Analyzing the Association between Citrus Farm Income and Extension Service Providers of Citrus Farmers of Central India

S. Bhattacharyya[1*], R. K. Sonkar[2], A. Saha[3], P. Pakhmode[4], K. Banerjee[5], P. Roy[6], and T. N. Roy[7]

ABSTRACT

The agricultural extension system of India has various kinds of service providers like state agriculture departments, universities, research institutes, Farm Science Centers and private players. This study was conducted in 2020 and attempted to explore the association between average annual net income earned from citrus cultivation and the source of availing citrus extension services through Correspondence Analysis (CA) method of 300 citrus farmers selected from three districts in Maharashtra, India. The farmers with high income (1808.31 to 2,411.09 USD ha^{-1}) received advisory services of the public research institute ICAR-Central Citrus Research Institute (CCRI) through either personal contact or electronic platforms. Awareness about CCRI services, source of seeking citrus cultivation related information, source of purchasing citrus planting material, using CCRI mobile app and website for citrus advisories, and contacting CCRI scientists for solving citrus farming related issues was found to have significant ($P < 0.05$) positive relationship with net income from citrus farming through Pearsons' correlation coefficient, while cost of cultivation and orchard age had negative significant relationship. The multi-linear regression analysis, depicted cost of cultivation, awareness about CCRI services, source of seeking citrus advisories, and source of purchasing planting material had significant association with net income. The findings of correlation and regression thus emphasized the positive significant association of CCRI's extension services to income from citrus farming. Identifying homogenous target groups of citrus farmers through Classification and Regression Tree (CART) method can serve as policy implication for extension service providers to deliver customized need-based advisories to target clientele.

Keywords: Advisory services, Citrus growers, Correspondence analysis, Customization of extension services, ICAR-Central Citrus Research Institute.

INTRODUCTION

Agricultural advisory services, or in other words, extension services (henceforth used interchangeably) act as the backbone of agricultural development of a country.

Extension services refer to the entire set of organizations that support and facilitate farmers to solve agriculture related problems and to obtain information, skills and technologies to improve their livelihoods (Anderson, 2007). Technically, agricultural

[1] Agricultural Extension, ICAR-Central Citrus Research Institute, Nagpur-440033, Maharashtra, India.

[2] Horticulture, ICAR-Central Citrus Research Institute, Nagpur-440033, Maharashtra, India.

[3] Indian Statistical Service, NSSTA, Ministry of Statistics & Programme Implementation, Greater Noida-201310, India.

[4] Agricultural Extension, ICAR-Central Citrus Research Institute, Nagpur-440033, Maharashtra, India.

[5] Agricultural Meteorology, ICAR- Mahatma Gandhi Integrated Farming Research Institute, Piprakothi, Motihari, Bihar – 845429, India.

[6] KAB-II, Indian Council of Agricultural Research, New Delhi-110012, India.

[7] Agricultural Economics, Uttar Banga Krishi Viswavidyalaya, West Bengal-736165, India.

*Corresponding author; e-mail: sangeeta.bhattacharyya2012@gmail.com

extension serves as the interface between scientists/researchers (lab) and farmers (land) by communicating and demonstrating innovative technologies on farmers' fields to encourage them and, as a result, enhance their production and income through scientific farming (Suvedi *et al*., 2017). Over the years, the role of agricultural extension has evolved, but the main target of all extension services remain the same, that is, bringing a positive change in farmers' income earned from agricultural activities. India being an agrarian country where more than 65 percent of population depend on agriculture for livelihood and most of them are smallholder farmers, extension services have a major role to play and government has developed a widespread extension system in the country to cater to the needs of farmers even at grass root level.

The extension system in India has various kinds of service providers (SPs henceforth) like state agriculture departments, agriculture universities, research institutes and their extension wings, Farm Science Centers (KVKs) and even private players. All SPs direct their activities towards increasing the farm income of their farmer clientele by improving the production, productivity, and marketing of the agricultural produce. An autonomous organization called Indian Council of Agricultural Research (ICAR) exists under the Ministry of Agriculture and Farmers Welfare, Government of India, which has established research institutes for every crop throughout the country. The extension activities of these research institutes primarily cater to dissemination of scientific technologies of farming amongst farmers and enhancing farm income through technology adoption.

Therefore, it was a matter of interest to the authors, as to how the farmers' income generated from a particular crop varies with the type of Extension Service Provider (ESP henceforth). In this context, the authors studied the profile of citrus fruit cultivating farmers of different income groups [average annual income in rupees per hectare (Rs. ha^{-1})

generated from citrus cultivation only considered here] in Vidharbha Region of Maharashtra, located in Central India. An attempt was made to discover the association between the farm income of citrus farmers and their sources of citrus extension services availed from. In the second part of the study, the authors attempted to identify target groups of farmers who were homogenous in certain socioeconomic and extension parameters and thus helped different ESPs to deliver need-based customized services.

In ICAR, the institute that works in the domain of citrus fruits is ICAR-Central Citrus Research Institute (ICAR-CCRI) located in Nagpur, Maharashtra. The institute develops technologies for overall improvement of productivity and profitability of citrus farmers across India and provides sustainable solutions to the problems of citrus growers through extension and farm advisory services (ICAR- Central Citrus Research Institute, 2021). Apart from ICAR-CCRI, state agriculture universities, Farm Science Centers (Krishi Vigyan Kendras or KVKs), state agriculture department machinery, private consultancies or nurseries or input dealers etc. are also involved in providing extension or advisory services to citrus growers of their respective regions.

Since the study was a part of the in-house project of ICAR-CCRI, the premiere research institute dealing with citrus under the largest research organization of ICAR, the institute has been considered as the principal ESP of citrus in this study. Different kinds of ESPs function in citrus industry of India, influencing the yield and income generated from citrus in differential patterns. However, the research question was whether there is a significant relation between the category of ESP and the income generated from citrus farming by farmers. If yes, there can be a possibility that a particular income group (citrus farmers generating a particular range of income from their citrus orchards) was availing service from a particular ESP and benefitting more

than the others. Further, for extension services to be better delivered, customization of advisories is necessary. In this context, how can target groups be identified and what can be the distinguishing factors for grouping the citrus farmers? There is no available literature in this context and on a large sample of citrus growers of India. Hence, all these issues led to formulate this study.

