Research Paper

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An approach to the use of technology in the cocoa-growing sector: a look from the producer

Katherin Castro-Ríos[*1], Claudia Nohemy Montoya-Estrada[1], María-Carolina Cuesta[2], Alejandro Gutiérrez Diaz[2]

[1] Instituto De Investigación En Microbiología y Biotecnología Agroindustrial, Universidad Católica de Manizales, Carrera 23 No. 60 - 63. Manizales, Caldas, Colombia
[2] Let Me Know, Carrera 23 # 62-16, Manizales - Caldas - Colombia

*Corresponding author: katherin.castro@protonmail.ch | +5768933050

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A study was conducted to keep a scientific record of the challenges and opportunities from the insertion of a mobile app for cocoa producers in the Colombia region as a prospective tool or strategy for technological transfer and appropriation into that sector. A survey with close-ended and open-ended questions that pertained to cocoa producer men and women was conducted. The questions were related to the general conditions of their labour activities and were discriminant in the following categories: cocoa-grower characteristics, access to technology, and farm characteristics. From this information, a descriptive analysis of cocoa grower characteristics was conducted, along with how the cocoa producer has access to technology on the farm, and what farm features can be an opportunity for mobile application use. Age and the education level of farmers are two threats to the implementation of a mobile app in Colombia that includes the cocoa grower sector; however, smartphones and mobile apps are used by farmers in this sector, even though the quality of service is deficient. An opportunity to include topics about agricultural management into mobile apps to enhance the transfer and appropriation to the crop producers were identified.

Introduction

Importance of the cocoa sector in Colombia (economic and social importance)

Cocoa is grown in countries geographically located on the tropical stripe of the earth. Although it is an America-originated species, most of its production is found in Africa, a continent that has three big producer countries: Ivory Coast, Ghana, and Nigeria; other producing areas along the tropic, include Asia, Oceania, Indonesia, New Guinea and Malaysia, and America, namely Brazil, Ecuador, Colombia and Mexico (Rojas & Sacristán Sánchez, 2013). Amazonia regions of Colombia, Peru, and Ecuador have been considered to be the geographic origin of the species because these are the regions with the most significant cocoa genetic diversity (Thomas et al., 2012).

Currently, cocoa is grown alongside other fruits and primary products around the world in the humid tropics (Osorio-Guarin et al., 2017). In Colombia, during 2013, 65.0% of the total agricultural area planted with potential industrial crops in rural areas belonged to coffee, palm, and sugar cane crops.The areas grown with other species were formed by cocoa at 6.6%, sesame, canola, fistula cane, scourer, fique, fig tree, wicker, bitter palm, iraca palm, and

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soybean. In some regions of Colombia, such as Santander, Nariño, Antioquia, Tolima Arauca and Huila, 124,685 hectares (62.5%) of their planted area was being cultivated with cocoa plantations. In ethnic group territories, 26.5% of their planted area was dedicated to coffee plantations, followed by sugar cane for panela (Jaggery) (21.3%), cocoa plantations (11.1%) and African palm (6.0%)(Departamento Administrativo Nacional de Estadística, 2016).

Cocoa is an economically, socially and environmentally product, highly relevant to Colombia and has become an essential species in the peasant agroforestry system in many regions that provides ecological benefits (Tscharntke et al., 2011). In the 20th century, Colombia ranked ninth in the World Ranking of Cocoa Producers and third in the Americas below Brazil and Ecuador but above Mexico (Ruiz Pacheco, 2014). By 2012, the country had approximately 147,000 cultivated hectares, produced 40,000 tons of cocoa per year, and supported more than 35,000 families (Instituto Colombiano Agropecuario & Ministerio de Agricultura, 2012). By 2013, which corresponds to the last agricultural census, the country had planted 199,549 hectares of this crop (Departamento Administrativo Nacional de Estadística, 2016).

Cocoa cultivation strengthens the country's economy because it requires direct labour at different stages of the cultivation process, such as cultural practices, grafting, and harvesting, calculating management and exploitation of every three hectares of cocoa, creating permanent rural employment opportunities (Rojas & Sacristán Sánchez, 2013). Often, cocoa is described as an "orphan crop" due to the lack of support in research and development (Jaimes Suárez & Aranzazu Hernández, 2010).In many cases, the type of planted clones are unclear, and a solution for the different pathogens is unknown; furthermore, a lot of the controls used in the growing of cocoa are implemented empirically, which causes poor administration that is reflected in the production. In order to try to help these farmers with the control of plagues and diseases, different campaigns and strategies have been created, encouraging application of good agricultural practices (GAP), which nowadays serve as more than an attribute and are a component of competitiveness that allows the rural producer to differentiate its product from other producers. GAP is a tool, especially for small producers, to achieve environmental, economic and social sustainability, thus creating a challenge as well as an opportunity, since their accomplishment depends on the entrance of their agricultural products to markets with high-quality standards overseas or locally (Inciarte, 2004). Another issue is the fact that cocoa exports are focused on select companies, which have no evidence of the social inclusion of primary producers (Ruiz Pacheco, 2014).It is foreseen that cocoa demands will rise by 30% by 2020; however, this demand may not be satisfied if there are no investments in small producers. Thus, a solution is "fair trade," by which decent incomes are ensured for producers, while a long-term supply of high-quality products is ensured for companies (Beg, Ahmad, Jan, & Bashir, 2017).

