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Original scientific paper

INVESTIGATING THE IMPACT OF ECONOMIC, POLITICAL, AND SOCIAL FACTORS ON AUGMENTED REALITY TECHNOLOGY ACCEPTANCE IN AGRICULTURE (LIVESTOCK FARMING) SECTOR IN DEVELOPING COUNTRIES

Marzieh Ronaghi[1], Mohammad Hossein Ronaghi[2*], Mohammad Ghorbani[1]

[1,3]Agriculture Faculty, Department of Agricultural Economics, Ferdowsi University, Mashhad, Iran (Marzieh.Ronaghiuk@gmail.com).
[2]Agriculture Faculty, Department of Management, University of Shiraz, Iran
[*]Corresponding author e-mail: mh_ronaghi@shirazu.ac.ir

ABSTRACT

The discussion of the factors affecting the tendency to accept new technologies in developing countries is very important. Lack of use of modern technologies in developing countries, especially in the agricultural (livestock farming) sector, leads to negative effects on the quality and quantity of products and the country loses its ability to compete in the international arena. The main purpose of this study is to investigate the factors affecting on Augmented Reality technology acceptance in the agricultural (livestock) sector of Iran. In this research, the dependent variable is a qualitative variable that is classified into five levels based on the theory of experts using the SWARA method. The dependent variable indicates the ability (awareness) and capability (financially) of a person to accept AR technology. We used the Multinomial Logit model due to the dependent variable is nominal and has more than two categories. The results showed that, the variables of public participation, and education have a significant effect on the willingness to adopt Augmented Reality technology at all levels among farmers. But variable costs and the number of family labor do not have a significant effect on the willingness to accept Augmented Reality technology. The policy recommendations of this research are that councils can play an important role in raising the level of public participation and conveying the demands of the people to the government. To do this, they must receive the necessary training in order to attract public participation. This is possible through training workshops to increase the level of farmers' awareness.

Key words: Augmented Reality, Multinomial Logit model, public participation.

INTRODUCTION

Looking back and examining the development of agriculture (livestock farming) in developed countries, it is important to note that when developed countries wanted to improve industry and agriculture, they gave priority to agriculture. Developing countries have generally abandoned the issue of agriculture (livestock), and farmers and ranchers still lag behind information technology (IT). Today, most agricultural work is done using modern machinery on a large scale. Due to the dense farming methods in mechanized agriculture, farmers lack practical experience to understand the condition of the farm.

Technology in the production process can prevent losses, increase productivity, variety and value of goods. Modern measurement methods and the application of new technologies have been proposed to assist precision agriculture in data collection, and with proper analysis, all growth stages can be controlled during the season. IT can optimize various inputs such as water, pests, fertilizers, and seeds. New technology can be used for proper and advanced education and promotion in agriculture and animal husbandry. One of the new technologies in this field is Augmented Reality (AR), which adds a live, direct or indirect physical view around the real world of people (and usually interacts with the user) (Huuskonen et al, 2018).

Robotics and AR[1] are closely related, and both are used to model the environment. Robotics uses models to guide devices, while AR uses them to give humans an augmented sensorial experience (Gorecky et al,2014). The exact nature of this augmented experience is limited to factors such as existing sensors, computing and display hardware (audio, touch), and how useful data is converted into overlays that enhance the human user's natural perception (Kehoe et al, 2015). What is useful is a function of the content of the overlays and latency - the amount of latency introduced by the computing hardware. Compared to slow computing hardware, faster computing hardware can produce more accurate overlays with similar latency, or similar overlays with lower latency (Makhataeva et al, 2020).

Examples of AR overlays that help farmers include: thermal imaging, soil moisture determination, soil water absorption capacity, soil surface pores, vertical surface fluctuations, runoff, and expected erosion rates for rainfall types, identification of all plants related to a particular species, identification of all plants that are deficient in nutrients or suffer from other damage, identification of bare soils (soils that do not have manure or vegetation), presence, effects, and the activity of various animal species, and many other uses.

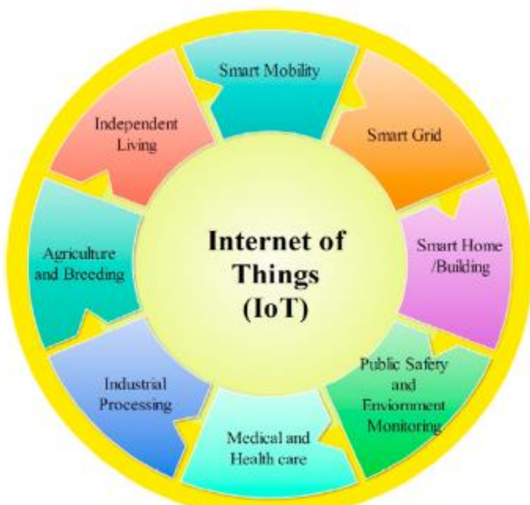

Figure 1. Various usages of IoT

AR is in its infancy and there is a lot of room for its improvement. AR technology provides a great option for enriching perceptual and interactive demands (Phupattanasilp et al, 2019). AR complements reality, which cannot be easily visualized in an object tag by placing virtual (computer-generated) objects, such as graphics, text, and sound, in the user's real-world environment. However, in AR, crop positioning is facilitated by internet of things (IoT) and content devices and can benefit from the visualization and interpretation of data that a farmer can

1- Augmented Reality

interact with the target crop and read daily records through virtual content (Various usages of IoT is shown in figure 1) (Daponte et al, 2014). With the aim of using AR technologies to support IoT data visualization, the present study proposes the factors affecting modern technology acceptance in a new framework that integrates the IoT into an AR-based environment, i.e. AR-IoT. The IoT section is based on a multi-camera identification approach. It must be able to accurately identify coordinates, while IoT data can be placed on a physical product or space in real time and the virtual contents can be simulated with AR (virtual cube or virtual infographic). Accordingly, it is designed in such a way that a farmer or rancher can visualize the production process from different angles, thus solving vision problems. The farmer can also communicate directly from the real world environment with IoT data. Thus, AR-IoT enhances regulatory tasks and helps farmers and ranchers to ensure product quality more accurately and reduce costs (Lee at al, 2018).

