yard | Zero budget natural farming | Crop insurance | Machinery guide | Harvest ma | Agrowon | riceXpert |
| Shetkari | Krishi Network | E-Gram | Farm Bee | Coconut expert Tamil | CCMobile | Agromedix | Mana Verusanaga app |
| Kisan Yojana | MSAMB | Fasal Salah | KVSMT | Napanda | Bijak | Bhajarbhav | Cane advisor |
| Agriculture business | Agri Live | Agri App | Plantix | eNAM | APEDA farmer connect | Digital Mandi India | |
| **Software's developed by Indian council for agricultural research** | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Groundnut-IPM and Groundnut-IFC | ICAR-CIRB Bhains Janan (Buffalo reproduction) app | Herbal Kisan | Fruitcrops | PIS | e-kalpa | Havaamaana-Krishi | Kisan Mitra |
| Saur shakti ICAR | mKRISHI® Fisheries | Vanami Shrimpapp | Food safety and indigenous dairy products | ICAR DMAPR | GypCal -Sodic Soil Reclamation | LRIS GOA | Annada |
| Training calendar | Feed calculator | VetMicro | VNMKV | ICAR IISR Black pepper | Oil palm pests english, oil palm nutrients english and oil palm cultivation english | PCZ Mapper | CGKV APP |
| Hoof Care | Infoequine by ICAR-NRCE | IVRI-Pashu Prajanan (animal reproduction) app | IVRI-Shukar Palan (pig farming) app | Seed Spices Info | GypCal-sodic soil reclamation | PCZ Mapper | CCRI-CITRUS |
| (Citrus Cultivation) VNMKV Parbhani | Ripe mango Products | Aam Ki Suraksha-ICAR patna | AAM-SURAKSHA | AgroTech VNMKV ( ) VNMKV Parbhani | Phule Krishidarshani | mAgIDS | Kheti Gyan |
| Solapur Anar | ICAR-NRCL | Grapes DSS | Malda Krishi Vigyan Kendra, UBKV, Ratua, Malda | malwa fasal | Krishi Sparsham | Emausamhau Krishi Mausam Seva | Micro Mitra |
| Mobile farm solutions (Q and A) | Weed manager | PDKV weed manager | chanamitra | ICAR IIOR Castor | ICAR IIOR sunflower | Rice-IFC | RKMP rice Vocs |
| IVRI-Shukar Palan(Pig Farming) App | ICAR-MUSHROOM | IVRI - artificial insemination App | IVRI-Pashu Prajanan (Animal Reproduction) App | ICAR IIOR Safflower | ICAR IIOR sesame | ICAR IISR black pepper | ICAR-IIOR |
| ICAR-CRIJAF | Genebank app | CCRI-citrus | E-Thilhan | GrapesDSS | Cane adviser tamil | Gypcal Hindi | CAZRI KRISHI |
| GypCal -Sodic Soil Reclamation | Agriculture: FEM@Mobile | | | | | | |
| **Other sector apps** | | | | | | | |
| Pashu Poshan | Dairy telugu and dairy kannada | | | | | | |
| mKrishi Fisheries App | RML farmer | | | | | | |
| Rythu Neshthum | Kultivate | | | | | | |
| FarmersGrid | | | | | | | |

Among all these apps many of the apps are free and the farmers are allowed to access them without any fee payment through the google play store and Apple app store.

Figure 3 shows that Google play store is the largest mobile app store through which many of the apps can be downloaded in the mode of payment or free of cost.

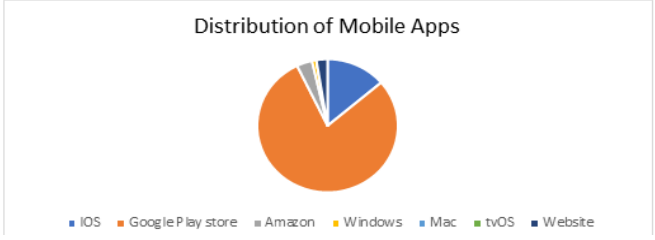


**Figure 3)** *Distribution of mobile apps*

Additionally, listed in the Table 1 is a list of popular mobile application software in India.

Digitalized India provokes agricultural technology to reach farmers faster than before a decade. According to TRAI, there are about 4 wireless operators and 345 internet service providers have been established in India. About 1151.81 million wireless subscribers are found to be a beneficiary of this network services (Table 2) [11].