There are substantial challenges for countries that produce cocoa, that institutions such as the National Federation of Cocoa Growers (Fedecacao) and the Colombian Agricultural Institute (ICA) have been articulated to mitigate the economic impacts of crop diseases and improve the production of dried cocoa beans nationwide (Jaimes Suárez & Aranzazu Hernández, 2010). However, there is a lack of unified efforts to form the cocoa grower guild, despite the aim to achieve an increased benefit for small producers that would guide the sustainability of this crop over time and generate incomes for families that depend on it. For this reason, the main objective of this research is the descriptive analysis of a population of cocoa producers to find an opportunity to implement a mobile application as a tool for farm process improvement.

Information and communication technologies in the agriculture sector worldwide

Information and communication technologies (ICT) have become an essential tool in the agriculture sector worldwide, especially when large land extensions must be monitored. The usage of mobile devices has allowed access to these tools for people who in the countryside so that they can obtain first-hand information in real-time. Thus, mobile devices help mitigate social exclusion and unequal development in rural zones. However, having physical access to these technologies does not guarantee equal access to information among rural people and it has been ignored because equal access depends on the appropriation of each user according to their characteristics and context (García Abad & Barreto Ávila, 2014). In order to gain this appropriation, physical extension of these technologies is not enough; the local, regional and national context as a whole, needs to be considered based on individual user needs and skills (Paz, Montoya, & Asensio, 2013).

Among the most-used ICT in agriculture are geographic information systems (GIS) and remote sensing techniques. The GIS allows for the reuniting of multiple information phases that have been derived from several sources in a unique environment and makes them useful, for example,

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in determining approaches for soil usage, especially when users present different perspectives and preferences about a specific territory. Remote sensing techniques allow for the monitoring of land resources such as vegetation, especially when only one institution is in charge of watching over a large area (Palmer, 2012). However, it is necessary to consider whether these systems can replace completely in situ evaluations; therefore, an equilibrium among tools is required.

To achieve equilibrium between ICT for agriculture and in situ evaluations, it is necessary to: elaborate on the right diagnosis regionally and nationally; to build interdisciplinary teams in addition to professionals to share their information on agriculture (e.g., agro-informatics, agro-robotics, agro-electronics); and to generate a scientific and technologic capacity that will exploit available instruments or create a new tool (CEPAL, 2012). In this way, a technological ambiance can be created that will support the information network, obtain cooperation among countries, and assist in resource assignment and international deployment for the control, management, and exploitation of species with economic importance.

Methodology

The data was collected through a survey conducted directly on voluntary cocoa growers in their farms or the cocoa association Asoprobel, located in Belalcázar (Caldas-Colombia). Each respondent gave their consent, their names and were made aware that their information would remain confidential in the archives of the Universidad Católica de Manizales.

The survey was carried out in two phases. In the first phase, a pre-test was carried out between March 5 and 14 of 2018, the objective of this phase was to make adjustments to the survey before performing it on the selected population. In the second stage the survey was completed and new data were collected on March 22 and April 15 of 2018 and applied to 53 cocoa growers in the towns of Belalcázar, Viterbo, and San José, located in the region of Caldas in Colombia (Figure 1).

The survey was divided into three sections and had 26 questions, 24 close-ended and 2 open-answer questions, allowing participants to provide a more detailed explanation of their choices. In Table 1, a more in-depth description of the survey sections and topics can be seen in accordance to the methodology set by Gray (2017). The survey was applied under the guidance of a professional with technical knowledge and experience in the management of rural communities to answer questions and guide cocoa growers in filling out the survey. All surveys were completed by the participants within 20 and 30 minutes. Respondents received no compensation to answer the survey.

