Nonparametric Procedures in ICTs-Based Agricultural Market Information Network Pattern Analysis in Western African Regions

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Abstract: - Information and communication technology (ICT) has become an important and essential decision support tool in agricultural products marketability. The high production cost of farms and the increasing demand for food have pushed ICT to the forefront of the food supply chain. In developing world such as Sub-Saharan African (SSA) regions where the farm profitability is generally low, efforts have been focused on agronomy and production technologies for enhancing farm productivity. In today's competitive global and regional marketplaces, however, producing a sound product is not enough to ensure agricultural farm viability. Market information is considered as a prerequisite of farm business to enable the management of the products flow and substantially increase the benefit. Furthermore, ICT can reduce poverty by improving poor people's access to the market information to have better managerial decisions for maximizing their farms profits. Nevertheless, the realistic availability and effectiveness of ICT in current market information network to farm management in Africa have not yet been much explored. Therefore, this study aims to (i) analyse the ICT contribution in agricultural products market information system (MIS) through nonparametric procedures and (ii) identify the main problems for seeking an effective market-oriented information network pattern. For this study, important data for horticultural marketing have been collected in Saint-Louis and Dakar regions located in Senegal, Western Africa. From the results of this study, it is mainly found that there are different market information network patterns in the survey areas. These market information network patterns mostly rely on weak personal social contacts of producers and one-way media. Statistically, it is observed that some widely available ICTs have not been used effectively for market information dissemination in the survey areas. Basically, the major constraints of ICTs application for MIS in Senegal are the poverty of information contents, disadvantages of the remote communities, language incapability and out-of-date information. Therefore, this study proposes an information network scheme as an effective strategy to enhance the existing market information system in Senegal.

Key-Words:- ICT, MIS, horticultural marketing, information network pattern, farm profit, effective strategy, Western African regions

1 Introduction

Information and communication Technology (ICT) plays a crucial role for connecting farmers to the market by providing effective information at real time for high farm profitability. According to [1], ICT can play an important role to bridge the information gap between the farmers and the market, and increase their access to the market information. ICT is a force that has changed many aspects of the way we live since in this twenty first century, we are all living in the age of digital technology [2]. In fact, improvements in market information system (MIS) may lead to sustain the farm profit and orient the production to the market needs. ICT can make a substantial contribution in several sectors related to the human life such as health and healthcare improvement [3]; quality management [4], social equity and sustainable development [1], industry real estate market

efficiency [5], emergence of a complex global urban system [6], world education [7], agriculture products traceability and environment monitoring [8], extension works and farming practices [9] and agricultural market information research [10].

The application of ICT for market information research has showed outstanding results since the prices of most of agricultural commodities from small famers showed a long-term declining trend. For instance, a global supply chain is linked to commercial buyers in Kenya [11]; an online trading and payment system is provided in Philippines [12]; e-learning is applied in United Stated, Australia, Canada, Pakistan, and even Sub-Saharan Africa [13]; market analysis and production forecast is provided in Ukraine [14]; and farmers can get market prices via mobile phone text message in Benin [11]. The most common ICT

applications include e-commerce, e-learning and market information system.

From the above reported studies, it is found that the utilizations of ICT were effective, and the information gap between urban and rural areas was narrowed in these cases, and more opportunities were provided to farmers to learn new knowledge and techniques. Farmers were able to achieve better quality and prices of products, to deepen and broaden cooperation in various fields, and also to promote and facilitate greater trade and investment. Basically, farmers and traders are all looking to higher value options in order to maximize their profits. In Senegal, a West African country, it often happens the scenario that the traders commonly dictate their price to the market. In this circumstance, effective usage of information and communication technologies can help small farmers and artisans by connecting them to markets. Nowadays in Africa, the great majority of households do not have generally direct access to MIS-related ICT services, and where they exist will be via the non-formal MIS body that provides such services to the general public, typically charging a time-dependent fee.

Indeed, the use of information technology has become a primary survival factor for business organizations in a global and regional competitive environment. Information technology is spreading through various domains violently in modern society [15]. Using ICT for Senegalese farmers to reach market information is an important factor to accelerate the increasing of national economy. Farmers can have market price information before deciding to bring their products to the market. Accordingly, the high incomes generated by farmers can help to reduce poverty by improving access to education, health and satisfy their basic needs. However, to the knowledge of the authors, research related to the ICT availability and application by Senegalese farmers for agricultural commodities marketability is still poor in literature. Besides, the effective contribution of ICTs-based MIS on Senegalese farmers is under explored. Therefore, the objectives of this present study are to analyse the contribution of ICT in Senegal agricultural commodities market information system through the nonparametric procedures, and then identify the major constraints for determining an effective market-oriented information strategy for the country. For this study, important data have been collected in two production sites; Saint-Louis and Dakar regions located in Senegal, Western Africa.