TABLE 2
Mobile telecom operators market share in India (as of 31 October 2020)

| S. no | Particulars | Owners | Market shares (%) |
|---|---|---|---|
| 1 | JIO | JIO platforms | 35.28 |
| 2 | AIRTEL | Bharti Airtel limited | 28.68 |

| | | | |
|---|---|---|---|
| 3 | VJ | Vodafone Idea limited | 25.42 |
| 4 | BSNL | Government of India | 10.33 |
| 5 | MTNL | Government of India | 0.29 |
| 6 | RCOM | Reliance communication | 0.001 |

It is observed from Table 2 that Jio platforms, a private telecom/network operator plays a major role contributing about 35.28 percent compared to the other operators followed by Bharti Airtel limited which contributed about 28.68. BSNL and MTNL, government telecom services were found to be less which contributes about 10.33 and 0.29, respectively (Table 3).

**TABLE 3**

**Number of farmers and agricultural laborers using mobile applications**

| **Cauvery delta zone** | | **South zone** | |
|---|---|---|---|
| Owners of farm (%) | Agricultural daily labourers (%) | Owners of farm (%) | Agricultural daily labourers (%) |
| 40 | 60 | 20 | 80 |
| 08:20 | 50:50 | 70:30 | 70:30 |
| ↓ | ↓ | ↓ | ↓ |
| (Android: Keypad) | (Android: Keypad) | (Android: Keypad) | (Android: Keypad) |

Initially, in both zones, mobile phones have been used only for communication and in recent five years only there was a boom in the usage of mobile phones. In both the regions, it is observed that owners of the farm are less and was about 40 percent in Cauvery delta region and 20 percent in the Southern region. Agricultural laborers were found to be high in both the zones accounting for about 60 percent in the Cauvery delta region and 80 percent in the Southern region, respectively.

The study also revealed that in both the regions, owners of the farms are big landlords and businessmen among the 40 percent of the farmers 80 percent of the farmers use android phones with touch screen facilities and 20 percent of the farmers use keypads phones in the Cauvery region. In this region agricultural laborers also use both android and keypad phones in the ratio of 50 percent each.

Similarly, in the Southern region out of 20 percent of the landlords, 70 percent of the farmers use android phones and 30 percent of the farmers use keypad phones. Also, among 80 percent of the agricultural laborers, 70 percent of the farmers use android phones and 30 percent of the farmers uses keypad phone [12].

The study also revealed that farmers from the upper-middle-class left farming due to other businesses and hence mobile apps used by these farmers are very less than the agricultural laborers.

Table 4 reveals that out of the total sample size, 72.27 percent of the farmers in the CDZ region adopts mobile application for agriculture and only 40 percent of the farmers were found to adopt mobile application for agriculture in the southern region. Farmers not adopting mobile applications are due to digital illiteracy and lack of awareness among rural farmers.

**TABLE 4**

**Usage of agricultural mobile applications by the farmers**

| **Region** | **Adopters (No)** | **%** | **Non-adopters** | **%** | **Total (Nos)** |
|---|---|---|---|---|---|
| CDZ | 80 | 72.27 | 30 | 27.27 | 110 |
| Southern zone | 40 | 36.36 | 70 | 63.63 | 110 |

In both regions it is found that the Jio network has more customers than the other service providers. The Table also shows that 46.36 percent of the farmers in the CDZ region and 62.72 percent in the Southern region use the services of the Jio network. This is due to the high-speed network coverage like 3G and 4G along with unlimited free calls and SMS package systems (Tables 5 and 6).

**TABLE 5**

**Percentage of popular mobile phone service provider in the study area**

| **Service provider** | **Cauvery delta zone (No. of farmers)** | **%** | **Southern zone (No. of farmers)** | **%** |
|---|---|---|---|---|
| BSNL | 23 | 20.9 | 12 | 11.9 |
| Vodafone | 15 | 13.63 | 18 | 16.36 |

| | | | | |
|---|---|---|---|---|
| Airtel | 21 | 19.09 | 11 | 10 |
| Jio | 51 | 46.36 | 69 | 62.72 |
| Total | 110 | 100 | 110 | 100 |