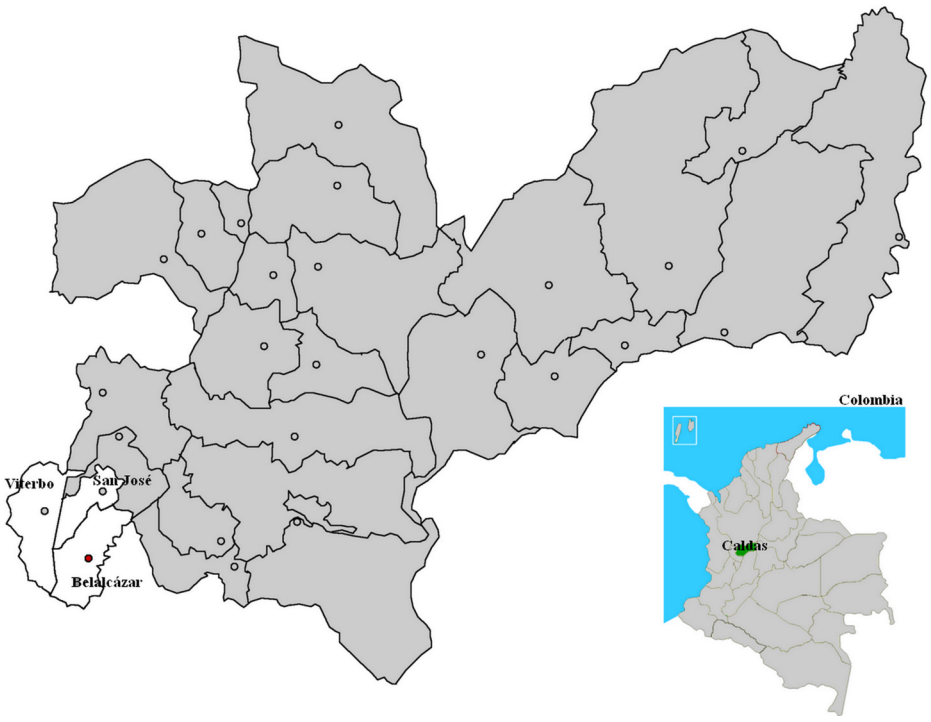

Figure 1: Towns of Belalcázar, Viterbo, and San José (Caldas in Colombia). Adapted from https://commons.wikimedia.org/wiki/File:MunsCaldas_Belalcazar.png

Due to the exploratory nature of the project, a non-probablistic, small population of 430 cocoa association members in 3 towns were selected; a homogenized sample size of 53 respondents according to the geographic distribution was then selected. The analysis of the close-ended questions was conducted with SPSS version 24 software. The open-ended questions had two objectives: to supplement the information of the closed-ended question or to include answers from very wide or unknown ranges to be considered in the answers. Open-ended questions could be quantified and subsequently analysed using statistical package SPSS version 24.

All study participants were adult men and women dedicated to cocoa cultivation, aged between 26 to over 60 years old. Most of the participants were male and only 17% were female. The primary education level achieved among the cocoa growers surveyed is full primary school (33.96%); only two people surveyed were illiterate.

Table 1. Survey sections and topics collected

Sections	Topics
Cocoa grower characteristics	Age, gender, place of residence, and education.
Access to technology	Access and quality of technology.
Farm characteristics	Farm size, economic activity, threats to farm productivity.

Findings

The results are presented in three sections, as described in the methodology. The first is a descriptive analysis of cocoa grower characteristics. The second section is how the cocoa producer has access to technology on the farm. Finally, the third, presents farm features as opportunities for mobile application use.

Cocoa grower characteristics

The majority of those surveyed were from Belalcázar. The next largest group were from Viterbo followed by San José. The cocoa producers were grouped in categories by age. Figure 2 illustrates that 49.06% of producers are over 60 years old, with both men and women producers placed in this age range; although, the number of men is slightly higher at 52.27%. In the range of 26 to 30 years, there are only men, however, among the ranges of 41-50 years and 51-59 years, women predominate.

When the surveyed asked about the level of education, it was found that the education level achieved among the cocoa growers is full primary school at 33.96%, which was slightly higher for men than for women; and less than 10% of cocoa growers have completed professional, technical or technological studies. Only two respondents (a man and a woman), who represent 3.77% of the total participants surveyed, declared they had not had any studies, hence presenting an analphabetic condition (Figure 3).

Access to technology

None of the surveyed participants have a home telephone, which shows the displacement of this service towards the use of mobile phones. However, 98.11% of those surveyed did not have Internet service in their homes. Only 1.9% gave a positive answer about it, which is an essential and impacting factor when implementing a mobile app since the farmers must have mobile data to be able to access the app through their cell phone and further generates a cost overrun for the producers. Another critical aspect of evaluating is the quality of the cell phone signal in the area; 45.3% of those surveyed said that the signal is regular, followed by 32.1% of the surveyed who affirmed having a "good signal", while 11.3% and 9.4% of the total reported having a "bad signal" or a "terrible signal", respectively.

The fact that all producers have electric energy service and Internet access is a relevant aspect when analysing the possibilities of implementing ICT tools among the surveyed population.