2. Research Methodology
2.1 Investigation Areas Description
The areas under study are Saint-Louis and Dakar regions

of Senegal, a West African country (**Figure 1**). Saint-Louis Region is located in northernmost Senegal at 22 m altitude, 16°1'8"N latitude and 16°29'43"W longitude. Meanwhile, Dakar Region is located in westernmost Senegal and lies between the 17°10 and 17°32 of Western longitude and the 14°53 and 14°35 of Northern latitude at 37 m altitude. In Saint-Louis Region, the surface accounts for approximately 10% of the national territory, and the estimated population represents for 7% of the national population [16]. Dakar Region accounts only for 0.28% of the national territory, with a large population about 21% of the national population [17]. Dakar Region is the center of politics and commerce in Senegal, accordingly privileged to advanced infrastructures to support its vast national and international trading activities and communication network. In the region, telecommunications are widely distributed. For the climate, Senegal has two seasons; rainy season (June to October) and dry season (November to May). The rainy season is short, and the rainfall is averagely low and irregularly distributed (about 300 mm in the North and 1200 mm in the South) [18]. The existence of the Senegal River in Saint-Louis Region provides abundant water resources and favorable irrigation potential for the development of competitive agriculture. On the other hand, Dakar Region profits from the low-lying coastland called Niayes which is rich in water resources for crop production, and agriculture in this area is largely dominated by the horticulture to meet the needs of urban and export markets.
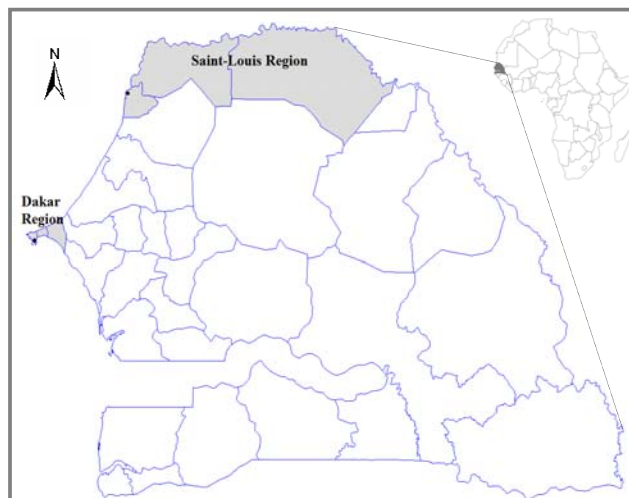

Figure 1. Sketch map of the survey areas.

2.2 Country MIS Context
Market information is indispensable for actively researching high market values for agricultural products which are generally perishable. In Senegal, despite of the production constraints and their high cost values, agricultural products can have high value through the

ICT system. In the country, with more than half of the population in rural areas, agricultural sector keeps being highly valued by the Senegalese government for national development. Agriculture contributed a gradually weaker percentage of 14.9% to GDP in Senegal in 2008 and accounted for 71.7% of the labour force [19]. Crop production is mostly organized through small-scale peasant units, but the market supply is actually influenced by few large-scale plantations. In Senegal, groundnut is the predominant cash crop. About one-third of cultivated land is devoted to groundnuts, and some 12% of groundnut production is for export [20]. However, the government has attempted to reduce dependence on groundnuts by diversifying cash and food crops due to great fluctuation in yield and price of groundnuts, as well as the sector lags behind others in terms of modernization and productivity [21]. Since groundnut producers received fewer inputs (e.g. seed and fertilizer) from the government, the harvested areas of groundnuts have been largely cut down as compared with the 1960s. Meanwhile, production of garden crops is rising rapidly in Senegal [20]. Recently, vegetables such as tomato and green bean are the emerging cash crops in the country. Additionally, some basic information and communication media such as TV and mobile phone have a large coverage in the country. In this context, ICT can provide variety of information and function to farmers producing vegetables with high market value.