In addition, recent studies have highlighted how the implementation of precision technologies in cattle breeding farms improves animal welfare and management (Fournel et al 2017; Caria et al, 2019; Halachmi et al, 2019), farm profits, and environmental sustainability (Caria et al, 2013). Similarly, Todd et al,(2017) addressed the issue of investing in farm technology and found a positive relationship between increased investment in technology and increased farm productivity. Figure (2) shows a new technology acceptance phase. AR technology can also help ranchers to manage livestock accurately. These technologies can easily provide people with useful information about identification, health status, productivity, diet, and so on (Wathes et al,2008).

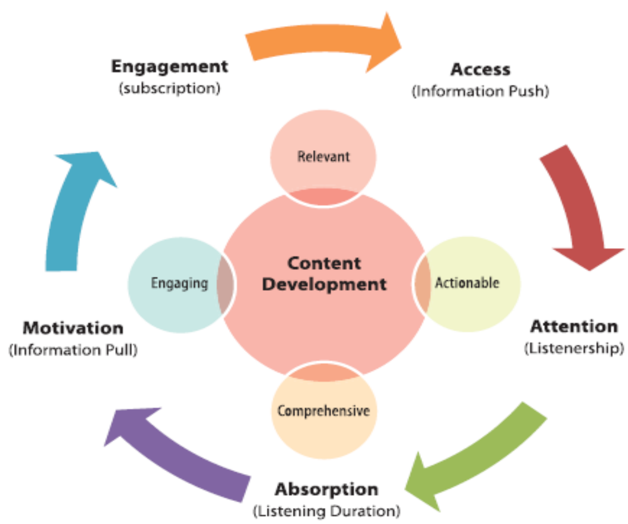

Figure 2. Stages of acceptance of modern technology

The issue of establishing and using modern technology has been on the government's agenda in Iran for several years, and without a doubt, the agricultural sector (livestock farming) is no exception to this rule. Unfortunately, the activities carried out in this regard have not been seriously supported by public and private sector managers due to the prevailing traditional views and sometimes, the illiteracy of the employees in this sector.

This perception of the agricultural sector society is equivalent to a kind of retreat and ignoring the demands of many enthusiasts and educated employees of the agricultural sector (livestock farming), who are looking for innovation and using new methods to better produce and sell their products.

A point that is often forgotten is the change of generation working in the agricultural sector and replacement of the traditional generation by the young and often educated one that seeks the use of new technologies. Therefore, they should be provided with appropriate services so that they are encouraged in the right way.

Perhaps the root of this problem can be traced to the weakness of proper agricultural (animal husbandry) governance in Iran. Agricultural (livestock farming) governance can be defined as a set of individuals and institutions, public and private, which have joint management. In good governance, the needs and perspectives of different institutions on a particular issue should be integrated as a strong participatory element. Good agricultural governance also involves the interaction of various institutions and stakeholders at the vertical level, from the national to the local level, as well as at the horizontal level, including environmental, agricultural, water, financial and transportation organizations. Good governance is based on the principles of participation, transparency of decisions, accountability, equality, predictability, democratic activities, civil liberties, and access to information (Janssen, and Van der Voort,. 2016). Governance is like a process that tries to specify the purposes and goals of the society and horizontally find mechanisms to achieve those goals in the best way (Applebaugh, 2010).

Since good governance can play an important role in the introduction of advanced technologies, this study emphasizes the role of governance in the introduction and acceptance of technology.

The authors believe that any achievement and innovation that can pursue the welfare and comfort of the agricultural community is certainly commendable and supportable, and everyone acknowledges that problems such as climate change affect the production and sale of products and goods in the agricultural and livestock farming sector, which is one of the old problems in the agricultural sector of Iran (Liao et al, 2017). There have been many cases that seeds grown on a farm have been destroyed in some parts of the country due to a lack of accurate information on climate change, soil science and improper irrigation.

With a little reflection, it can be clearly seen to what extent the use of modern technology in the agricultural (livestock farming) sector of Iran can have positive effects on the production, supply and sale of goods, significantly reduce costs, and eliminate unnecessary intermediaries.

Now the question arises that what factors affect the adoption of AR technology in the agricultural (livestock farming) sector of Iran? What are the factors influencing AR acceptance?

Literature review

The history of AR dates back to the invention of VR in the 1960s, the concept of "final display", which stands for simulation of an artificial environment similar to real reality that was introduced by (Sutherland, 1956). There are three components to this concept: 1) Head-Mounted Display (HMD) with audio and touch feedback to create a real-virtual environment, 2) user interaction with virtual objects, and 3) computer hardware to create a virtual environment.

At MIT's Lincoln Lab, the author conducted several experiments with the first augmented HMDs/virtual reality, one of which was called the "Sword of Damocles." This invention was characterized by its large size. Instead of a camera, a computer was used. Therefore, the overall system was attached to the ceiling. The term VR was first coined by Jaron Lanier, who founded the first company in 1984 to produce VR products (MacKenzie, 1995).

Throughout the history of AR, one of the main issues was the correct identification of the user's position in the 3D environment, which is necessary to increase the user's visibility on the AR device. Various methods have been proposed to solve this problem in robotics, such as simultaneous localization and mapping (SLAM), which are described in Durrant-Whyte and Bailey (Durrant-Whyte et al, 2006). With the help of SLAM, a moving robot creates a map in an unknown environment and at the same time determines its position within the generated map.

Tati´c et al (2017), introduced an AR system for occupational safety. Instructions and checklists are displayed as virtual objects on the screen that show a list of tasks and instructions of each worker based on their competencies and responsibilities. In addition, structural analysis of the AR system (integration with the AR system) is provided by (Huang et al, 2015). The measurement visualization uses a three-dimensional mesh model and clear images that changes their color according to the stress weight. Velázquez et al (2018), has done a learning unit, "Energy and its transformation," in which students can analyze or receive wind turbines with small turns or small movements.

ElSayed et al (2016), suggested the use of AR to allow consumers to visually interact with information. Moreover, consumers are able to compare information related to multiple physical objects.

Alam et al, (2017) used AR and VR as a comprehensive analytical tool for maintenance works. Using this proposed system, the user can monitor and decide what to do based on the safety information displayed. This method ensures the safety of workers, because they can make decisions quickly with more information. Similarly, a driver assistance system has been explored to increase road safety for vehicles (Gomes et al, 2012).