Farm characteristics

Most of the producers surveyed own their land (67.92%). It was also determined that the number of people living on

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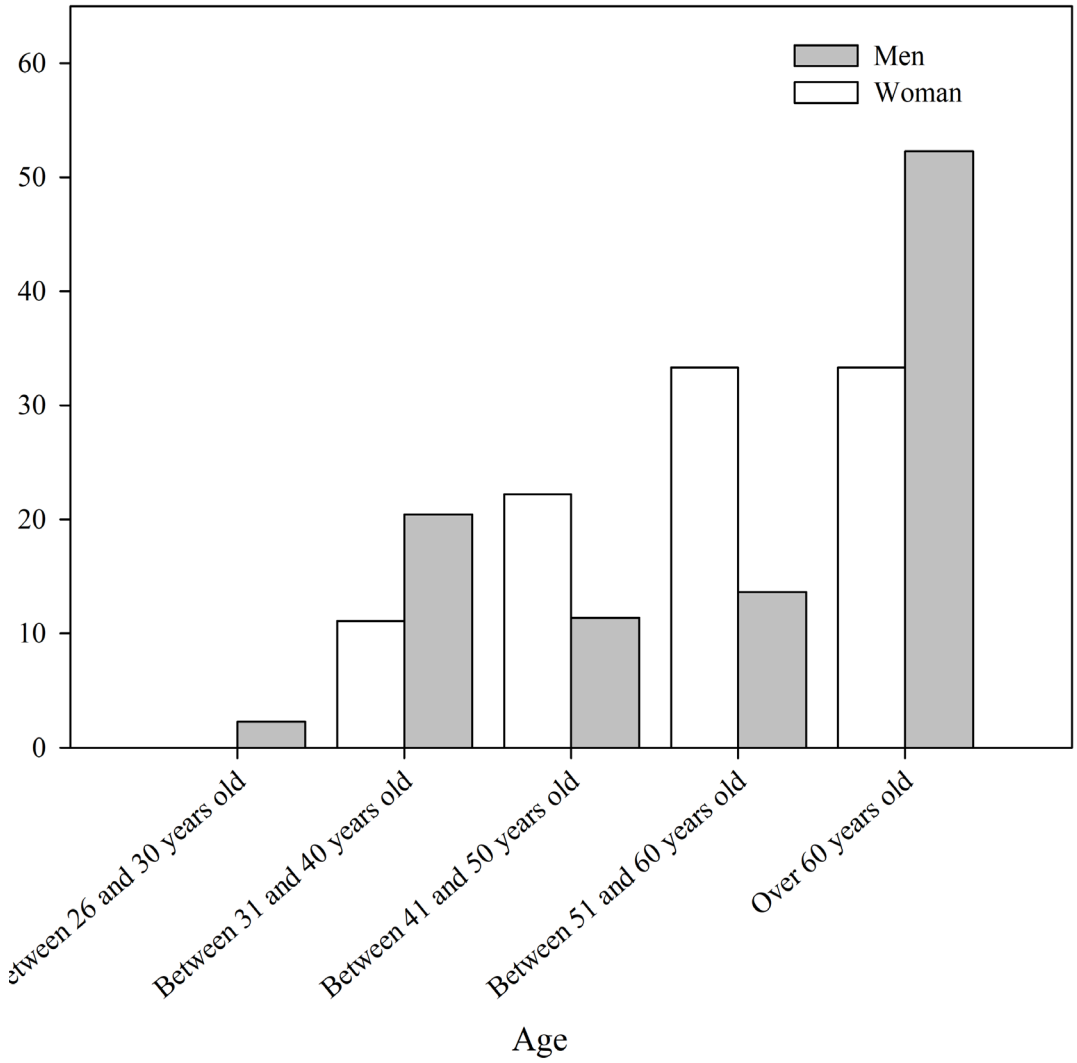

Figure 2: Cocoa farmers surveyed according to gender and age

a farm is 3 to 4 people, which is equivalent to 24.5% of the participants surveyed, followed by 20.8% equivalent to 2 inhabitants per farm (data not shown). Of the producers, 45% established their cocoa cultivation between 5 and 14 years ago and most of them produce less than 500 kg per crop growing season. It was observed that most of the cocoa growers surveyed did not know or were not informed about their cocoa production in the last two years (data not shown). It is necessary for the grower to know this information to determine the financial state of their crop and productivity per year; thus, tracking this information should be a potential feature of the mobile app, as this kind of data gives the growers tools that allow for decision-making in terms of the costs of their crops.

All surveyed participants have at least one agricultural product associated with to an additional source of income; most of the producers also grow bananas (94.34%), avocados (60.38%) and fruits (88.68%), which were related to the conditions of the cultivation area. Also, 79.25% of the producers raised some animal that is useful as an additional source of income or food. These data are essential when designing and implementing a mobile application focused on the management of the agricultural enterprise. The mobile application must include characteristics of these other associated products. For instance, an application for the region of Caldas (Colombia) that is associated with the cultivation of bananas would require additional banana-related information. If the application focuses on issues of good agricultural practices, then

phytosanitary management and fertilization of fields should be considered, as shown in Figure 4.