2.3 Crop Information

The present study selected two of the most popular horticultural crops, tomato and green beans, in the survey areas based on the preliminary crop production information data sampled. According to [20] and Senegalese Direction of Horticulture [22]**,** tomato has become the most dominant vegetable crop in Senegal. Saint-Louis region has the highest production (85.4%) and the largest cultivation area (64.8%) of tomato among all the regions of the country [22]. As the commerce center of exportation, Dakar region occupies the largest cultivation area (66.7%) and the highest production (66.6%) of green bean in Senegal [22]. Moreover, tomato is followed by green bean and both considered as the major vegetables for exports in Senegal with 37% and 22% of the exports in 2008, respectively [22].

2.4 Sampling and Data Processing

A survey questionnaire was designed to investigate on the current market information system of tomato and green bean producers in Saint-Louis and Dakar regions, respectively. The data have been collected from 150 producers in each region through the questionnaires in year 2006. Recently, in year 2009, in-depth interview with respondents have also been conducted to collect

addition nal information. Moreover, literature reviews of related publications as well as statistical documents have been included in the survey too. The data collected during the survey are summarized in **Table 1**.

Table 1. Categories of data collection during the survey.

Categories of Data	Items
Basic Socio-Economic Information	Gender, Age, Education, Ethnic Group, Membership (of Producers' Associations)
Information and Communication Technologies (ICTs) Widely Available in the Region	Radio, CD Player, TV, DVD Player, Household Telephone, Telecenter, Beeper, Mobile Phone, WAP-Enabled Cellphone, Personal Computer, Handheld Computer, Household Internet, Cybercafé, Digital Camera, PDA, None of the Above
Market Information System (MIS)	Type, Media, Accessibility, Language, Format, Ease of Use, Content, Relevance of Contents, Frequency, Timeliness, Accuracy, Price Reasonableness, Popularity

For this study, the SPSS 17.0 statistical software was used to carry out the nonparametric tests for analyzing the relationship between the variables. The statistical tests conducted for tracking the independency and relationship between variables are given as followed.

Chi-Square Goodness of Fit Test

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i} \tag{1}$$

Where χ^2 is the test statistic that asymptotically approaches a χ^2 distribution; O_i is the observed frequency for bin i; E_i is the expected frequency for bin i; and n = the number of possible outcomes of each event.

Chi-Square Test of Independence

$$\chi^2 = \sum \sum \frac{(n_{ij} - m_{ij})^2}{m_{ij}} \tag{2}$$

Where n_{ij} is the observed frequency of the ith row and jth column; and m_{ij} is the expected frequency of the ith row and jth column.

Binomial Test

$$Z = \frac{x \pm 0.5 - np_0}{\sqrt{np_0 q_0}} \tag{3}$$

Where x is the proportion of the observed score, which is then converted to a z-score; p is the probability of chance; q is the reciprocal of p, given as $q = 1 - p$; and n = the total number of observations.

One-Sample Kolmgorov-Smirnov Test

$$D = \max |S_n(x) - F_0(x)| \tag{4}$$

Where the D value is the largest absolute difference

between the cumulative observed proportion $S_n(x)$ and the cumulative proportion expected on the basis of the hypothesized distribution $F_0(x)$; and n is the sample size.

Mann-Whitney U Test

$$Z = \frac{U - E(U)}{\sqrt{V(U)}} \qquad (5)$$

Where n_1 and n_2 are the sample sizes of the two groups; U expressed as $U_i = n_1 n_2 + n_i(n_i+1)/2 - R_i$; R_i is the sum of rank scores for group i; U is the smaller value of U_i and equal to min (U_1, U_2); $E(U)$ is the expectation of U; and $V(U)$ is the vairance of U.

Kruskal-Wallis One-Way ANOVA Test

$$H = \frac{SSt}{MST} = \frac{\sum R_{.j}^2 / n_j - n(n+1)^2/4}{n(n+1)/12} \qquad (6)$$

Where SSt is the sum of squares for treatments; MST is the mean squares for treatment; and $R_{.j}$ denotes the rank of observation $X_{.j}$.

3. Results and Discussion
3.1 Goodness of Fit Tests

A one-sample binomial test is used in this study to compare the observed proportion of categorical dichotomous variable with the expected proportion (p=0.5). The results indicate that there is significant difference in the frequency distribution of the two elements of each dichotomous variable, except MIS media-mobile phone of Dakar Region. The respondents of Dakar Region basically distibuted equally into the non-users and users group that employed mobile phones as media for market information. For other MIS Media, all categories of widely available ICTs as well as MIS contents, gender, and membership of producers' associations, there is statistically significant evidence to suggest an unequal probability of their two mutually exclusive outcomes.