Lima et al, (2017), introduced a system that allows users to track the vehicle and identify its parts using markerless techniques. Bauer et al, (2017), used a markerless vision-based camera to illustrate anatomy. For some AR and IoT applications, the unique use of a vision-based tracking method may not provide a robust tracking solution due to differences in viewing angle observations (Daponte et al, 2014).

AR is an approach that provides comprehensive visualization of objects and visualization of supporting data. Few studies have integrated lOT agricultural data visualization with AR solutions to allow a farm manager to achieve such information in a realistic and interactive way. Hence, our study considers progress towards this goal. Multi-camera is one of the useful factors used for erent-angled visualization, identifying the coordinates of physical objects, and mounting virtual objects on the coordinates of physical products. A simple visual object is used to display physical products, while its interaction with the environment allows farmers to identify and explore to gather more information.

Janson et al(2018), examined the acceptance of AR mobile applications at the retail level. Their research result shows that price performance has the highest usage and information performance the lowest, and yet consumers are convinced to use AR technology.

As shown in various studies, most studies have examined the type of technology and the specific effects of that technology, and few studies have examined the factors affecting the acceptance of technology in the agricultural (animal husbandry) sector of Iran. Therefore, in the present study, factors affecting the acceptance of AR technology in various economic, social and political fields in the agricultural (animal husbandry) sector of Iran are investigated.

MATERIALS AND METHODS

Meta synthesis model

Since there are many studies on AR technology using qualitative and quantitative methods, meta-synthesis is a good way to find complete information on the factors influencing AR technology acceptance. In this method, the researcher conducts a complete study and analyzes the findings of relevant studies (Dekker and Bekkers,. 2015). This means that instead of providing a comprehensive summary, this method creates an interpretive synthesis of findings. Figure (3) describes stages of meta-synthesis method.

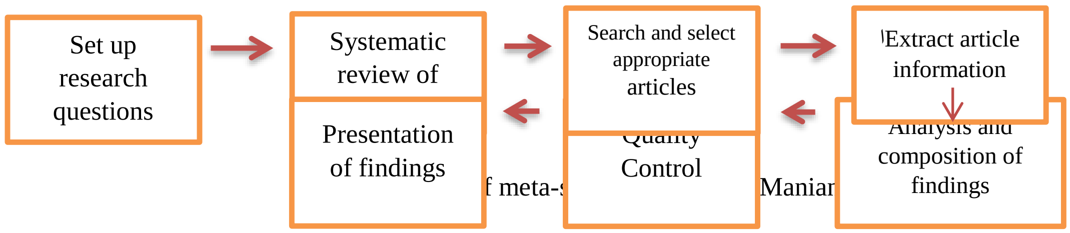

Figure 3. Stages of meta-synthesis method

Table 1. Coding of research studies

research studies
1- Technology Acceptance of Augmented Reality and Wearable Technologies, Wild et al, (2017)
2- Consumer Acceptance of Mobile Augmented Reality Shopping Applications in Stationary Retail Trade, Janssen (2018)
3. Understanding the Agriculture Income Pathway, USAID Feed the Future Improving Nutrition through Agriculture, Technical Brief Series, Brief 3, (2014)
4. Socio-economic impact of mobile phones on Indian agriculture, S, Mittal, S Gandhi, G Tripathi, Indian Council for Research on International Economic Relations, (2010)
5. Review of Agricultural Extension in India, CJ Glendenning, S Babu, K Asenso-Okyere, IFRI, (2010)
6. Naomi J. Halewood and Priya Surya, Mobilizing the Agricultural Value Chain, ICT4D (2012)
7. Using ICT to reduce transaction costs in agriculture through better communication: A case-study from Sri Lanka, Harsha de Silva and Dimuthu Ratnadiwakara, (2009)
8. Small holders and Micro-enterprises in Agriculture: Information needs and communication patterns, Sriganesh Lokanathan, Nilusha Kapugama, LIRNEasia, (2012)
9. Micronutrients, Agriculture and Nutrition: Linkages for Improved Health and Well Being, Ross M. Welch, USDA-ARS, U.S. Plant, Soil and Nutrition Laboratory
11-Global Director-Mobile, CAB International, Banerjee, (2017)
12- The Food and Agriculture Organization of the United Nations, (2017)
13-Muralimohan, K, (2016)
14- Lauro, Atienza, IT Specialist for the Rice Knowledge Bank and Rice Doctor, IRRI, Los Baños, Philippines, (2017)
15-Augmented Reality in the Integrative Internet of Things (AR-IoT): Application for Precision Farming, Phupattanasilp et al, (2019)
16-Performance and Usability of Smart glasses for Augmented Reality in Precision Livestock Farming Operations, Caria et al, (2020)
17-Intelligent Infrastructure for Smart Agriculture: An Integrated Food, Energy and Water System, Shekhar et al, (2017)
18-Beckmann et al (2015)
19- An empirical analysis of the relationship between environmental performance and sustainable e-governance in China. Technological Forecasting & Social Change,,Yu (2015)
20- Public participation in environmental governance in the Philippines:The challenge of consolidation in engaging the state, Gera (2016)
21- Hornidge et al (2015)

22- Roles of citizens in environmental governance in the Information Age four theoretical perspectives, Soma et al (2016)
23- ENVIRONMENTAL GOVERNANCE, Lemos and Agrawal (2006)
24- Vulnerability of Inuit food systems to food insecurity as a consequence of climate change, Ford (2009)
25- Evaluation of the Performance Characteristics of the Lightning Imaging Sensor, Bitzer et al (2016)
26- emporal network analysis identifies early physiological ,Gehan et al (2014)
27- Climate Change ,Dryzek et al (2011)
28- Structure and transport mechanism of the sodium, Paulino (2014)
29- Earth system governance,Biermann (2007)
30- Knowledge Systems for Sustainable Development, Cash et al (2003)
31- evironmental and Gender Impacts of Land Tenure Regularization in Africa,Deininger et al (2011)

Table 2. Maturity levels

Level	Characteristics	Degree of maturity
y=1	Fully aware of AR technology and financial ability	0 < M<20
y=2	Fully aware of AR technology and Financial inability	20 < M<40
y=3	Unaware of AR technology and financial inability	40 < M<60
y=4	Unaware of AR technology and financial ability	60 < M<80
y=5	Incomplete information about AR technology and financial inability	80 < M<100

Source: Research Findings

Based on the studies as summarized in Table (1), the variables are considered as factors affecting the acceptance of AR technology in the agricultural (livestock farming) sector.
The research method is descriptive-analytical. Based on this, the required information and data are collected using documentary, library and field studies (completion of questionnaires by ranchers) and STATA software is used to analyze the econometric model.