Two open-ended questions were given to the participants: how many hectares did the farm have? and, how many of them were destined to cocoa cultivation? Overall, 47.17% of the producers have less than 5 hectares, 39.62% between 5 to 10 hectares and 13.21% between 10 to 50 hectares. Additionally, 69.81% use the land mainly for cocoa cultivation.

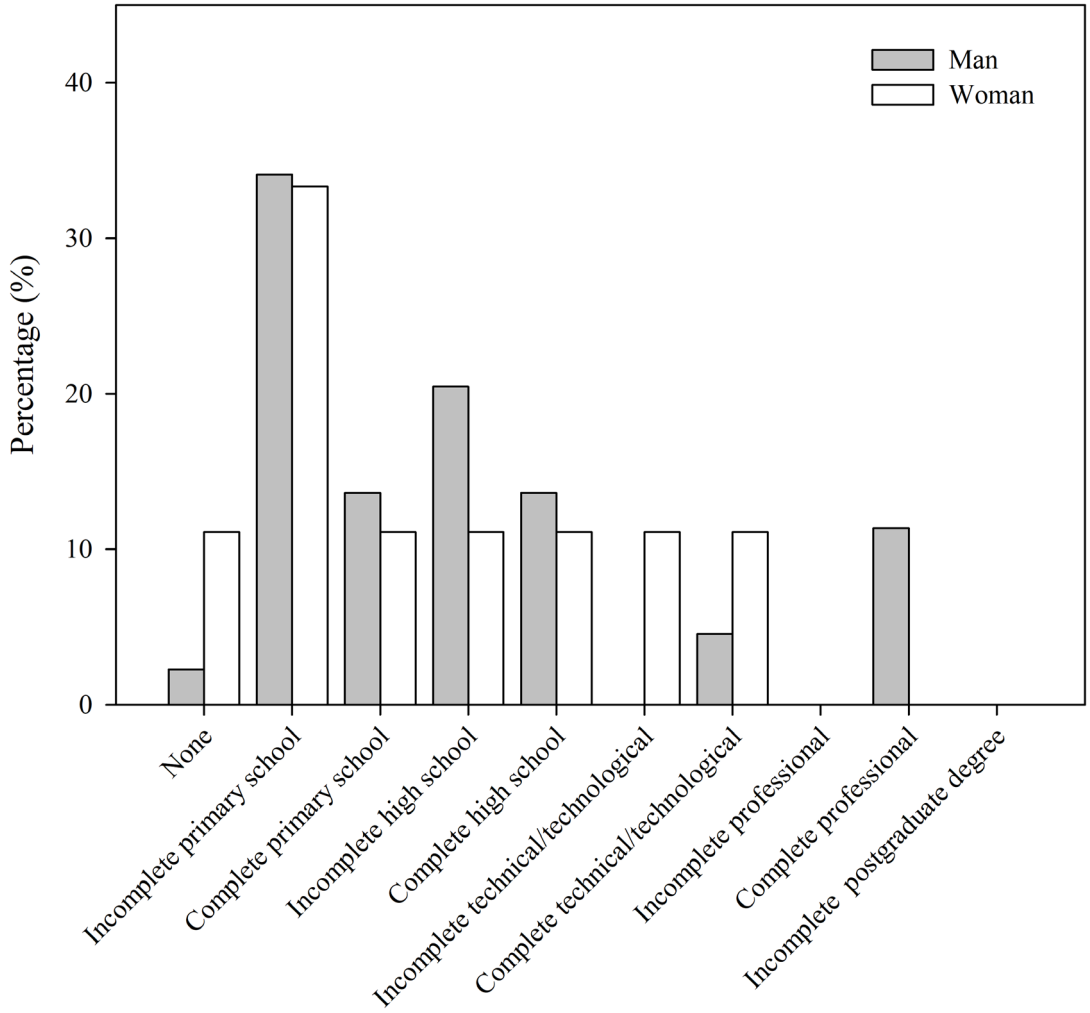

Figure 3: Distribution of cocoa growers surveyed according to education level and gender

Prospects

The results showed that the majority of cocoa farmers surveyed are over 51 years of age, these numbers are not a novelty, since it is known nationally and worldwide that the problem of "ageing in rural areas" is a phenomenon that occurs mainly due to the migration of young people to cities in search of better employment opportunities(Karen, 2017; Pardo, 2017). However, a mobile app would provide an opportunity for young people to stay and encourage better training in rural areas. Regarding this, Food and Agriculture Organization of the United Nations (FAO) reports the following "It is required to focus on integrated training so young people can respond to most modern agricultural sector needs; modern information and communication technologies offers big potential" (FAO/FIDA/CTA, 2014). Mobile apps for the rural area in Colombia can be a tool that motivates new generations to work in the agricultural sector, thus deterring their migration to cities. If mobile apps help to reduce the burden of performing jobs in the countryside and allows the new generation to earn better incomes, they may avoid migrating to cities in search of better labour opportunities.