MATERIALS AND METHODS

Location of Study

ICAR-CCRI is located in Nagpur district of Maharashtra State of India. Maharashtra is the second largest producer of fruit crops in India, producing 12.296 million tons of fruit in 2021-22, among which citrus production was 1.849 million tons. Citrus occupies the second position among all fruits cultivated in Maharashtra, of which 0.118 million hectares are under mandarin cultivation with production of 0.987 million metric tons in 2021-22 (Ministry of Agriculture and Farmers Welfare, 2023). Accordingly, Maharashtra State was selected

for the study and the citrus cultivar selected was Nagpur Mandarin (*Citrus reticulata* Blanco). The Amravati and Nagpur districts of Maharashtra contribute about 80% of the total area under mandarin orchards in Maharashtra state sharing 48.88 and 31.45%, respectively (Wankhede *et al.,* 2017). The third in number is Wardha District. So, mandarin growing farmers of three districts of Nagpur, Amravati and Wardha were selected for the study (Figure 1).

Schedule for Interview

Data were collected from all the respondents by using a semi-structured interview schedule that was prepared keeping in conformity with the objectives of the study during April – June 2020. The schedule included questions related to socio-economic information and availing of citrus advisory services (Table1).

Research Design and Sampling Plan
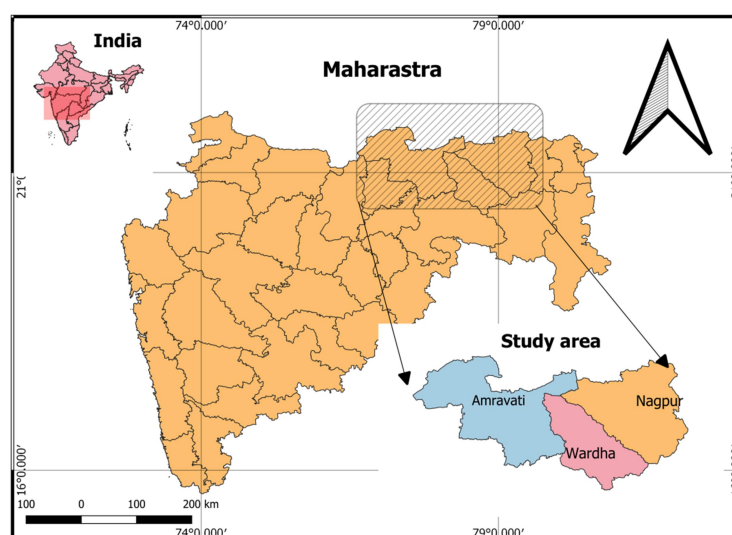
The *ex-post facto* research design was

Figure 1. Location of the study.

Table 1. Interview Schedule used for Data Collection of the Study.

Part 1: Socio-economic profile
1. Name, Age, Sex
2. Address and phone no
3. Size of mandarin orchard (in hectares abbreviated as ha henceforth)
4. Age of orchard (in years)
5. Gross income yearly obtained from citrus cultivation (USD ha^{-1})
6. Average cost of cultivation incurred yearly in citrus cultivation
7. Average annual (net) income obtained from citrus cultivation (USD ha^{-1})
Part 2: Extension services/Contact related information
1. Do you know about ICAR-CCRI? (Yes= 1, No= 0)
2. If yes, for how many years?
3. Do you contact the scientists of ICAR-CCRI when you face any problem in your citrus orchard? (Yes= 1, No= 0)
4. How frequently do you contact them? (Whenever needed= 1, Yearly= 2, During citrus seasons=3, Monthly= 4)
5. Do you use CCRI mobile app or visit CCRI website for acquiring knowledge on package of practices related to citrus cultivation? (Only app= 1, Only website= 2, Both app and website= 3, None= 0)
6. Where did you purchase your planting materials? (a) CCRI=3; (b) State nursery= 2, (c) Local Nursery= 1
7. From where do you receive citrus cultivation related information/advisory service? (a) CCRI= 5; (b) Private advisory services= 4 (c) Krishi Vigyan Kendra (KVK)= 3; (d) State Agriculture University (SAU)= 2, (e) State Department of Agriculture= 1
8. Are you member of CCRI Whatsapp group? (Yes= 1, No= 0)

followed. A sample of 100 citrus growers were selected for the study through stratified random sampling method from each of the three districts thus making the total sample size as 300. Since economic production age of citrus plants range from 6 to 25 years, the strata were based on the productive age of their citrus orchards like 6-10 years, 11-15 years and 16-25 years.

Correspondence Analysis (CA)

Correspondence Analysis (CA) was used to determine the relationship between services of different ESPs (categorical variable) and different income group of the farmers (ordinal variable). Income from citrus farming was only considered to find whether a farmer with high or low production level received advisory services from any particular ESP. And if yes, which kind of services? Since both variables were categorical, CA, being a nonparametric tool,

was used. The variables used in the analysis were given codes (Table 2).

A two-way contingency table was prepared for all the 3 districts using variables of Table 2. The contingency table for Nagpur is given below (Table 3). The income groups were in rows and the number of farmers receiving different types of citrus extension services from different service providers was arranged in columns.

Similar contingency tables were prepared for Wardha and Amravati. In this analysis, three packages were used for viz., FactoMineR (data analysis) factoextra and ggplot2 (data visualization) of R software version 4.2.2. Balloon plots were used to graphically depict the two-way contingency table of the CA in this study.