Independent variables affecting the tendency to use AR technology include off-farm income, education, age, number of livestock, number of family workers per unit in terms of day-person, and income from unit. The variables of age, education and off-farm income were divided into three intervals, zero to three, based on the questionnaire data. For example, off-farm income was considered between 2-4 million Tomans (one), between 4-6 million Tomans (two), 6 million Tomans and above (three). Also, the age variable is considered as under 30 years (one), from 30-50 years (two), from 50-70 (three), and similarly, the education variable was people under diploma (one), diploma-bachelor (two), and bachelor-master (three). But the variables of number of livestock, income from unit, and family workers were determined based on their number and amount as provided in the questionnaire.

According to the definition of good governance, governance is based on the principles of cooperation and transparency of decisions with democratic methods, civil liberties and easy access to information. Group participation establishes a link between the people and the government so that the demands of the people can be easily conveyed to the government. These factors are important in agricultural governance (Soma et al., 2016). Group participation relies on an accountability approach in which ordinary farmers or cooperatives demand accountability. The role of group participation is not to replace but to complement and enhance the public accountability mechanism (Bitzar et al., 2016). Since the participation of farmers (ranchers) is one of the most important factors of agricultural governance, the variable of farmers' participation has entered the model as one of the independent variables of the study in three ranges of non-participation, participation in special cases, and participation in all matters.

Multinomial logit model

The model parameters were estimated after collecting information through a questionnaire, using a regression model, with Stata software. In the regression model, independent variables might be quantitative, qualitative, or a combination of the two. Also, The dependent variable might be quantitative or qualitative. In this study, the dependent variable is a qualitative variable that is classified into five levels based on the theory of experts using the SWARA method.

If the dependent variable is y = 1, it indicates that a person is fully aware of AR technology and has the financial ability to provide it.

If the dependent variable is y = 2, a person is fully aware of technology AR but has no financial ability to provide it.

In the dependent variable y = 3, a person is unaware of AR technology and has no financial ability.

y = 4 a person is unaware of AR technology and has financial ability.

y = 5 a person has incomplete information about AR technology and has no financial ability.

In this research, the Multinomial Logit model has been used. The Multinomial Logit model is used when the dependent variable is nominal and has more than two categories. As mentioned, the dependent variable in this study takes 5 modes and since the order of the options is not particularly important, Multinomial Logit regression was used instead of ordered logit model. Parallel regression test was used to ensure the use of Multinomial Logit model. Parallel regressions evaluate the rationale of the parameter equality hypothesis for all groups. The results of the test are presented in Table (3), indicating the irrationality of parameter equality hypothesis for all groups in the estimated model. Considering the significance level of X^2 statistic of parallel regression test, it can be assumed that the value of the parameter changes from one group to another and the general pattern is accepted. Therefore, the Multinomial Logit model has solid foundations.

Table 3. Results of parallel regression test

Model	-2log likelihood	Chi-square	Sig.
Null hypothesis	1134.924		
General	1044.623	72.435	0.000

Source: Research Findings

The structure of the Multinomial Logit model is as follows:

$$\text{Pr} = (\text{y} = \text{m}\boldsymbol{I}\boldsymbol{x}) = \boldsymbol{X'\beta_m} \quad \textbf{(1)}$$

$$\beta_m = (\beta_{0m}, \beta_{1m}, \dots, \beta_{km})$$

It shows the effect on the outcome m. Equation (2) is used to construct the probability model for multinomial logit. (2)

$$pr(Y_i = m\boldsymbol{I}\ \boldsymbol{x}) = \frac{\boldsymbol{exp(x_i\beta_m)}}{\sum_{\boldsymbol{j=1}}^{\boldsymbol{j}} \boldsymbol{exp(\ x_j\beta_i)}}$$

Equation (2) states that the probability that the dependent variable y takes a value such as m, (provided that the independent variables x are vectors), is equal to the Likelihood function of the independent variables multiplied by the parameters divided by their sum.

Since logit models are discrete models, the logarithm of the likelihood function is used for their estimation, which is shown in Equation (3).

$$\ln L((\boldsymbol{\beta_2}, \dots, \boldsymbol{\beta_j})\boldsymbol{y}, \boldsymbol{x}) = \sum_{\boldsymbol{m=1}} \sum_{\boldsymbol{y=m}} \frac{\boldsymbol{exp(x_i\beta_m)}}{\sum_{\boldsymbol{j=1}}^{j} \boldsymbol{exp(x_j\beta_m)}} \quad \textbf{(4)}$$

To evaluate the effects of change in each of the independent variables on the probability of knowledge and application of technology by individuals, we take a partial derivative from Equation (2) to the variable under study as follows. (5)

$$\frac{\partial pr(y = m\boldsymbol{I}\ \boldsymbol{x_i})}{\partial x_k} = pr(y = m\boldsymbol{I}\ \boldsymbol{x})\left[\boldsymbol{\beta_{km}} - \sum_{\boldsymbol{j=1}}^{\boldsymbol{j}} \boldsymbol{\beta_{kj}}\ \boldsymbol{pr(y = jIx)}\right]$$

Thus, it is possible to calculate the partial derivatives that indicate the degree of effectiveness of each of the variables.

3-3- Individual, social and economic characteristics of the studied sample:

Due to the importance of individual, social and economic characteristics of the studied sample members, individual and social characteristics of the studied sample such as age, level of education, number of family workers, economic characteristics such as number of livestock, livestock and non-livestock income, personal capital used in the unit, and variable costs, and political characteristics such as the level of public participation in the demand for AR technology have been examined in this section. The required data to gain a knowledge of the willingness of farmers to accept AR technology was obtained through questionnaires and interviews with farmers as shown in Table (4).