In Colombia, it was reported that 87.2% of productive agricultural units had received technical assistance in GAP, so there are deficiencies in the transfer of information to the producer, which could be strengthened through another type of technological solution (Departamento Administrativo Nacional de Estadística, 2016). In the development of a mobile app for the countryside, critical points of the chain

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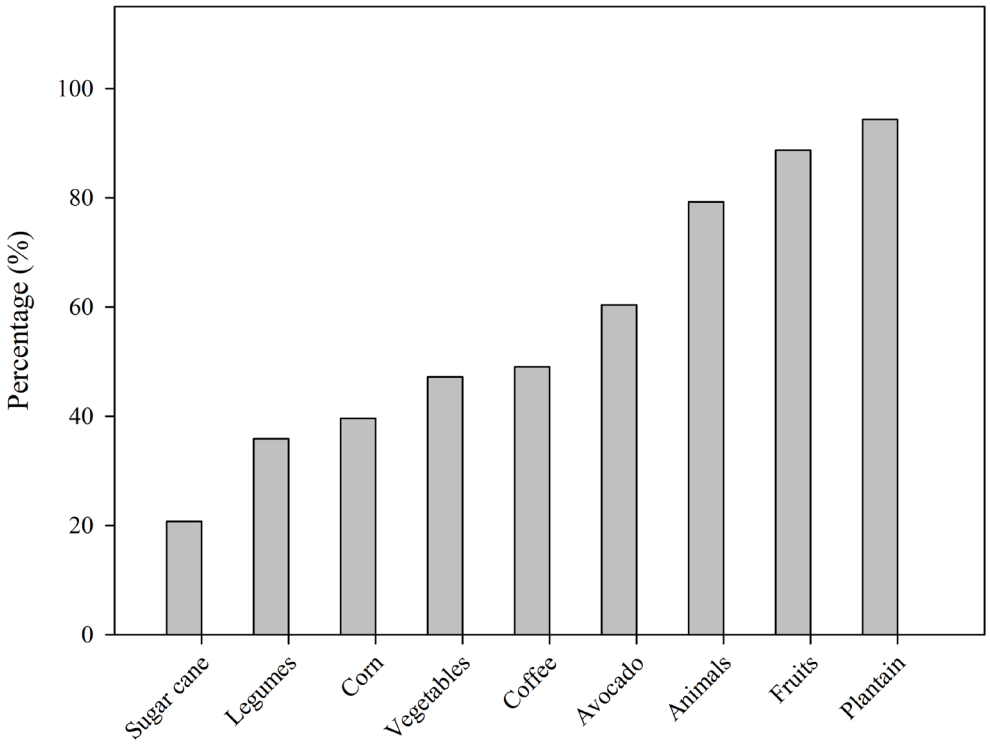

Figure 4: Crops grown or animals raised in association with cocoa production

must be considered, such as the agricultural management of the crops, prevention, and control of plagues and diseases, good farming practices, improvement of production and constant training for growers, weather information, growth information, and monitoring. That allows identification of the state of diseases and plagues before they appear and also integrates other crops associated with the cocoa farm which are an essential part of the agricultural enterprise. All of this would give additional tools to the cocoa farmer to make decisions and act quickly and would provide integral support to the farm activities.

Discussion

The first section of the study was a descriptive analysis of cocoa grower characteristics focusing on age, sex, and educational level. The data shows that most producers are males over 60 years of age and that women are mostly over 51 years of age and predominate in this agricultural activity. The main level of education among respondents corresponds to incomplete elementary school, and with the exception of two people, all know how to read and write. These results bring several future challenges in the design and implementation of a mobile application, because it is known that adult interaction with ICT creates difficulties, usually the higher the age, the higher the ICT access gap is, but it can also help improve quality, promoting independence and inclusion (Ministerio de Tecnologías de la Información y las Comunicaciones, 2018; Navabi, Ghaffari, & Jannat-Alipoor, 2016). Therefore, developers should take into account the impact of age and educational level on the design of an application focused on the Colombian rural sector, incorporating specific characteristics of navigation, applicability, and usability, such as the design of buttons, font and menu size, voice commands, and the integration of visual and sound notifications (Barros, Leitão, & Ribeiro, 2014; Goumopoulos, Papa, & Stavrianos, 2017).