Correlation Analysis

Correlation analysis through Pearson's correlation coefficient was done to

Table 2. Variables used in CA Model. [a]

Sl. No.	Variables	Codes
1	Farmer has contact with CCRI	Contact_CCRI
2	Has no contact with CCRI	No_Contact_CCRI
3	Farmer either uses CCRI mobile app or visits CCRI website	CCRI_App_Web
4	Neither uses CCRI mobile app nor visits CCRI website	No_CCRI_App_Web
5	Farmer purchased planting materials from CCRI	Planting_CCRI
6	Purchased planting materials from State Department of Agriculture	Planting_State
7	Purchased planting materials from local nursery (private)	Planting_Local
8	Farmer seeks extension services from CCRI	Info_CCRI
9	Seeks extension services from private agencies	Infor_Pvt_advisory_srvs
10	Seeks extension services from KVKs	Infor_KVK
11	Seeks extension services from SAUs	Info_SAU
12	Seeks extension services from State Dept. of Agriculture	Info_State_Dept
13	Farmers who had less than 602.80 USD as average annual income	Less 0.5
14	Who had 602.80 USD as average annual income	Less 1
15	Who had 1205.54 to 1808.31 USD as average annual income	Less 1.5
16	Who had 1205.54 to 1808.31 USD as average annual income	Less 2
17	Who had more than 2411.09 USD as average annual income	More 2

[a] The USD exchange rates have been calculated as per 1 Indian Rupee (INR)= 0.121 US Dollar (USD) as on 19th March, 2024.

Table 3. Two-way contingency table of Nagpur for Correspondence Analysis (n= 100).

AAI[a] from citrus farming (USD ha^{-1})	No. of farmers receiving different types of citrus extension services from different sources (f)											
	Contact_CCRI	No_Contact_CCRI	CCRI_App_Web	No_CCRI_App_Web	Planting_CCRI	Planting_State	Planting_Local	Info_CCRI	Infor_Pv_.advisory_srvs	Infor_KVK	Info_SAU	Info_State_Dept
less 0.5	0	3	1	2	0	0	3	0	0	0	1	2
less 1	2	6	1	5	0	0	8	3	0	2	1	2
less 1.5	19	24	19	14	5	4	34	23	5	2	9	4
less 2	14	0	10	4	11	0	3	14	0	0	0	0
more 2	25	7	21	11	20	2	8	22	1	0	5	4

[a] Average Annual Income.

determine whether a linear relationship between average annual (net) income from citrus farming and economic and extension contact related variables existed. It is a parametric way of exploring whether income variable has any relation with the extension services or other variables at all.

Regression Analysis

A multi-linear regression was done to determine the extent of significant influence economic and extension variables have on average annual (net) income from citrus farming.

$$Y= \alpha+\beta_1 X_1+\beta_2 X_2+\beta_3 X_3+\beta_4 X_4+\beta_5 X_5+\beta_6 X_6+\beta_7 X_7+\beta_8 X_8+\beta_9 X_9+\beta_{10} X_{10}+\mu$$

Where, Y= Avgerage annual (net) income from citrus (Rs ha^{-1}), α= Constant, X_1= Cost_of_cultivation (Rs ha^{-1}), X_2= Orchard_age (in years), X_3= Know_CCRI, X_4= Years_known, X_5= Source of seeking citrus advisories (Citrus_info), X_6= Source of planting material purchase (Citrus_PP), X_7= Use of CCRI mobile app or website

(CCRI_app_web), X_8= Contact CCRI scientists for solving problems related to citrus farming (CCRI_Scntsts), X_9= Member of CCRI Whatsapp group (CCRI_whtsp), X_{10}= Frequency of contacting CCRI scientists (freq_cntct), and μ= Random error term. The net income (Y) is expected to change by a certain factor (β) if any of the independent variables increase by one unit.

Classification and Regression Tree (CART)

For better customization of citrus advisory services, target groups based on income of citrus farmers were needed to be identified. Accordingly, Classification and Regression Tree (CART) was used, which requires less data cleaning, does not require normalization and scaling of data, not largely influenced by missing values or outliers, and can handle both categorical and numerical data.

In this study, CART was used to generate sub groups (target groups) of response variable (income) based on four predictor variables or best attribute (socioeconomic and extension parameters). The variables were given codes (Table 4). The model automatically selects the data points (Table 4) that helps in dividing sample respondents into mutually exclusive and exhaustive sub groups. These groups are homogenous in socioeconomic and extension parameters, so, can be treated as target clientele for customized extension services.

RESULTS

Socioeconomic Profile of Respondents
An analysis of the socioeconomic profile of the respondents showed that the majority of citrus growers of all three districts- Nagpur (55%), Amravati (59%), Wardha (67%) were middle aged (30-50 years), followed by farmers aged more than 50 years and those aged less than 30 years, respectively (Table 5).

It was also evident (Table 5) that in Nagpur, the majority of famers (52%) had mandarin orchards of size 2-4 hectares, while Amravati (61%) and Wardha (62%) had dominance of farmers having orchards less than 2 hectares, thus showing that small farmers were in majority. It was found that in all 3 districts, the majority of farmers (Nagpur-43%, Amravati-44%, Wardha-46%) had average annual income between 1,205.54 to 1,808.31 USD ha^{-1} obtained from citrus cultivation.

Information Access Pattern of the Respondents

The respondents received different kinds of citrus advisory services from different service providers. It was found that 89% of respondents of Nagpur, 87% of Wardha and 90% of Amravati (Table 6) had heard about ICAR-CCRI or were well in contact with the institute. About 62% of citrus growers of Nagpur accessed information related to citrus cultivation from ICAR-CCRI followed by the advisory service of private agencies (22%). Similar information access pattern was found in Wardha (58% from CCRI and 29% from private) and Amavati (53% from CCRI and 34% from private). Respondents had less access to information from KVKs, SAU and State Agri/Horti Departments. While establishing their citrus orchards, majority (56% of Nagpur, 70% of Wardha) of the farmers had purchased the planting materials from local nurseries, but in Amravati, farmers had preferred ICAR-CCRI for their purchase (85%).