TABLE 6
**Brands of mobile phones used by the farmers in the study area**

| Mobile phone brands | CDZ (%) | Southern zone (%) |
|---|---|---|
| Samsung | 26 | 14 |
| OPPO | 21 | 12 |
| REDMI | 25 | 55 |
| REALMI | 14 | 5 |
| 5Asus | 0 | 2 |
| Vivo | 11 | 11 |
| Apple | 1 | 0 |
| Others (LG, Panasonic, China make unbranded mobiles) | 2 | 20 |
| Total | 100 | 100 |

Nowadays a variety of mobile phones are available in the market at a lower cost. Table 5 result shows that Samsung in the CDZ region and REDMI in the Southern zone reached well among the farmers which accounted for about 26 percent and 55 percent, respectively. Mobile phones like LG, Panasonic and unbranded china make products are found to be high in the southern region than CDZ region. This may be due to the poor socio-economic status of the people who resides in the southern zone since it comes under a very backward area among the other regions in the state (Table 7).

TABLE 7
**Farmers knowledge on the functions of mobile phones**

| Particulars | Cauvery delta zone (Nos.) | % | Southern zone (Nos.) | % | Total (110 farmers in each zone) |
|---|---|---|---|---|---|
| Call to other fellow Farmers | 99 | 90 | 105 | 95.45 | 110 |
| Receive the call | 110 | 100 | 110 | 100 | 110 |
| Texting message | 87 | 79.09 | 49 | 44.54 | 110 |
| Using for audio/video chat | 67 | 60.9 | 43 | 39.09 | 110 |
| Email/Facebook | 25 | 22.72 | 19 | 17.27 | 110 |
| Use of mobile torch | 92 | 83.63 | 97 | 88.18 | 110 |

It is noted that 100 percent of the farmers use mobile phones for receiving calls in both zones. 87 percent of the farmers in CDZ and 44.54 percent of the farmers in SZ know knowledge of text messages. Mobile phones used for audio/video chat in both zones are about 67 percent and 39.09 percent, respectively. It is also found that more than 90 percent of the farmers use mobile phones as a torch during power failure at nighttime (Table 8).

TABLE 8
**Responses of farmers on mobile application usage in farm management**

| Particulars | CDZ (Nos) | % | Southern zone | % |
|---|---|---|---|---|
| Bio fertility management | 0 | 0 | 0 | 0 |
| Market price of produce | 15 | 13.63 | 7 | 6.36 |
| Crop varieties | 0 | 0 | 9 | 8.18 |
| Crop field management | 0 | 0 | 0 | 0 |
| Pest and disease management | 4 | 3.63 | 6 | 5.45 |

| | | | | |
|---|---|---|---|---|
| Irrigation management | 0 | 0 | 0 | 0 |
| Weather updates | 71 | 64.54 | 48 | 43.63 |
| Input prices | 2 | 1.81 | 12 | 10.9 |
| Fertilizer application | 4 | 3.63 | 6 | 5.45 |
| Marketing activities | 8 | 7.27 | 15 | 13.63 |
| Pest/disease management | 6 | 5.45 | 7 | 6.36 |
| Total | 110 | 100 | 110 | 100 |

It is observed from the Table 7 that 64.64 percent of the farmers in the CDZ zone and 43.63 percent of the farmers in the southern zone use mobile apps for getting information regarding weather updates. This is because both zones are highly prone to natural disasters. Flood and cyclones are common in the CDZ region and drought is common in the SZ region. Hence the farmers are interested in knowing the weather updates regularly to carry out their farming activities (Table 9).

TABLE 9
**Mobile app services known by the respondents**

| Mobile app services | CDZ | % | SZ | % |
|---|---|---|---|---|
| M-KRISHI | 5 | 4.54 | 0 | 0 |
| e-Governance | 7 | 6.36 | 3 | 2.72 |
| AGRISNET | 0 | 0 | 0 | 0 |
| UZHAVAN | 92 | 83.63 | 107 | 97.27 |
| Rice expert | 6 | 5.45 | 0 | 0 |
| Total | 110 | 100 | 110 | 100 |

Among all the mobile apps, the most common mobile app used by farmers in all the regions of Tamil Nadu is the Uzhalavan application. Farmers can get complete information from these apps on government schemes, subsidies, input availability, equipment, market price information, weather updates, etc. Farmers prefer this application since all the information is available in the Tamil language.