The second section of the study was the assessment of the access to the technology. A significant advantage of the implementation of a mobile app among the cocoa farmers is that all the surveyed participants have cell phone access (whether their own or belonging to a relative who lives with them). Most of the surveyed participants have a Smartphone, which is either their cell phone or belongs to a close relative. Additionally,participants use mobile apps, and at the time of the survey, that included the most mentioned messaging service app "Whatsapp". When impl-

-ementing a mobile app, the type of population, the available and type of technology that is in demand should be considered. The results are essential because it indicates that the people surveyed are familiar with this type of technology and that they manage at least one messaging service, which could be considered when designing an application for the rural sector.In the case of older adults, a messaging service can be a useful app, since it allows them to access new activities, boosts their confidence, and enhances their communication and social interactions (An, Shim, & So, 2014; Goumopoulos et al., 2017). However, as mentioned above, it is necessary to be aware of the design, usability, and learning required for the use of the interface which can include its similarity to other familiar app; thus, the educative restrictions of the rural population must also be considered.

The third phase involves the analysis of the characteristics of the farm, which included the farm size, economic activity, and threats to farm productivity; the results show problems of crop productivity. The low productivity of the rural sector in Colombia significantly affects competitiveness. One of the OECD (2015), recommendations on this issue involves agricultural innovation and the country is making its efforts through sector development and resource injection policies to improve productivity through innovation strategies (Corpoica & MinAgricultura, 2016). A mobile application for the rural sector can be a useful tool for finding new markets, accessing various suppliers, supporting information on agricultural crop activities, geographical information, technical assistance, alert systems for threats of pests or diseases through messaging (Costopoulou, Ntaliani, & Karetsos, 2016; Engotoit, Kituyi, & Moya, 2016). These would help the producer have up-to-date information on the farm, productivity, and financial status in a more straightforward and friendly way and to make decisions with more information. Information technologies also shown to be a novelty option for knowledge transfer of better agricultural practices and cocoa farm technical activities, including different methodologies that can reach different types of farmers in the rural population; however, it is necessary to increase efforts to enhance rural connectivity (CEPAL, 2012).

Conclusions

Age and the education level of farmers are two threats to the implementation of a mobile app in Colombia that includes the cocoa grower sector. Most of the cocoa growers who were surveyed are more than 60 years old, and their highest educational level is completed or incomplete primary school education, which implies the need for specialized developments for this population group, such as techniques that help with the appropriation and use of a mobile app. A simple interface is recommended, one which has similarities to simple apps or that allows them to familiarise themselves easily for a smoother appropriation process.

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References

An, A.-J., Shim, W.-H., & So, H.-J. (2014). Developing a mobile application for elderly people: human-centered design approach. Paper presented at the Proceedings of HCI Korea, Seoul, Republic of Korea.

Barros, A. C. d., Leitão, R., & Ribeiro, J. (2014). Design and Evaluation of a Mobile User Interface for Older Adults: Navigation, Interaction and Visual Design Recommendations. Procedia Computer Science, 27, 369-378. doi: 10.1016/j.procs.2014.02.041

Beg, M. S., Ahmad, S., Jan, K., & Bashir, K. (2017). Status, supply chain and processing of cocoa - A review. Trends in Food Science & Technology, 66, 108-116. doi: 10.1016/j.tifs.2017.06.007

CEPAL. (2012). TIC y agricultura. Newsletter eLAC, 18(Marzo), 12. http://www.cepal.org/socinfo/noticias/paginas/3/44733/newsletter18.pdf

Corpoica, & MinAgricultura. (2016). Plan estratégico de ciencia, tecnología e innovación del sector agropecuario Colombiano (2017-2027). Bogotá (Colombia): Corpoica & MinAgricultura.

Costopoulou, C., Ntaliani, M., & Karetsos, S. (2016). Studying Mobile Apps for Agriculture. IOSR Journal of Mobile Computing & Application, 3(6), 44-99.

Departamento Administrativo Nacional de Estadística. (2016). Tercer Censo Nacional Agropecuario. Tomo 2. Resultados. Bogotá (Colombia): DANE Retrieved from http://www.dane.gov.co/files/images/foros/foro-de-entrega-de-resultados-y-cierre-3-censo-nacional-agropecuario/CNATomo2-Resultados.pdf.

Engotoit, B., Kituyi, G., & Moya, M. (2016). Influence of performance expectancy on commercial farmers' intention to use mobile-based communication technologies for agricultural market information dissemination in Uganda. Journal of Systems and Information Technology, 18(4), 346-363.

FAO/FIDA/CTA. (2014). Los Jóvenes y la Agricultura: Desafíos clave y soluciones concretas. Roma (Italia): Organización de las Naciones Unidas para la Alimentación

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y la Agricultura (FAO), el Fondo Internacional de Desarrollo Agrícola (FIDA) y el Centro Técnico para la Cooperación Agrícola y Rural (CTA).