In the context of digital advisory services, CCRI mobile app was preferred by the majority of farmers (39% of Nagpur and 51% of Amravati). For discussing problems and seeking solutions for citrus farming related problems, majority of the farmers contacted CCRI scientists from all 3 study areas and mostly they contacted on need basis. The majority were members of Whatsapp groups run by the institute (Table 6).

Table 4. Variables used in CART Model.

Sl. No.	Variables	Codes
1	Contact with CCRI	Contact CCRI= 0 (The No node of this variable in CART model means farmer contacted CCRI and yes node means he/she has no contact)
2	Age of mandarin orchard	Yrsoforc>= 3 (The No node of this variable in CART model means orchard age is less than the 3rd strata age group of 16-25 years i.e age can be anywhere between 6-15 years and yes node means orchard is of age group 16-25 years or more) Yrsoforc< 2 (No node means age11-15yrs or 16-25 yrs and Yes node means 6-10 years)
3	Usage of CCRI mobile app or website	Appweb< 1 (No node means farmer uses either CCRI app or website and Yes node means he/she uses none) Appweb< 2 (No node uses both CCRI app and website and Yes node means uses none)
4	Size of mandarin orchard (in acres)	Mandacres>= 3.2 (No node means size of orchard is less than 3.2 acres &Yes node means more than or equal to 3.2 acres) [3.2 acres= 1.29 hectares (ha)]. Mandacres>= 1.8 (No node means less than 1.8 acres while Yes node means more than or equal to 1.8 acres) [1.8 acres= 0.72 hectares (ha)]. Mandacres< 1.6 (No node means more than 1.6 acres while Yes node means less than 1.6 acres) [1.6 acres= 0.64 hectares (ha)] Mandacres>= 1.2 (No node means less than 1.2 acres while Yes node means more than or equal to 1.2 acres) [1.2 acres= 0.48 hectares (ha)]. Mandacres>= 1.6 (No node means less than 1.6 acres while Yes node means more than or equal to 1.6 acres) [1.6 acres= 0.64 hectares (ha)]. Mandacres< 4.3 (No node means more than 1.2 acres while Yes node means less than 4.3 acres) [4.3 acres= 1.74 hectares (ha)].

Table 5. Socioeconomic Profile (N= 300).

Category (%)	Age of farmer (Years)			Orchard size (Hectares)			Net Income from citrus per hectare (USD ha⁻¹)				
	< 30	30-50	> 50	< 2	2-4	> 4	<602	602-1205	1205-1808	1808-2411	> 2411
Nagpur (n= 100)	15	55	30	32	52	16	3	8	43	14	32
Amravati (n= 100)	18	59	23	61	23	16	0	18	44	20	18
Wardha (n= 100)	13	67	20	62	23	15	2	17	46	12	25

Relation between Category of ESPs and Average Annual (net) Income from Citrus

Table 7 shows that there are significant dependencies between rows and columns in Nagpur and Wardha as the null hypothesis of no association between rows and columns is rejected at 5% level of significance. However, Amravati has not shown significant dependencies. Therefore, CA could be done with the data for Nagpur and Wardha only.

From Figure 2, it can be concluded that most of the citrus farmers who earned average annual income of 1,808.31 USD ha⁻¹ from citrus cultivation had contacted CCRI scientist, used CCRI app and/or website, purchased planting material from CCRI and obtained advisories related to citrus cultivation from CCRI. It was also found that most farmers with income less

Table 6. Pattern of information access (Extension Contact) (N= 300).

Extension Contact Variables	Category	Nagpur (n= 100)	Wardha (n= 100)	Amravati (n= 100)
Know_CCRI (%)	Yes	89	87	90
Source of information related to citrus cultivation techniques (%)	Private agencies	22	29	34
	ICAR-CCRI	62	58	53
	KVK	4	3	7
	SAU	4	3	1
	State Agric. Hortic. Dept.	8	7	5
Source of purchase of citrus planting materials (saplings) (%)	ICAR-CCRI	38	25	11
	Local Nursery	56	70	85
	State Agric. Dept./Nursery	6	5	4
Use of CCRI Mobile App or website for information on citrus cultivation (%)	Both app and web	14	14	8
	Only CCRI app	39	37	51
	Only CCRI website	9	9	8
	None of the above	38	40	33
Contact with CCRI scientists for guidance related to citrus cultivation (%)	Yes	60	63	68
Frequency of contact with CCRI scientists (%)	Whenever needed	77	75	66
	Yearly	0	6	8
	During citrus seasons	8	7	9
	Monthly	15	12	17
Membership of CCRI whatsapp groups (%)	Yes	85	87	90

Table 7. Chi-square test for CA.

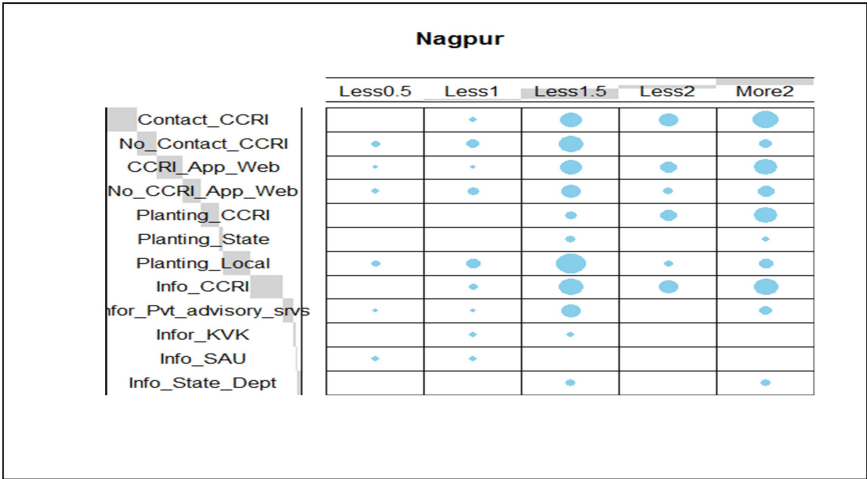| Location	Chi-squared	P-value
Nagpur	144.28	< 0.001
Wardha	69.40	0.008
Amravati	37.18	0.280

Figure 2. Balloon Plot of the contingency table for Nagpur.

than 1,808.31 USD ha^{-1} had not contacted CCRI and purchased planting material from local nurseries. Most of the farmers who had income less than 602.80 to 1,205.54 USD ha^{-1} had neither any contact with CCRI nor used CCRI app and/or website. They had purchased citrus planting materials from local nurseries.