Meanwhile, a chi-square goodness of fit test applied for apprehending the deviation between the observed and expected distribution are significant for each categorical variable, except MIS Language in Saint-Louis Region and MIS media-mobile phone in Dakar Region. These variables include gender, ethnic group, membership of producers' associations, all categories of widely available ICTs, type, media, format, contents, and price of MIS in both regions.

The one-sample Kolmogorov-Smirnov test is designed to measure a particular distribution consistency with a normal distribution which accordingly meet the assumption for parametric tests. **Table 2** shows that the ordinal variables in both Saint-Louis and Dakar regions are not normally distributed, therefore the further data analysis should apply nonparametric procedures.

Table 2. The one-sample Kolmogorov-Smirnov test for ordinal variables in Saint-Louis and Dakar regions.

Variable	Saint-Louis		Dakar	
	Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)	Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
Ages Average	4.085	0.000	5.225	0.000
Education	5.447	0.000	3.957	0.000
Quality of ICTs	4.305	0.000	5.12	0.000
Accessibility	3.588	0.000	3.691	0.000
Ease of Use	3.086	0.000	3.545	0.000
Frequency	2.678	0.000	2.574	0.000
Timeliness	3.892	0.000	3.452	0.000
Price Reasonableness	2.151	0.000	3.553	0.000
MIS Popularity	3.771	0.000	3.173	0.000

3.2 Categorical social variables implication in ICT availability

Information and communication technology (ICT) availability is crucial to provide equal market information to users regardless to their socio-economic status. Accordingly, the present section looks into the linkage between the existing ICTs and the categorical variables. Two of the most important economic crops in Senegal have been selected from their main production areas, i.e. tomato and green bean in Saint-Louis and Dakar regions, respectively. A descriptive crosstabulation and Chi-Square statistics from nonparametric procedures are used to investigate the categorical social variables independency implication to the ICT availability and utilization in the investigation areas. From the survey data in Saint-Louis Region, 16.1% are females and 83.9% are males; and 59.4% are between 26 to 45 years old. For Dakar agricultural region surveyed, the percentages of females and males are 23.6% and 76.4%, respectively; and about 72.2% are ranged between 26 to 45 years old. Based on the survey data collected, the major ethnic group producing tomato in Saint-Louis Region is Fula (70.6%). While for Dakar Region, Lebou (52.5%) ethnic group is most involved in green bean production. About 76.8% and 52.2% do not have formal Western education in Saint-Louis and Dakar regions, respectively. It is noticed that in the production areas, the percentages of illiteracy among farmers are high in both Saint-Louis (79.7%) and Dakar (63.3%) regions.

For better representation of the statistical significant levels, radar plot is adopted to illustrate the obtained results. **Figures 2a and 2b** display the Chi-Square statistic for ICT availability according to the categorical social data for Saint-Louis and Dakar regions, respectively. From **Figure 2a**, radio shows significant differences with a p-value close to zero and less than 0.05 for ethnic group and respondent membership status for Saint-Louis region. While, TV is significantly associated to the respondents ethnic group. It is noticed that the telecenter is associated ($p<0.05$) to

most of the social variables except age and education level. Mobile phone is significantly related to gender and ethnic group. Radio is related to ethnic group and membership. These significant differences could be probably explained by the gender implication particularly the males' higher perception for ICTs than females. This indicates that females have disadvantage for accessing to ICTs when compared to males. The associations found with ethnic group in Saint-Louis region are due to the fact that all of the Wolof (100%) believe that telecenter and mobile are widely available in their neighborhood. Whilst, for Fula, not that much share the same belief for telecenter (58.3%) and mobile phone (74%). Such perception must be due to the difference between the two ethnic groups in term of location, social resources and the life style. In Dakar region, **Figure 2b** shows that radio, telephone and internet are the majors ICTs that are related to the multi social variables. Additionally, age, education, ethnic group and membership all are related to ICT availability. Compare with Saint-Louis region, Dakar is more developed and has reasonably more facilities since it represents the center of economic and politics.

Figure 2. Radar plots of Chi-Square *p*-values for ICTs availability in Saint-Louis (**a**) and Dakar (**b**) regions according to the respondents' categorical social variables.