Table 4. Individual, social and economic characteristics of farmers

Variables	unit	Standard deviation	Minimum	Maximum
Age	Year	10.04	23	83
Education	Grade	1.01	0	3
public participation	-	0.80	0	3
Number of livestock	the unit	3.69	2	40
Number of family labor	Day-person	1.62	1	15
Variable costs per period (100 days)	Million Tomans	3.5	2.16	86.5
Off-farm income	Million Tomans	2.6	0	15
Personal capital	Million Tomans	4.2	3	25.1

Source: Research Findings

As shown in Table (4), the mean age of farmers is 50 years, which indicates that farmers are old on average, their maximum age is 83 years, and minimum age is 23 years. Regarding the level of literacy of farmers, most farmers had a primary school degree. According to interviews with farmers, very few had a university degree, who also considered farming as a second job.

According to this table, the number of livestock was at least 2 and at most 40 livestock.

The average number of family workers per farmer is 2, the minimum of which is 1 and the maximum is 15. The cost of variable inputs in each period was at least 2.16 million Tomans and the maximum was 86.5 million Tomans per hectare. The reason for high costs is due to the increase in the number of livestock and the larger level of animal husbandry.

Also, a small number of ranchers are active outside the farm in the questionnaires. The ranchers under study earn a maximum of about 15 million Tomans per month of income outside the farm.

Ranchers of the have a minimum personal capital of at least 3 and a maximum of 25 million Tomans.

RESULTS

The results of estimating the Multinomial Logit model are shown in Table (5). It is noteworthy that one level is considered as the base class in the Multinomial Logit model. In this research, the third level (a person is unaware of AG technology and does not has the financial ability to provide it) is considered as the base or reference level.

Table 5. Results from the multinomial logit model

	variables	Coefficient	standard error	Z Statistics
Y=1	L	0.12	0.07	1.73
	C	-4.34	1.30	-0.33
	NF	-0.26	0.21	-1.21
	P	0.025	0.011	2.28
	Yf	3.78	5.24	0.72
	I	7.65	4.17	1.82
	K	0.049	0.02	2.45
	E	0.17	0.07	2.43
	O	-0.25	0.46	-0.56
Y=2	L	0.12	0.08	1.58
	C	-3.08	1.29	-0.24
	NF	0.04	0.13	0.31
	P	0.048	0.020	2.41
	Y_f	3.33	5.23	0.64
	I	8.69	1.19	0.73
	K	0.22	0.31	0.71
	E	0.57	0.30	1.87
	O	-0.47	0.23	-2.04
Y=4	L	-0.05	0.08	-0.67
	C	-2.03	2.21	-0.93

	NF	-0.29	0.21	-1.38
	P	0.03	0.02	1.54
	Y_f	4.91	2.33	2.10
	I	5.02	1.16	0.43
	K	0.37	0.29	1.26
	E	0.29	0.12	2.42
Y=5	O	-0.12	0.05	-2.41
	L	0.05	0.02	2.49
	C	-1.84	1.24	-1.49
	NF	0.20	0.20	0.99
	P	0.04	0.02	2.03
	Y_f	3.56	4.94	0.72
	I	1.01	1.18	0.86
	K	0.02	0.01	1.66
	E	0.34	0.14	2.43
	O	-0.06	0.04	-2.05

L = number of livestock, C = variable costs, I = personal capital, Y_f = livestock income, O = age, E = education, K = off-farm income,, NF = number of family labor, P = public participation.

The results of Table (5) showed that, at the level of y = 1, the variables of number of livestock, public participation, personal capital, off-farm income and education are significant at the level of 90% confidence, meaning that by increasing number of livestock, the farmer's income increases, as well as by increasing the level of capital and off-farm income, the individual's financial ability to provide technology, increases. In addition, increasing the level of education also has a positive effect on a person's awareness of the acceptance of AR technology. Given that public participation establishes a link between the people and the government so that the demands of the people can be easily transferred to the government. Increasing public participation has a positive and significant effect on meeting the demand for modern technology.

At the level of y = 2, the variables of public participation, age and education are significant at the level of 90% confidence. This means that increasing public participation has a positive and significant effect on meeting the demand for modern technology. Also, increasing the level of education has a positive effect on the individual's awareness of the acceptance of AR technology.

However, increasing age due to decreasing awareness and increasing risk aversion, has a negative and significant effect on the tendency to adopt AR technology.

At the level of y = 4, the variables of farmers' income, public participation, age and education are significant at the level of 90% confidence. Increasing livestock income, increases the financial capacity of farmers to access modern technology. Also, as mentioned earlier, given that public participation establishes the relationship between the people and the government, increasing public participation has a positive and significant effect on meeting the demand for modern technology. Increasing the level of education has a positive effect on individual awareness and increasing age has a negative and significant effect on the desire to adopt AG technology.

At the level of y = 5, the variables of number of livestock, public participation, off-farm income, age and education are significant at the level of 90% confidence.

As shown in the table (5), the variables of public participation, and education have a significant effect on the willingness to adopt AR technology at all levels among farmers. But variable costs and the number of family labor do not have a significant effect on the willingness to accept AR at any level among farmers.

DISCUSSIONS

The likelihood ratio test is used to measure the significance of the model and the fit goodness in the logit model, . In this model, the value of the logarithm of likelihood function is equal to 532 with a probability of 0.03, which indicates that the model is correctly estimated and the independent variables have been able to describe the dependent variable well.

Since the equations estimated are nonlinear in the Multinomial Logit model, the values of the coefficients cannot be interpreted as the final effects of the explanatory variable on the dependent variable. Therefore, the final effects are calculated in Table (6).