From the CA factor map (Figure 3) based on proximity of variables to each other, it was seen that the farmers who earned average annual income from citrus cultivation in the range of less than 2,411.09 USD ha^{-1} to more than 2,411.09 USD ha^{-1} had contacted CCRI. Similarly, they used CCRI app/website for information (CCRI_App_Web) and purchased planting materials from CCRI (Planting_CCRI). It was also observed that the farmers with income less than 1,808.31 USD ha^{-1} purchased planting materials from local nurseries (Planting_Local) or state department run farms (Planting_State), obtained farm advisories from private agencies (Infor_Pvt_advisory_srvs). The farmers who had income less than 1,205.54 USD ha^{-1}, got citrus related information from KVK (Farm Science Centre, an extension project of ICAR locally known as Krishi Vigyan Kendra) (Infor_KVK). The farmers who had less than 602.80 USD income obtained farm advisories from State Agricultural Universities (Info_SAU).

From Figure 4, it can be concluded that most of the farmers had income less than 1,808.31 USD ha^{-1} and had purchased local planting material and obtained farm advisory from CCRI. The farmers having income more than 2,411.09 USD ha^{-1}
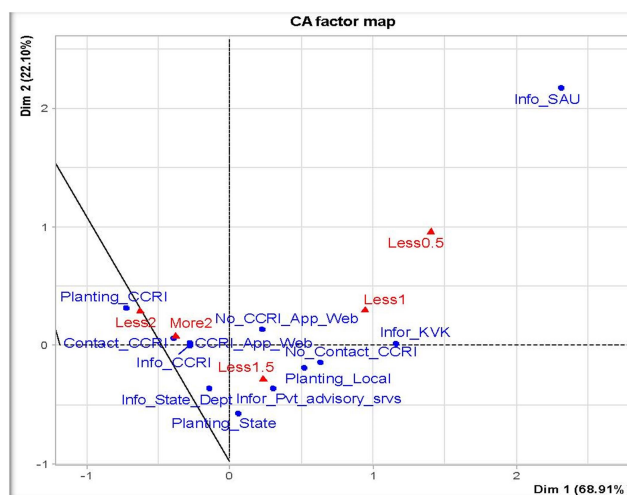
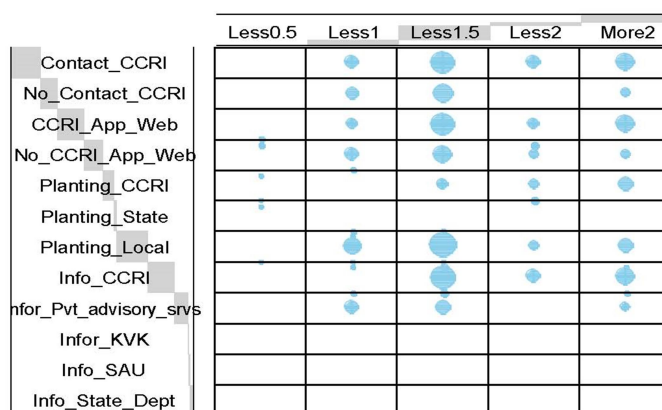**Figure 3.** CA factor map for Nagpur.

Figure 4. Balloon Plot of the contingency table for Wardha.

had contacted CCRI and used CCRI website and app. The farmers who got information from private agencies (Infor_Pvt_advisory_srvs), purchased planting material from local nursery (Planting_Local), and did not contact CCRI (No_Contact_CCRI) had income less than 602.80 USD ha^{-1}.

In the CA factor map of Wardha district, two-dimensional representation is quite satisfactory since the first two components account for 86.90 % of the variance (Figure 5). From this CA factor map, it was seen that the farmers who had income in the range between less than Rs. 2 lakhs ha^{-1} to more than 2,411.09 USD ha^{-1} had access to advisory services of CCRI, used CCRI App- Website, purchased planting material from CCRI. It can be observed that the farmers with income less than 2,411.09 USD ha^{-1} had purchased planting material from local nurseries (Planting_local) and state
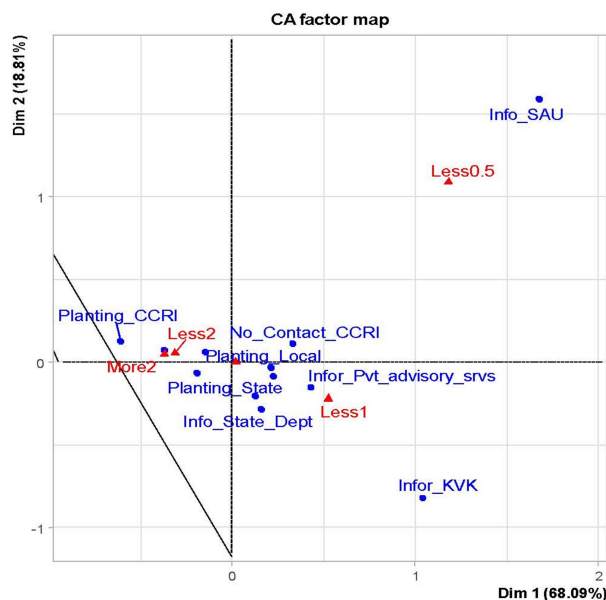
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Figure 5. CA factor map for Wardha.

department farms (Planting_State), obtained advisories from private agencies (Infor_pvt), and had no contact with CCRI. The farmers who had income of 1,808.31 USD ha^{-1} had obtained citrus advisories from KVK and those with less than 602.80 USD ha^{-1} had obtained from SAUs.