3.3 ICT Utilization in Market Information System

Market information system (MIS) assists in improving the farm production and its marketing activities. Therefore, the effectiveness of MIS needs new information technology to provide reliable information at right time. Under this consideration, this paper evaluates the existing ICT contribution in market information system in Senegal. As it is important to understand the current performance of the MIS in the regions under study, issues like where, when, how and what kind of information farmers access have been discussed. The results obtained from respondents have shown that most of the current MIS are not formal. In addition, 66.7% of respondents in Saint-Louis Region and 70.8% in Dakar Region directly get their information through personal contact in the market instead of relying on the regular agribusiness information announced by related official agencies. In Saint-Louis Region, although some of the respondents surveyed about 33.3% received their information from the agricultural extension agencies or from their own producers group, these information channels remains irregular. In Dakar Region, about 25.7% receive government public information through radio and TV, while the rest only 3.5% get the information from the private company. A previous survey of FAO conducted in 120 countries also indicated only 13 functioning Market Information Systems engaged in daily price information [23]. The results of this study obviously implied the existence of different market information network pattern. The coverage area of current MIS is limited in local regions rather than nationwide. **Table 3** gives the percentages of ICTs widely available in Saint-Louis and Dakar regions.

Based on the valid information retrieved from the respondents, the most widely available ICTs in Saint-Louis are mobile phone (81.9%), telecenter (71.0%), radio (22.5%) and TV (15.9%). In Dakar Region, the widely available ICTs are ranked from mobile phone (100%) to telecenter (86.1%), household telephone (72.2%) and radio (65.3%). From these retrieved data, it is found that mobile phone and telecenter have been often used in Saint-Louis Region for market information research. For Dakar Region, radio and TV are the most commonly used media by farmers to reach market information. A survey done by [24] in Kenya, an African country, also reported that the diffusion of ICT provides diversified channels for farmers to reach agircultural information. However, it is worth noticed that some widely available media such as radio and TV in Saint-Louis Region and telephone and mobile phone in Dakar Region are not sufficiently engaged in market information supply. Therefore, in both Saint-Louis and Dakar regions, it can be concluded
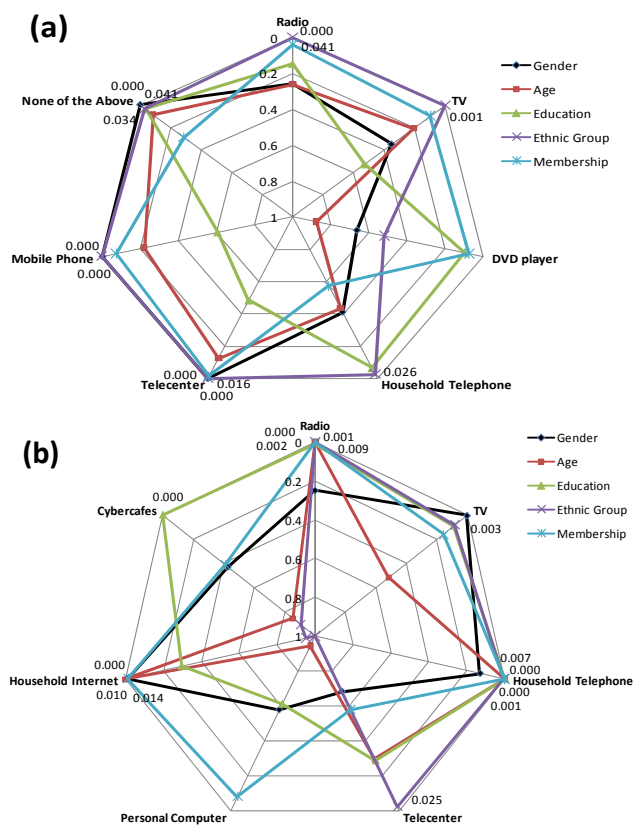
that the widely available ICTs are not effectively used for market information. Similar evidence was also found in Central Asia and Caucasus [25], which implied the availability of ICT does not quarantee its effective usage for farmers to obtain agricultural information. Moreover, some other media including CD and DVD player, beeper, WAP-enabled cellphone, personal computer, handheld computer, household Internet, cybercafé, digital camera, PDA and others were completely not or occasionally mentioned by the respondents. Evidence in India also proved that low level of education and illiteracy impeded the poor, mainly farmers, to use computer, Internet, and other morden electronic devices [26]. Thus, they will not be considered for further analysis in study since they are not available and do not provide any service in the regions under study.