Table 6. Results of final effects

	variables	dy/dx	prob
Y=1	L	0.05	0.28
	C	0.02	0.41
	NF	0.26	0.94
	P=1	0.57	0.64
	P=2	0.15	0.001
	P=3	0.004	0.015
	Y_f	0.13	0.07
	I	0.018	0.30
	K=1	0.02	0.15
	K=2	0.04	0.12
	K=3	0.06	0.002
	E=1	0.013	0.56
	E=2	0.04	0.12
	E=3	0.06	0.001
	O=1	0.46	0.56
	O=2	0.018	0.30
	O=3	0.02	0.50
Y=2	L	0.004	0.73
	C	0.02	0.36
	NF	0.04	0.12
	P=1	0.02	0.15
	P=2	0.005	0.70
	P=3	0.05	0.03

	Y_f	0.005	0.78
	I	0.09	0.001
	K=1	0.31	0.71
	K=2	0.02	0.21
	K=3	0.02	0.41
	E=1	0.30	1.65
	E=2	0.02	0.50
	E=3	0.06	0.002
	O=1	0.004	0.87
	O=2	0.03	0.21
	O=3	0.05	0.02
Y=4	L	0.62	0.57
	C	0.27	0.17
	NF	0.57	0.64
	P=1	0.59	0.73
	P=2	0.02	0.01
	P=3	0.05	0.02
	Y_f	0.30	0.11
	I	0.10	0.008
	K=1	0.61	0.56
	K=2	0.02	0.99
	K=3	0.05	0.02
	E=1	0.18	1.62
	E=2	0.27	0.66
	E=3	0.06	0.001
	O=1	0.70	0.75
	O=2	0.58	0.79
	O=3	0.063	0.001
Y=5	L	0.07	0.41
	C	0.75	0.66
	NF	0.54	0.64
	P=1	0.26	0.16
	P=2	0.05	0.03
	P=3	0.07	0.001
	Y_f	0.90	0.85
	I	0.26	0.16
	K=1	0.01	0.66
	K=2	0.07	0.44
	K=3	0.03	0.51

	E=1	007	0.001
	E=2	0.63	0.72
	E=3	0.37	0.33
	O=1	0.59	0.73
	O=2	0.40	0.37
	O=3	0.15	0.001

Source: Research Findings

According to Table (6), if y = 1, (full knowledge of AR technology and financial ability) the final effect of public participation is significant in the levels of specific cases and participation in all matters. Also, the final effect of off-farm income variable and education at the third level are significant and show that when a person is fully aware of AR technology, by increasing off-farm income at a high level, the person's financial ability increases and the probability of adopting AR technology increases by 6%. In other words, by increasing income, the tendency to adopt AR technology increases. Also, by increasing the level of public participation in the second and third levels and education, awareness AR technology increases and the probability of adopting AR technology increases by 15, 0.4 and 6%, respectively.

As shown, public participation, with the highest significant final effect, is a tool to collect the environmental information to decide about the adoption of new technologies (Primmer et al, 2006). In fact, Public participation is a tool for empowering people and enabling them to make decisions about their problems and use new technological methods (Muraleedharan, 2008).

If y = 2 (full knowledge of AR technology and lack of financial ability) the final effect of variables of public participation in all areas, personal capital and education at the third level are significant. The final effect of age at the third level is significant too. It means that by increasing personal capital by one unit, the probability of adopting AR technology increases by 9%. In addition, by increasing the level of undergraduate education by one unit, the level of technology awareness increases and the probability of adopting AR technology increases by 6%. But if the age variable increases one unit at the level of 50-70 years, the tendency to adopt modern technology decreases by 5%.

At y = 4 (unaware of AR technology and financial ability). The final effect of participation variables in significant cases and all area levels, personal capital, education and off-farm income and age at the third level are significant. This means that by increasing personal capital and off-farm income and education by one unit, the probability of adopting AR technology increases by 10, 5 and 6 percent, respectively.

Also, by increasing of each unit of participation, it is possible to increase the individual's awareness and financial ability to access technology, and the probability of accepting AR increases by 2 and 5 percent respectively.

At y = 5 (incomplete information about AR technology and financial inability) the final effect of public participation at the level of special cases and all matters, age at the third level and education at the first level is significant. This means that by increasing education by one unit, the probability of adopting AR technology increases by 7%.

But for the age variable at the level of 50-70 years, by increasing one unit of age, the tendency to accept modern technology decreases by 15%, which shows by increasing age, people's level of awareness about up-to-date technologies has decreased and they are in the age of risk taking.

Recommendations

One of the limitations of this study was the use of Multinomial Logit model based on questionnaire data filled by farmers in several regions. Future studies are suggested to use time series or panel data models to study a wider area. Also, one of the interesting topics in future studies is the comparison of the level of acceptance and the factors affecting the acceptance of new technologies between developing and developed countries, so that with the help of these studies, solutions can be provided for agricultural development in developing countries. Accordingly, the quantity and quality of production will be improved to alleviate poverty and malnutrition in many societies.

CONCLUSION

Today, the discussion of the factors affecting the tendency to accept new technologies in developing countries is very important. Lack of use of modern technologies in developing countries, especially in the agricultural (livestock farming) sector, leads to negative effects on the quality and quantity of products and the country loses its ability to compete in the international arena. Since the speed of production and the reduction of negative consequences in agriculture are important, the present study examined the factors affecting AR technology acceptance in the agricultural (livestock farming) sector. As shown in the results' section, the components of public participation and the level of education and age have a significant effect on each of the dependent variable levels.

Given that public participation is an important variable in governance, so the existence of some problems in the implementation of the participatory model is an effective factor in the failure of access to modern technologies, including AR.

Decreased motivation for public participation due to not meeting the minimum demands of the people, lack of trust in the government, lack of formation of the public sphere over the sphere of government, and priority of personal interests of managers and officials over the public interest are among the political causes that should be improve for the purpose of public participation.

Also, lack of belief in collective decisions, lack of proper awareness of up-to-date technologies and financial inability to access these types of technologies, weak education system to increase awareness of farmers (ranchers), and proper training and promotion to teach new technologies are among the cultural and social causes of the lack of access to AR technology. In this regard, the government must take measures to remove obstacles.

Having an informed and trained workforce is one of the factors that ensures success in accessing and using a new technology. Councils can play an important role in raising the level of public participation and conveying the demands of the people to the government. To do this, they must receive the necessary training to attract public participation. This is possible through training workshops to increase the level of farmers' awareness.

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REFERENCES

Alam,M.F. Katsikas, S. Beltramello, O. and Hadjiefthymiades, S. (2017). Augmented and virtual reality based monitoring and safety system: A prototype IoT platform. J. Netw. Comput. Appl. 89: 109–119. https://doi.org/10.1016/j.jnca.2017.03.022

Applebaugh, J, Governance Working Group. power-point presentation, National Defense University and ISAF, slide 2. 2010. https://www.slideteam.net/governance-model-powerpoint.