## Analysis of Heckman probit model

Heckman probit model was used to study the factors that determine adaptation to mobile applications. It is revealed from the table that out of the entire sample size of 220 farmers, 60 percent of the farmers are aware of mobile phones and their applications and 40 percent were not aware of mobile applications (Tables 10-12).

TABLE 10
**Explanation of selection variables used in Heckman probit model**

| Farmers perception on disaster events | Farmers who perceived changes | Farmers who did not perceived changes |
|---|---|---|
| Independent (%) | 60 | 40 |
| Description | Mean | Standard deviation |
| Literacy level of the farmer | 5.69 | 4.31 |
| Age of the farmers | 51.75 | 8.27 |
| Farm income from crop cultivation in Rs. (continuous) | 27324 | 17676 |
| Non-farm income (Rs) | 36215 | 19785 |
| Knowledge on IT on agriculture (%) | 0.9 | 0.5 |

TABLE 11
**Description of variables of the outcome used in Heckman probit model**

| Dependent variables | Adopted farmers (Percent) | Non adopted farmers (percent) |
|---|---|---|
| Adoption to mobile apps (dummy=1 if adopted and 0 otherwise) | 55 | 45 |
| **Independent variables** | | |

| Description | | |
|---|---|---|
| Adoption of mobile apps | Mean | Standard deviation |
| Education of the household head in years (years) | 5.69 | 4.31 |
| Experience in farming (years) | 29.16 | 10.84 |
| Non-farm income (Rs) | 36215 | 19785 |
| Size of the household (numbers) | 5.28 | 1.72 |
| Farm size (ha) | 2.21 | 1.14 |
| Visit of extension officers to farmers field (dummy:1 if extension service is accessed and otherwise) | 0.43 | 0.18 |
| Credit to buy phones (Dummy: 1 if there is access and 0 otherwise) | 0.83 | 0.19 |

TABLE 12
Outcome of Heckman probit technique

| Descriptive variables | Adoption technique | | Selection technique | |
|---|---|---|---|---|
| | Values of regression | MV | Values of regression | MV |
| | Co-eff | Co-eff | Co-eff | Co-eff |
| Education | 0.002 | 0.003 | 0.432* | 0.213* |
| | (0.856) | (0.976) | (0.000) | (0.000) |
| Experience | 0.045** | 0.122** | - | - |
| | (0.0020) | (0.024 | | |
| Age of the household | - | - | -0.004 | -0.002 |
| | | | (0.597) | (0.767) |
| On-farm income | 5.63E-05 | 3.20E-05 | 0.001 | 0.0002 |
| | (0.273) | (0.213) | (0.379) | (0.376) |
| Off-farm income | - | - | 0.00001* | 0.00002* |
| | | | (0.000) | (0.000) |
| Household Size | 0.104** | 0.103** | - | - |
| | (0.002) | (0.002) | | |
| Farm size (ha) | 0.084* | 0.042* | - | - |
| | (0.023) | (0.032) | | |
| Credit to buy phones | 0.145* | 0.160* | - | - |
| | (0.09) | (0.02) | | |
| Information on IT on agriculture | - | - | -0.032* | -0.0152* |
| | | | (0.000) | (0.000) |
| Visit of extension officers to farmers field | -0.213* | -0.201* | | |
| | (0.021) | (0.031) | | |
| Constant | -4.238* | | -3.42* | |
| | (0.000) | | (0.000) | |
| Total observations | 220 | | | |
| Censored | 98 | | | |
| Uncensored | 122 | | | |
| Wald *Chi square* (Zero slopes) | 71.82 | | | |
| | P<0.000 | | | |

It is also revealed from the table that out of the total sample size of 220 farmers 55 percent of the farmers adopted mobile applications from their mobile for knowing about various information like weather data, price-related information, agricultural information like pesticide application, fertilizer application, etc. and 45 percent of the farmers were not adopting mobile application technology.

It is seen from the result that all the variables show a positive and significant impact on the adoption the mobile applications among the respondents.

Family size shows a positive coefficient which implies that when the size of the household increases by one person then it increases the probability of adaptation to mobile phones by 10.30 percent. This indicates that as more family members, more will be the adoption of mobile apps [13].

Likewise, when the size of the farm increases, farmers tend to use different technologies, which can be possible by adopting a new mobile technology application. The coefficient of farm size is positively and significantly correlated implying that large-scale farmers are more likely to adopt due to their wealth and possible for them to invest in new technologies through the information drawn through high-end mobile phones. Results also show that increased farm size increases the adaptation of mobile apps by 4 percent.