Table 3. ICTs widely available in the survey areas.

Items	ICTs Widely Available	
	Saint-Louis	Dakar
Radio	22.5	65.3
TV	15.9	34.7
DVD Player	0.7	0.0
CD Player	0.0	0.0
Household Telephone	2.2	72.2
Telecenter	71.0	86.1
Beeper	0.0	0.0
Mobile Phone	81.9	100.0
WAP-Enabled Cellphone	0.0	0.0
Personal Computer	0.0	0.7
Handheld Computer	0.0	0.0
Household Internet	0.0	1.4
Cybercafé	0.0	1.4
Digital Camera	0.0	0.0
PDA	0.0	0.0
Others	0.0	0.0
None of the Above	7.2	0.0

3.4 Functional Features of MIS

The functional features of MIS in the present study include language, format, frequency, accessibility, ease of use, contents, relevance of contents, timeliness, accuracy, price, and price reasonableness, and popularity. Language is one of the important aspects of the market information system. Official language which is French and local language are both adopted by 50.5% of respondents in Saint-Louis Region. Meanwhile in Dakar Region, the majority of the respondents about 85.4% have adopted both languages for market information needs. In both Dakar and Saint-Louis regions, 9.8% and 49.5% of respondents communicate in their local languages, respectively. Despite some media like radio and TV which provide audio and visual information mode, the dissemination of market information in Saint-Louis and Dakar regions is basically through vocal communications (100%).

Mobile text messages are rarely used (1.1% in Saint-Louis and 12.8% in Dakar regions), and it might be explained by the illiteracy level of most users.

The contents of the information that respondents obtained were mostly wholesale prices of the products about 97.9% in both regions. In Dakar Region, particularly, information regarding the prices of retail markets (93.6%) and inputs (76.6%) have also been requested extensively by green bean producers. It is clearly revealed that market information network does not provide more diversified information but only price information. Similar cases and problems of merely overweighting price information have also been indicated by some previous studies in different countries [23, 27]. Meanwhile, a Chi-Square test of independence applied to determine the association between MIS contents and MIS media showed obviously that the media in Saint-Louis Region are related with the access to market information about wholesale prices. Significant negative associations were found between TV as well as household telephone and wholesale price information while telecenter appeared to play a positive role in Saint-Louis Region. Moreover, radio used for market information also showed a significant high proportion to receive wholesale price information in Dakar Region. The different effectiveness of media that current market information network adopted has also been observed. **Tables 4 and 5** summarized the independence test results in the study areas.

Table 4. Chi-Square test of independence between MIS media and MIS contents in Saint-Louis Region.

MIS Media MIS Contents	TV	Telephone	Telecenter
	Pearson Chi-Square		
Wholesale Price	31.660 (0.000)	14.992 (0.000)	14.992 (0.000)
Wholesale Volume	0.079 (0.779)	0.159 (0.690)	0.159 (0.690)
Retail Price	0.055 (0.815)	0.111 (0.739)	0.111 (0.739)
Retail Volume	0.021 (0.884)	0.043 (0.836)	0.043 (0.836)
Agricultural Policies	0.021 (0.884)	0.043 (0.836)	0.043 (0.836)

NB: ( ) Asymp. Sig. (2-sided)

Table 5. Chi-Square test of independence between MIS media and MIS contents in Dakar Region.

MIS Media MIS Contents	Radio	TV	Household Telephone	Telecenter	Mobile Phone	Household Internet
	Pearson Chi-Square					
Wholesale Price	14.986(0.000)	2.980(0.084)	0.276(0.599)	0.122(0.727)	1.646(0.199)	0.022(0.882)
Retail Price	0.218(0.640)	0.103(0.749)	0.278(0.598)	0.381(0.537)	0.033(0.855)	0.070(0.792)
Retail Volume	0.070(0.792)	0.350(0.554)	0.276(0.599)	0.122(0.727)	0.634(0.426)	0.022(0.882)
Input Price	3.346(0.067)	0.023(0.880)	0.082(0.774)	1.710(0.191)	0.311(0.577)	0.312(0.576)

NB: ( ) Asymp. Sig. (2-sided)

The release frequency of market information in Saint-Louis Region has polarized into either daily (34.4%), weekly (18.3%) or yearly (41.4%). In contrast, the frequency in Dakar Region only centralized in daily (21.4%) and weekly (78.6%). This implies that in the remote areas, information accessibility is not as frequent as in the suburban areas.