The correlation analysis showed that knowledge about CCRI, source of seeking citrus cultivation related information, source of purchasing citrus planting material, using CCRI mobile app and website for citrus advisories, and contact with CCRI scientists for solving citrus farming related issues had a significant (P< 0.05) positive relationship with net income from citrus farming through Pearsons' correlation coefficient, while cost of cultivation and orchard age had negative significant relationship (Table 8).

Contacting CCRI scientists had the second highest significant r value (0.23) along with knowing CCRI (0.16) and using CCRI digital platforms (0.16), which showed that CCRI extension services had a positive relationship with income from citrus farming.

The multi-linear regression analysis showed that cost of cultivation, knowledge about CCRI, source of seeking citrus advisories, and source of purchasing planting material had significant association with net income (Table 9).

It was also seen that, amongst all significant variables that played a role in influencing the net income of a citrus farmer, their knowledge of CCRI, hence contact with the institute, in some form was a major factor (beta coefficient 28870.426) in determining their income from citrus farming. A farmer being aware of CCRI and tracking its extension services can have a difference of 348.04 USD than a farmer who did not know about the existence of CCRI.

Identifying Target Groups for Better Customization of Extension Services

To identify citrus farmers of different income groups who can serve as target groups for better customization of extension services, CART was used. For CART analysis, citrus growers were classified

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Table 8. Relationship between income from citrus farming and economic and extension parameters.

Independent variables	Pearson's correlation coefficient (r)
Know about CCRI	0.16**
Years known	0.07[NS]
Source of seeking citrus cultivation related information	0.20**
Source of purchasing citrus planting material	0.39**
Using CCRI mobile app and website for citrus advisories	0.16**
Contacting CCRI scientists for solving citrus farming related issues	0.23**
Frequency of contact	0.08[NS]
Cost of cultivation (Rs ha^{-1})	-0.23**
Orchard age (Years)	-0.14**
Member of CCRI Whatsapp group	-0.03[NS]

** Significant at 0.05 level of probability, NS= Non-Significant.

Table 9. Multiple regression results showing the influence of various regressants on income from citrus.[a]

Variables	Coefficient	Std. error	t-Statistic	P
Cost of cultivation	-0.729	0.369	-1.972	0.049**
Orchard_age	-888.619	673.298	-1.319	0.187[NS]
Know_CCRI	28870.426	12385.615	2.330	0.020**
Yrs_known	-1144.287	641.921	-1.782	0.075[NS]
Citrus_info	9017.995	3310.293	2.724	0.006**
Citrus_PP	28104.806	4267.393	6.585	0.00**
CCRI_app_web	2804.887	3899.381	0.719	0.472[NS]
CCRI_Scntsts	12355.730	8734.746	1.414	0.158[NS]
CCRI_whtsp	1184.947	11039.541	0.107	0.914[NS]
Freq_cntct	2476.363	0.369	-1.972	0.049[NS]
Constant	90283.964	34216.498	2.638	0.008[NS]

[a] Number of observations= 300, F (10, 289) = 9.86, Prob> F= 0.0000**, R^2= 0.7217, Adjusted R^2= 0.7080.
** Significant at 5% level, NS= Not Significant.

based on their orchards aged 6-10 years (Yrsoforc= 1), 11-20 years (Yrsoforc= 2) and more than 21 years (Yrsoforc= 3).

The classification and regression (CART) analysis of Nagpur (Figure 6) revealed 8 mutually exclusive groups comprised of homogenous population within the groups. The group having average annual income from citrus farming as 2,555.91 USD ha^{-1} (12% of the respondents and right hand side of Figure 6) were homogenous in terms of certain socioeconomic and extension parameters. They had contacted CCRI, had orchards of age 11-20 years (No node of Yrsoforc< 2) with average size of orchard less than 1.8 hectares (No node of Mandacres>= 1.8). The next homogenous

group (22%) was with income 184,000 Rs ha^{-1} and orchard size more than 1.8 ac. The other groups (last row of blocks) can be seen in Figure 6. ESPs can customize their services according to the needs of these homogenous target groups and thus reach out to farmers more effectively.

In Wardha district, 6 mutually exclusive groups (Figure 7) were identified. The highest average annual income from citrus cultivation was 2,399.18 USD ha^{-1} (15% of respondents and right hand side of Figure7) who had orchards aged 11-20 years (No node of Yrsoforc< 2) and orchard size less than 1.2 ac (0.48 ha) (No node of Mandacres>= 1.2).

In Amravati District (Figure 8), 7 mutually exclusive groups were identified. The highest average annual income generated from citrus cultivation was 3,074.32 USD ha^{-1}

(7% of respondents and right hand last block of Figure 8) and they had obtained CCRI advisory services through either website or app or both (No node of Appweb< 2). These farmers had mandarin orchards of sizes more than 4.3 ac (1.74 ha) (No node of Mandacres< 4.3).

DISCUSSION

The socioeconomic profile of the respondents revealed that the majority were of the age group 30-50 years. The finding is concurrent to that of the majority of potato farmers of Himachal Pradesh, lemon farmers of Bangladesh, and citrus farmers of Haryana who were also middle aged (Pandit *et.al.*, 2010; Sarkar *et.al.*, 2017; Kumari *et.al.*, 2021). Majority of the farmers were able to generate an average annual (net) income of 1,205.54 to 1,808.31 USD ha^{-1} from citrus farming and had orchards of sizes less than 2 ha, except in Nagpur where the majority had orchards of 2-4 ha.

The citrus growers showed a major preference of seeking extension advisory services from the public research institute of ICAR-CCRI. Citrus farmers, in large numbers, not only contacted scientists of CCRI for guidance on citrus farming but also were members of CCRI Whatsapp groups, and sought solutions to their farming related issues from CCRI scientists. For urgent dissemination of farm advisories, CCRI utilized digital platforms like social media, mobile apps, websites, SMS, bulk messaging systems, etc. along with attending phone calls and physical interactions with farmers. More than 3500 farmers were in contact with scientists of ICAR-CCRI through 13 social media (Whatsapp) groups. The findings are in conformity with the study of Das *et al.* (2021), which stated that ICT tools were the most effective way for ESPs to reach out to farmers.