The result shows that credit accessibility is positively and significantly related indicates if a farmer has access to credit his probability of adopting mobile phones and their application increases by 16 percent. A majority of the farmers in the study area were found to be small farmers, they purchase mobile phones based on monthly installments.

It is also noted that perception about mobile usage is also positively related to education, non-farm income and farm income. It shows that farmers with good educational backgrounds use more mobile application technology that is believed to create awareness among them and shows the probability of perceivers by 21 percent. Likewise, on-farm income and off-farm income increases the chance of adoption of mobile application by 0.02 percent, respectively [14].

The coefficients on visits of extension officials to the village show negative sign which implies that communication between farmers and extension officials are poor. Normally farmers get advice regarding agriculture from nearby fertilizer shops or from other experienced persons. Similarly, in the selection model, the coefficient of the age of the household shows a negative sign which indicates that age-old farmers are unaware of using mobile phones and their applications are of using mobile phones and its applications.

## Farmer's opinion on agricultural mobile application

Table 12 reveals that in both the zones farmer's opinions about recent updates regarding the agricultural information was found to be extremely poor which accounts for 61 percent from CDZ and 77 percent from SZ opined bad about recent updates. Sometimes taking research activities may get delayed due to several factors like climatic conditions, financial conditions, failure in research, etc. This might be the reason for the delay in updating the current information by the service providers (Table 13).

**TABLE 13**

**Farmers opinion on agricultural mobile application**

| Indicator | CDZ (range) | | | SZ (range) | | |
|---|---|---|---|---|---|---|
| | Bad | Average | Good | Bad | Average | Good |
| Reliability | 47 | 38 | 25 | 86 | 15 | 9 |
| Recent updates | 61 | 38 | 11 | 77 | 21 | 12 |
| Price of the app is cost-effective | 0 | 22 | 88 | 0 | 13 | 97 |
| Good visibility of the content | 34 | 23 | 57 | 46 | 40 | 24 |
| Technologically applicable | 22 | 32 | 56 | 11 | 27 | 72 |
| Need-based information | 43 | 62 | 19 | 23 | | 62 |

Interestingly the opinion about the price of the app in both the zones the farmers were found to be good. Most of the government apps in the market are free apps that have been created mainly for the benefit of the farmers. The majority of the farmers get access through only government applications.

Opinion about the technology applicability was also found to have a positive impact among the farmers in both the zones, which accounts for 57 percent of the farmers in CDZ and 72 percent of the farmers in SZ respectively.

## CONCLUSION

Recently mobile phone usage played a vital role in enhancing the lifestyle of the farmers. Future trend prediction until 2050 shows that there will be a boom in the use of mobile phones and a comparatively reduction in landline connections. As a majority of Indian farmers are semi-illiterate, the complete adoption of mobile technology in the farming field is challenging. The fact is that most of the farmers are small and marginal farmers; their landholding size is the major drawback in using the ICT technology among the farmers. Moreover, a significantly less percentage of the farmers are the owners of the land and the vast majority of their lands are not properly utilized under cultivation, also the application of agricultural mobile apps by these landlords is significantly less. Agricultural laborers and other small farmers may use mobile phones for taking up the calls but less awareness about the application of mobile software leads to incredibly low usage of mobile applications in the study area among the farmers. It is also revealed from the survey that the younger generation from the farming community helps the age-old family members in easy handling of mobile phones and their applications. Still, the importance of mobile phones and their application has to be disseminated among the rural farmers directing them through formal meetings and training by the officials from the state/central universities or by the state agricultural department to meet the self-sustainability in food production. Mobile server has to be updated regularly with reliable information. Knowledge-based technical assistance has to be provided by also creating public awareness pointing out the positive impact of mobile culture among the agrarian community. In this technological age, smart phones are almost a need and they are even more affordable in India.

In this technological era, smart phones are highly inevitable and even smart phones are available with a cheaper rate in India. Even though Indian farmers are small and marginal farmers, the benefits of cellphones for agriculture make the cost of investing in smartphones worthwhile. Changes in the policy from the government agenda can be made to provide subsidies or to arrange financial support to the farmers to avail smart phones at fair prices. The use of the most recent upgrades for mobile applications can also be encouraged through the provision of training.

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