Bauer, A. Neog, D.R. Dicko, A.H. Pai, D.K. Faure, F. Palombi, and O. Troccaz, J. (2017). Anatomical augmented reality with 3D commodity tracking and image-space alignment. Comput. Graph. 69:140–153. DOI:10.1016/j.cag.2017.10.008

Bitzar, V. Bertus, W. and Steenhuijsen, P. de. (2016). The governance of agricultural extension systems, kit working papers. https://www.kit.nl/wp-content/uploads.

Cˇ olakovic´, A. Hadžialic´,M. (2018). Internet of Things (IoT): A review of enabling technologies, challenges, and open research issues. Comput. Netw. 144:17–39. DOI:10.1016/j.comnet.2018.07.017

Cari,a M. Todde, G. and Pazzona, A. (2019). Evaluation of automated in-line precision dairy farming technology implementation in three dairy farms in Italy. Front Agric. Sci. Eng. 6: 181–187. doi: 10.15302/J-FASE-2019252.

Caria, M., Boselli, C., Murgia, L., Rosati, R., Pazzona, A. (2013). Influence of low vacuum levels on milking characteristics of sheep, goat and buffalo. J. Agric. Eng. 44: 217–220. doi: 10.4081/jae.2013.285.

Chatzopoulos, D. Bermejo, C. Huang, Z. Hui, P. (2017). Mobile augmented reality survey: From where we are to where we go. IEEE Access, 5: 6917–6950. DOI: 10.1109/ACCESS.2017.2698164

Daponte, P. Vito, L.D. Picariello, F. and Riccio, M. (2014). State of the art and future developments of the Augmented Reality for measurement applications. Measurement, 57: 53–70. https://doi.org/10.1016/j.measurement.2014.07.009

Dekker, R., and Bekkers, V. (2015). The contingency of governments' responsiveness to the virtual public sphere: A systematic literature review and meta-synthesis, Government Information Quarterly, 32: 496–505. https://doi.org/10.1016/j.giq.2015.09.007

Durrant-Whyte, H. Bailey, T. (2006). Simultaneous Localization and Mapping: Part I. IEEE Robot. Autom. Mag. 13: 99–110. DOI: 10.1109/MRA.2006.1638022

ElSayed, N.A.M. Thomas, B.H. Marriott, K. Piantadosi, J. Smith, R.T. (2016). Situated Analytics: Demonstrating immersive analytical tools with Augmented Reality. J. Vis. Lang. Comput. 36: 13–23.

Fournel, S., Rousseau, A., Laberge, B. (2017). Rethinking environment control strategy of confined animal housing systems through precision livestock farming. Biosyst. Eng. 155: 96–123. doi: 10.1016/j.biosystemseng.2016.12.005.

Gomes, P., Olaverri-Monreal, C., Ferreira, M. (2012). Making Vehicles Transparent Through V2V Video Streaming. IEEE Trans. Intell. Transp. Syst. 13: 930–938. DOI:10.1109/TITS.2012.2188289

Gorecky, D. Schmitt, M. Loskyll, M. Zühlke, D. (2014). Human-machine-interaction in the Industry 4.0 era. In Proceedings of the 12th IEEE International Conference on Industrial

Informatics (INDIN), Porto Alegre, Brazil, 27–30 July, 289–294. DOI:10.1109/INDIN.2014.6945523

Gushima, K, and Nakajima, T. (2017). A Design Space for Virtuality-Introduced Internet of Things. Future Internet;
9, 60. DOI:10.3390/fi9040060

Halachmi I., Guarino M., Bewley J., Pastell M. (2019). Smart Animal Agriculture: Application of Real-Time Sensors to Improve Animal Well-Being and Production. Annu. Rev. Anim. Biosci. 7: 403–425. doi: 10.1146/annurev-animal-020518-114851.

Hamuda, E., Ginley, B.M., Glavin, M., Jones, E. (2018). Improved image processing-based crop detection using Kalman filtering and the Hungarian algorithm. Comput. Electron. Agric. 148: 37–44. DOI:10.1016/j.compag.2018.02.027

Hamuda, E., Ginley, B.M., Glavin, M., Jones, E. (2017). Automatic crop detection under field conditions using the HSV colour space and space and morphological operations. Comput. Electron. Agric. 133: 97–107. DOI:10.1016/j.compag.2016.11.021

Hirschmüller, H. (2017). Improvements in Real-Time Correlation-Based Stereo Vision. In Proceedings of the IEEE Workshop on Stereo and Multi-Baseline Vision, Kauai, HI, USA, 9–10 December 2001. http://dx.doi.org/10.1109/SMBV.2001.988772

Hirschmüller, H., Innocent, P.R., and Garibaldi, J. (2002). Real-time Correlation-Based Stereo Vision with Reduced Border Errors. Int. J. Comput. Vis. 47: 229–246. https://link.springer.com/article/10.1023/A:1014554110407

Hockstein, N.G., Gourin, C., Faust, R., and Terris, D.J. (2007). A history of robots: From science fiction to surgical robotics. J. Rob. Surg. 1: 113–118. doi: 10.1007/s11701-007-0021-2

Huang, J.M., Ong, S.K.., and Nee, A.Y.C. (2015). Real-time finite element structural analysis in augmented reality. Advances in Engineering Software. Adv. Eng. Softw. 87: 43–56. https://doi.org/10.1016/j.advengsoft.2015.04.014

Janssen, M., and Van der Voort, H. (2016). Adaptive governance: Towards a stable, accountable and responsive government', Government Information Quarterly, 33: 1-5. https://doi.org/10.1016/j.giq.2016.02.003

Janssen, c. (2018). Consumer Acceptance of Mobile Augmented Reality Shopping Applications in Stationary Retail Trade. Bachelor thesis. URN: urn:nbn:se:miun:diva-34171. OAI: oai:DiVA.org:miun-34171. Diva, id: diva2: 1232271

Jeone, B., and Yoon, J. (2017). Competitive Intelligence Analysis of Augmented Reality Technology Using Patent Information. Sustainability. 9, 497. https://doi.org/10.3390/su9040497