ICAR-CCRI also extended its extension services in the form of sale of disease-free planting material of citrus at minimal cost to farmers after doing rigorous viral and bacterial indexing of mother plants and maintaining best quality of graft material. Further, unlike other ESPs, CCRI is a research institute conducting need-based problem-solving research experiments on current challenges of citrus industry like climate change, high temperatures, erratic rainfall patterns influencing disease and pest incidence in citrus crop etc. CCRI also timely disseminated the research outputs in the form of advisories to farmers in large scale. Hence, farmers were getting effective solutions and guidance for a myriad of farming related problems. These two can be the reasons for the significant association (through CA) found between farmers having high farm income (1,808.31 to 2,411.09 USD ha^{-1} and more) and they obtaining citrus extension services from CCRI. Effective solutions from a research institute and its scientists, for unsolved emerging problems to which other ESPs did not have answers and supplying healthy, high yielding, disease-free planting materials to farmers, can be attributed as the two main reasons for influencing the production, as a result income, of citrus farmers who were in direct contact with CCRI. The strong positive association between CCRI extension services and income of farmers was also established through correlation analysis (knowledge about CCRI, using CCRI digital platforms and contacting CCRI scientists variables were significant). The regression analysis re-established this by concluding that a farmer being aware of CCRI and tracking its extension services can have a difference of 28,870.42 Rs. than a farmer who was unaware about the existence of CCRI.

The importance of advisory services in improving the innovativeness of farmers and instilling the spirit of scientific farming has also been established by Bruce *et al.* (2021). CCRI hence maintained a strong credibility amongst citrus farmers of the region. The
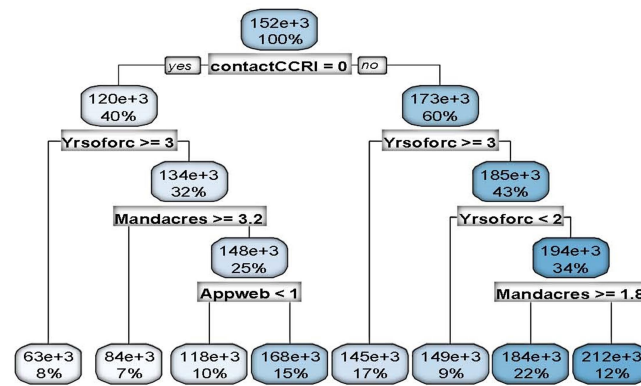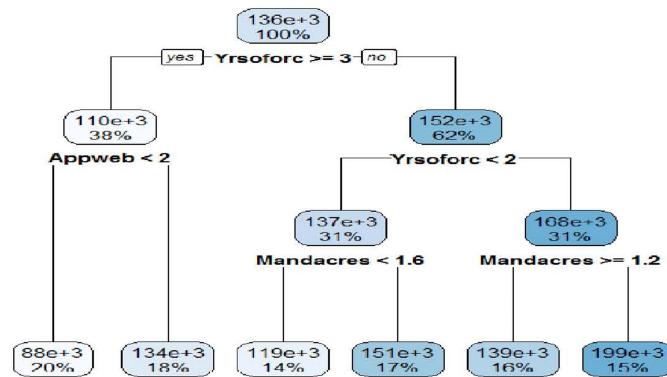
Figure 6. CART for Nagpur.

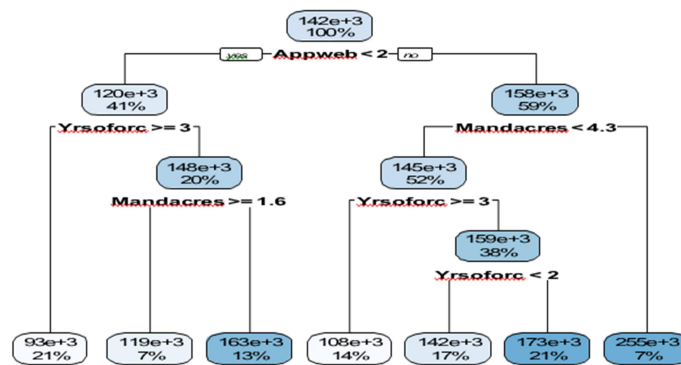**Figure 7.** CART for Wardha.

Figure 8. CART for Amravati.

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findings are concurrent to the findings of Kumar *et al*. (2018) who stated that farmers of Andhra Pradesh, India, preferred seeking information from public ESP due to their credibility as compared to private agencies, NGOs etc. Hence, the study restores faith on public extension system of India and also highlights importance of using digital platforms for information dissemination amongst farmers.

CART analysis identified target groups for each location of the study. These groups had homogenous characteristics in terms of socio-economic and extension parameters and, thus, can be easily targeted by ESPs for disseminating customized, need-based citrus advisory services catering to problems and demands of the respective groups. This finding is highly important from the perspective of ESPs who seek strategies for effectively reaching out to their clientele and delivering services for their satisfaction (Das *et al.*, 2021; Birner and Anderson, 2007). Delivering only need-based customized advisory services becomes not only easier for the extension agency but also improves information retention by farmers, thus encouraging adoption of scientific management practices amongst them.

CONCLUSIONS

The study shows that public advisory services still serve as essential role for improving socio-economic development of small farmers. The study provides evidence of higher income of citrus farmers with the help of advisory services of CCRI. The CART analysis identifies the target groups for customized and demand-driven extension service delivery. Customized citrus advisory services for farmers with orchards of specific age groups can deliver age-specific information of package of practices instead of directing bulk information. Customization not only eases information intake but also improves information retention, reduces loss of information, noise in communication

channel as well as saves time and energy of the sender agency. The findings show that small holder farmers with less than two hectares also receiving public advisory services hence having faith in public extension system, which in turn, motivates extension experts to make the information delivery system more efficient through the use of digital advisory platforms.