For pricing, it has been observed that currently market information is partially free. In Saint-Louis Region, 43.5% of the respondents indicated a payment of 5.5 Euro per month on average, while it is mostly free of charge in Dakar Region, and simply 13% of the respondents paid averagely 3.0 Euro per month. However, likely many farmers might not be aware of the inconspicuous cost for using these ICT tools since those information providers do not directly charge them a price.

The relevance, accuracy, and timeliness of the contents are critical to the value of information. The interface of the media and the format of the information may also influence the usefulness of the information that users perceive. Moreover, the cash cost of information obtainment is one essential issue for the willingness of usage. The reasonableness of price has to be taken into account as well. Likert scale employed in this study presents the attitude of the respondents toward current market information network. **Figure 3** represents the means and standard deviations of MIS functionality features according to the degree of agreement of the respondents. Most of them in Dakar Region endorsed the concept that market information network performs positively in every aspect. The means for all these features in Dakar Region are above 3.8 which represents relatively higher acknowledgement for the quality of current network. While the respondents in Saint-Louis
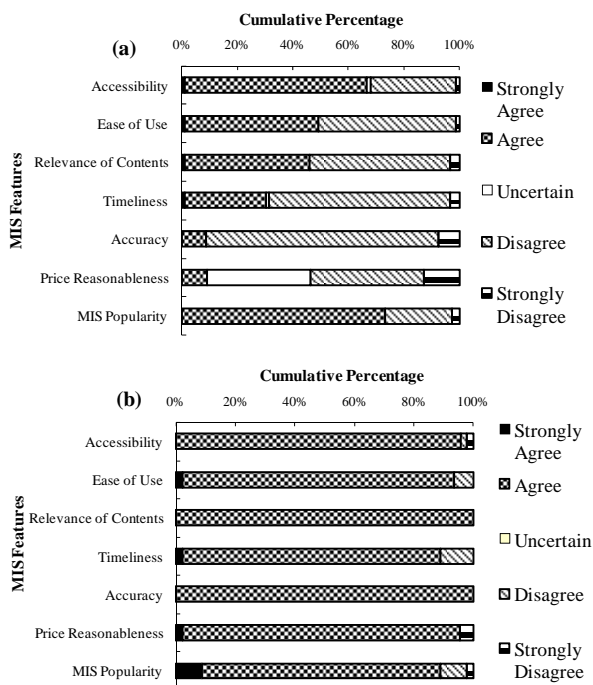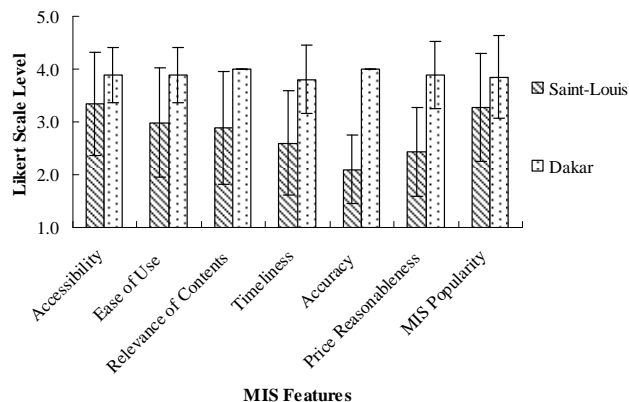

Figure 4. Likert scale level variation according to MIS features in the study area.

Region marked relatively lower values, which indicated the unsatisfaction with the effectiveness of market information network. Particularly for the accuracy of the market information, it only registered an average of 2.1 which is poorly agreed by the respondents in Saint-Louis Region. Further observations show that in Saint-Louis Region, the ease of use, relevance of contents, timeliness, accuracy, and price reasonableness, received relatively low means that are below 3. The appreciation of the respondents towards MIS is inadequate in Saint-Louis Region. **Figure 4** represents the Likert scale level variation.