García Abad, A., & Barreto Ávila, M. (2014). El uso, apropiación e impacto de las TIC por las mujeres rurales jóvenes en el Perú. Revista de estudios para el desarrollo social de la comunicación, (9), 251-269.

Goumopoulos, C., Papa, I., & Stavrianos, A. (2017). Development and Evaluation of a Mobile Application Suite for Enhancing the Social Inclusion and Well-Being of Seniors. Informatics, 4(3), 15.

Gray, A. (2017). Dueling the consumer-activist dualism: The consumption experiences of modern food activists. Future of Food: Journal on Food, Agriculture and Society, 5(3), 35-45.

Inciarte, R. (2004). Las Buenas Prácticas Agrícolas. Roma (Italia): Organización de las Naciones Unidas para la Alimentación y la Agricultura (FAO).

Instituto Colombiano Agropecuario, & Ministerio de Agricultura. (2012). Manejo fitosanitario del cultivo del cacao (Theobroma cacao L.): Medidas para la temporada invernal. Bogotá (Colombia): ICA Retrieved from http://www.ica.gov.co/getattachment/c01fa43b-cf48-497a-aa7f-51e6da3f7e96/-.

Jaimes Suárez, Y., & Aranzazu Hernández, F. (2010). Manejo de las enfermedades del cacao (Theobroma cacao L) en Colombia, con énfasis en monilia (Moniliophthora roreri) Colombia: Corpoica/Ministerio de Agricultura y Desarrollo Rural/Fedecacao Retrieved from http://www.fedecacao.com.co/site/images/recourses/pub_doctecnicos/fedecacao-pub-doc_04A.pdf.

Karen, G. (2017). Jóvenes agricultores: relevo generacional en la agricultura y la permanencia en el campo (pp. 34). Lima (Perú): Movimiento Regional Por la Tierra y Territorio.

Ministerio de Tecnologías de la Información y las Comunicaciones. (2018). Encuesta de acceso, uso y apropiación de las TIC por parte de las mujeres en Colombia. Bogotá (Colombia): MinTIC.

Navabi, N., Ghaffari, F., & Jannat-Alipoor, Z. (2016). Older adults' attitudes and barriers toward the use of mobile phones. Clinical interventions in aging, 11, 1371-1378. doi: 10.2147/CIA.S112893

Organisation for Economic Co-operation and Development (OECD). (2015). OECD Review of Agricultural Policies: Colombia 2015. Retrieved July 2016, from http://www.oecd.org/countries/colombia/oecd-review-of-agricultural-policies-colombia-2015-9789264227644-en.htm

Osorio-Guarin, J. A., Berdugo-Cely, J., Coronado, R. A., Zapata, Y. P., Quintero, C., Gallego-Sanchez, G., & Yockteng, R. (2017). Colombia a Source of Cacao Genetic Diversity As Revealed by the Population Structure Analysis of Germplasm Bank of Theobroma cacao L. Front Plant Sci, 8(Nov 21), 1994. doi: 10.3389/fpls.2017.01994

Palmer, N. (2012). Las TIC y la agricultura en el contexto del "Crecimiento verde". In CIAT (Ed.), Las TIC en la Agricultura (Vol. 2, pp. 9). e-agriculture: CIAT.

Pardo, R. (2017). Diagnóstico de la juventud rural en Colombia. Grupos de Diálogo Rural, una estrategia de incidencia Serie documento Nº227 (pp. 49). Santiago (Chile): Centro Latinoamericano para el Desarrollo Rural (RIMISP).

Paz, Á., Montoya, M. P., & Asensio, R. H. (2013). Escalando Innovaciones Rurales. Lima (Perú): IEP/IDRC-CRDI/FIDA.

Rojas, F., & Sacristán Sánchez, E. J. (2013). Guía ambiental para el cultivo del cacao. Bogotá (Colombia): Federación Nacional de Cacaoteros, Fondo Nacional del cacao.

Ruiz Pacheco, J. A. (2014). Cacao y su aporte al desarrollo colombiano. Especialización Gerencia Comercio Internacional Bogotá (Colombia).

Thomas, E., van Zonneveld, M., Loo, J., Hodgkin, T., Galluzzi, G., & van Etten, J. (2012). Present Spatial Diversity Patterns of Theobroma cacao L. in the Neotropics Reflect Genetic Differentiation in Pleistocene Refugia Followed by Human-Influenced Dispersal. PLoS One, 7(10), e47676. doi: 10.1371/journal.pone.0047676

Tscharntke, T., Clough, Y., Bhagwat, S. A., Buchori, D., Faust, H., Hertel, D., . . . Wanger, T. C. (2011). Multifunctional shade-tree management in tropical agroforestry landscapes - a review. Journal of Applied Ecology, 48(3), 619-629. doi: 10.1111/j.1365-2664.2010.01939.x