REFERENCES

1. Anderson, J. 2007. *Agricultural Advisory Services*. A Background Paper for "Innovating through Science and Technology". Chapter 7 of the WDR 2008. https://documents1.worldbank.org/curated/en/490981468338348743/pdf/413540Anderson1AdvisoryServices01PUBLIC1.pdf

2. Birner, R. and Anderson, J. R. 2007. How to Make Agricultural Extension Demand Driven? The Case of India's Agricultural Extension Policy. IFPRI Discussion Paper 00729. Washington, DC.

3. Bruce, A., Jackson, C. and Lamprinopoulou, C. 2021. Social Networks and Farming Resilience. *Outlook Agric.*, **50(2)**: 196–205.

4. Das, S., Munshi, M. N. and Kabir, W. 2021. Strategies of Extension Service Providers To Meet the Information Needs of the Farmers. *SAARC J. Agric.*, **19(1)**: 249-258.

5. ICAR-Central Citrus Research Institute. 2021. Director's Message. Available at: https://ccri.icar.gov.in/ccringp/ (Accessed on 11 June 2021).

6. Kumar, N., Reddy, P. G. and Ratnakar, R. 2018. Perception of Farmers on Agricultural Extension Service Providers (Public, Private and NGO Extension Service Providers) in Andhra Pradesh, India. *Int. J. Curr. Micro. App. Sc.*, **7(3)**: 3772-3779.

7. Kumari, V., Chander, S. and Sharma, S. 2021. Knowledge and Adoption of Drip Irrigation in Citrus Crops among Farmers of Western Haryana. *Ind. J. Ext. Educ.*, **58(1)**: 151–156.

8. Ministry of Agriculture and Farmers Welfare. 2023. *2021-2022. (First Advance Estimates) of Area and Production of Horticulture Crops.* Ministry of Agriculture and Farmers Welfare, Government of India.

9. Pandit, A., Kumar, A., Rana, R. K., Pandey, N. K. and Kumar, N. R. 2010. A Study on Socio-Economic Profile of Potato Farmers: Comparison of Irrigated and Rain-fed Conditions in Himachal Pradesh. *Potato J.*, **37(1-2)**: 56-63.

10. Sarkar, M. N. I., Barman, S. C., Islam, M., Islam, R. and Chakma, A. S. 2017. Role of Lemon (*Citrus limon*) Production on Livelihoods of Rural People in Bangladesh. *J. Agric. Econ. Rural Dev.*, **2(1):**167-175.

11. Suvedi, M., Ghimire, R. and Kaplowitz, M. 2017. Farmers' Participation in Extension Programs and Technology Adoption in Rural Nepal: A Logistic Regression Analysis. *J. Agric. Educ. Ext.,* **23(4)**: 351-371.

12. Wankhede, Y., Kale, N. M., Bhople, P. P. and Jangwad, N. P. 2017. Profile and Constraints of Orange Growers in Adoption of Soil Testing Techniques in Amravati District. *Agric. Update*, **12(1)**: 52- 60.

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تحلیل ارتباط بین درآمد حاصل از پرورش مرکبات و ارائه دهندگان خدمات ترویجی مرکبات‌کاران هند مرکزی

س. پاتاچاریا، ر. ک. سونکار، آ. ساها، پ. پخمود، ک. بنرجی، پ. روی، و ت. ن. روی

چکیده

سامانه ترویج کشاورزی در هند شامل سازمان‌های مختلفی از ارائه دهندگان خدمات مانند ادارات کشاورزی دولتی، دانشگاه‌ها، موسسات تحقیقاتی، مراکز علمی مزرعه (Farm Science Centers) و مجریان خصوصی است. این مطالعه در سال ۲۰۲۰ انجام شد و تلاش کرد تا ارتباط بین میانگین سالانه درآمد خالص کسب شده از کشت مرکبات و منبع بهره مندی از خدمات ترویج مرکبات را از طریق روش تحلیل مکاتباتی (Correspondence Analysis :CA) برای ۳۰۰ کشاورز مرکبات انتخاب شده از سه منطقه در ماهاراشترا (Maharashtra) هند بررسی کند. کشاورزان با درآمد بالا (۱۵۰ تا ۲۰۰ هزار روپیه در هکتار) خدمات مشاوره ای مؤسسه تحقیقاتی عمومی ICAR–Central Citrus Research Institute [(CCRI)] را از طریق تماس شخصی یا پلت فرم‌های الکترونیکی دریافت کردند. . آگاهی از خدمات CCRI، منابع جستجوی اطلاعات مربوط به کشت مرکبات، منابع خرید مواد کاشت مرکبات، استفاده از برنامه موبایل و وب سایت CCRI برای خدمات مشاوره مرکبات و تماس با دانشمندان CCRI برای حل مسائل مربوط به کشت مرکبات در رابطه با درآمد خالص حاصل از پرورش مرکبات، در تحلیل با ضریب همبستگی پیرسون رابطه مزبور مثبت و اثری معنی دار (P< ۰/۰۵) داشت، در حالیکه هزینه کشت و سن باغ رابطه منفی و معنادار داشتند. تجزیه و تحلیل رگرسیون چند خطی نشان داد که هزینه کشت، آگاهی در مورد خدمات CCRI، منبع جستجوی مشاوره مرکبات، و منبع خرید مواد کاشت با درآمد خالص ارتباط معنی‌داری داشت. بنابراین، یافته‌های همبستگی و رگرسیون بر ارتباط مثبت و معنی‌دار خدمات

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ترویجی CCRI با درآمد حاصل از پرورش مرکبات تأکید کرد. شناسایی گروه‌های هدف همگن از کشاورزان مرکبات با روش طبقه‌بندی و رگرسیون درختی (CART) می‌تواند به عنوان پیامد سیاست‌گزاری برای ارائه‌دهندگان خدمات ترویجی در زمینه ارائه مشاوره‌های "مبتنی برنیاز" به مشتریان هدف باشد.