King T.M., LeBlanc S.J., Pajor E.A., Wright T.C., DeVries T.J. (2018). Behaviour and productivity of cows milked in automated systems before diagnosis of health disorders in early lactation. J. Dairy Sci. 101: 4343–4356. doi: 10.3168/jds.2017-13686

Ku, K.., Chia, K.W., and Cheok, A.D. (2008). Real-time camera tracking for marker-less and unprepared augmented reality environments. Image Vis. Comput. 26: 673–689. DOI:10.1016/j.imavis.2007.08.015

Kehoe, B., Patil, S., Abbeel, P., and Goldberg, K. (2015). A survey of research on cloud robotics and automation. IEEE Trans. Autom. Sci. Eng. 12: 398–409. DOI: 10.1109/TASE.2014.2376492

Lee, A.; Jang, I. (2018). Robust Multithreaded Object Tracker through Occlusions for Spatial Augmented Reality.
Etri J. 40: 246–256. https://doi.org/10.4218/etrij.2017-0047

Liao, M.S. Chen, S.F. Chou, C.Y. Chen, H.Y.; Yeh, S.H. Chang, Y.C. and Jiang, J.A. (2017). On precisely relating the growth of Phalaenopsis leaves to greenhouse environmental factors by using an IoT-based monitoring system. Comput. Electron. Agric. 136: 125–139. https://doi.org/10.1016/j.compag.2017.03.003

Lima, J.P. Roberto, R. Simões, F. Almeida, M. Figueiredo, L. Teixeira, J.M. and Teichrieb, V. (2017). Markerless tracking system for augmented reality in the automotive industry. Expert Syst. Appl. 82: 100–114. https://doi.org/10.1016/j.eswa.2017.03.060

Liao, M.S. Chen, S.F. Chou, C.Y. Chen, H.Y. Yeh, S.H. Chang, Y.C. Jiang, J.A. (2017). On precisely relating the growth of Phalaenopsis leaves to greenhouse environmental factors by using an IoT-based monitoring system. Comput. Electron. Agric. 136: 125–139. https://doi.org/10.1016/j.compag.2017.03.003

MacKenzie, I.S. (1995). Input devices and interaction techniques for advanced computing. In Virtual Environments and Advanced Interface Design; Oxford University Press: Oxford, UK, June 1995; 437–470.

Makhataeva, Z.; Zhakatayev, A.; Varol, H.A. (2019). Safety Aura Visualization for Variable Impedance Actuated Robots. In Proceedings of the IEEE/SICE International Symposium on System Integration (SII), Paris, France,
14–16 January 2019; 805–810. https://doi 10.1109/SII.2019.8700332

Manian, A. And Ronaghi, m. (2016). Providing a comprehensive framework for implementing Internet marketing using the meta-combined method. University of Tehran Press. 7 : 901-920. https://doi.10.22059/JIBM.2015.57097

Muraleedharan. K., (2008). Dynamics of People Participation in Development: A Study with Special Reference to Women Participation in the Local Level Planning in Kerala, Eldis Participation Resource Guide, Handbook of Cultural Geography, Sage, London.

Phupattanasilp, P., and Tong, S.R. (2016). Application of multiple view geometry for object positioning and inquiry in agricultural augmented reality. In Proceedings of the 2nd International Conference on Agricultural and
Biological Sciences, Shanghai, China, 23–26.

Primmer, E. and Kyllonen., S. (2008). Goals for Public Participation Implied by Sustainable Development and the Preparatory Process of the Finnish National Forest Program, Forest Policy and Economics, 8(8): 838– 853. https://doi.org/10.1016/j.forpol.2005.01.002

Rashid, Z., Melià-Seguí, J., Pous, R., and Peig, E. (2017). Using Augmented Reality and Internet of Things to improve accessibility of people with motor disabilities in the context of Smart Cities. Future Gener. Comput. Syst. 76: 248–261. https://doi.org/10.1016/j.future.2016.11.030

Soma, K., Onwezen,M., Salverda, I.E., and I van Dam, R. (2016). Roles of citizens in environmental governance in the Information Age four theoretical perspectives. Current Opinion in Environmental Sustainability, 18: 122–130. https://doi.org/10.1016/j.cosust.2015.12.009

Sutherland, I.E. The Ultimate Display. In Proceedings of the IFIP Congress; Macmillan and Co.: London, UK,
1965; pp. 506–508. http://www.wired.com/beyond_the_beyond/2009/09/augmented-reality-the-ultimate-display-by-ivan-sutherland-1965/

Tati´c, D., and Teši´c, B. (2017). The application of augmented reality technologies for the improvement of occupational safety in an industrial environment. Comput. Ind. 85, 1–10. https://doi.org/10.1016/j.compind.2016.11.004

Teitel, M.A. (1990). The Eyephone: A head-mounted stereo display. In Stereoscopic Displays and Applications; SPIE: Bellingham, DC, USA, 1256: 168–171. https://doi.org/10.1117/12.19902

Todde G., Caria M., Gambella F., Pazzona A. (2017). Energy and Carbon Impact of Precision Livestock Farming Technologies Implementation in the Milk Chain: From Dairy Farm to Cheese Factory. Agriculture. 7:79. doi: 10.3390/agriculture7100079.

Tullo E., Finzi A., Guarino M. (2019). Environmental impact of livestock farming and Precision Livestock Farming as a mitigation strategy. Sci. Total Environ. 650: 2751–2760. doi: 10.1016/j.scitotenv.2018.10.018.

Todde G., Murgia L., Caria M., Pazzona A. (2016). A multivariate statistical analysis approach to characterize mechanization, structural and energy profile in Italian dairy farms. Energy Rep. 2: 129–134. doi: 10.1016/j.egyr.2016.05.006.

Wathes C.M., Kristensenb H.H., Aertsc J.M., Berckmans D. (2008). Is precision livestock farming an engineer's daydream or nightmare, an animal's friend or foe, and a farmer's panacea or pitfall? Comput. Electron. Agric. 64: 2–10. doi: 10.1016/j.compag.2008.05.005.

Velázquez, F. and Morales Méndez, G. (2018). Augmented Reality and Mobile Devices: A Binominal Methodological Resource for Inclusive Education (SDG 4). An Example in Secondary Education. Sustainability 10: 34-46. DOI:10.3390/su10103446