Among the MIS media applied by farmers to receive the transmitted market information, the capacity, efficiency, and practicability of ICTs may vary from one to another and accordingly cause the difference in usage. In this study, Mann-Whitney rank-sum test is used to determine the relationship between MIS media and their features and meanwhile also explore the connection of gender and membership with MIS funcational features in both regions. The results show that individual farmers in Saint-Louis Region got relatively higher satisfaction at several MIS functional features, including accessibility, ease of use, and relevance of contents. The reasons may be probably due to their personal resources, so they do not need to rely on producers' associations. However, regarding to the frequency of information supply, the individual farmers do not receive information frequently as those who participate in the producers' associations. The accessibility, accuracy, and popularity of MIS also have significantly lower approval from the respondents using TV for market information. This means that TV is not an easily accessible medium. Household telephone also encountered similar problems in Saint-Louis Region. On the contrary, telecenter is being considered relatively accessible for providing more accurate information with more reasonable prices and larger numbers of users. But, the situation is not exactly similar in Dakar Region. The

Figure 3. Cumulative percentage of MIS features effectiveness evaluation in Saint-Louis **(a)** and Dakar **(b)** regions.

respondents using radio for market information consider the frequency of information supplied relatively less, but with a more reasonable price. TV users are relatively satisfied with the accessibility and the ease of use and perceive it as a popular information medium although unsatisfactory answers about its frequency have been reported. Household telephone is considered as a not accessible medium contrary to telecenter which is being recognized as very popular. As for mobile phone, the respondents in Dakar Region seem to admit its mobility that makes the information more frequent, despite that it is not relatively easier to use. These findings may indicate the relatively higher difficulty to access household telephone and the relatively higher popularity of telecenter.

Furthermore, the Kruskal-Wallis test is used to understand the attitude of respondents across different categorical social variables that have more than 2 levels toward ordinal MIS functional feature variables. **Tables 6** and **7** detailed the results from Kruskal-Wallis test in Saint-Louis and Dakar regions, respectively. It is found that the respondents in different ages do not have significant difference in attitude toward MIS functional features in Saint-Louis as well as Dakar regions. Types of MIS, languages and prices show significant differences in MIS features effectiveness.

Table 6. Kruskal-Wallis test of categorical variables and MIS features in Saint-Louis Region.

Categorical Variables	Age Average	Education	Ethnic Group	Type of MIS	Language	Format	Price
MIS Features				Chi-Square			
Accessibility	1.095(0.778)	1.301(0.729)	0.348(0.555)	10.892(0.004)	18.391(0.000)	-	21.793(0.000)
Ease of Use	6.428(0.093)	3.954(0.266)	1.033(0.310)	20.541(0.000)	35.669(0.000)	0.977(0.323)	39.890(0.000)
Relevance of Contents	1.597(0.660)	0.408(0.939)	4.959(0.026)	1.130(0.568)	0.428(0.513)	1.003(0.316)	1.053(0.591)
Frequency	3.596(0.309)	8.244(0.041)	0.197(0.657)	30.163(0.000)	46.383(0.000)	1.466(0.226)	46.393(0.000)
Timeliness	2.758(0.430)	4.832(0.185)	0.051(0.822)	4.678(0.096)	4.596(0.032)	0.351(0.554)	10.176(0.006)
Accuracy	1.143(0.767)	5.004(0.172)	0.000(1.000)	0.623(0.733)	1.333(0.248)	-	3.215(0.200)
Price Reasonableness	2.706(0.439)	4.564(0.207)	11.231(0.001)	9.150(0.010)	9.714(0.002)	0.410(0.522)	16.598(0.000)
MIS Popularity	1.400(0.705)	5.891(0.117)	2.072(0.150)	17.951(0.000)	16.524(0.000)	-	26.102(0.000)

NB: ( ) Asymp. Sig. (2-sided)

Table 7. Kruskal-Wallis test of categorical variables and MIS features in Dakar Region.

Categorical Variables	Age Average	Education	Ethnic Group	Type of MIS	Language	Format	Price
MIS Features				Chi-Square			
Accessibility	0.890(0.641)	2.049(0.359)	0.831(0.934)	17.165(0.000)	4.034(0.133)	0.299(0.584)	13.630(0.000)
Ease of Use	0.366(0.833)	10.239(0.006)	2.153(0.708)	11.252(0.004)	6.817(0.033)	6.948(0.008)	6.780(0.009)
Relevance of Contents	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)
Frequency	2.897(0.235)	6.319(0.042)	4.448(0.349)	27.385(0.000)	14.037(0.001)	17.539(0.000)	12.627(0.000)
Timeliness	0.075(0.963)	0.744(0.689)	1.010(0.908)	3.680(0.159)	5.137(0.077)	3.292(0.070)	3.394(0.065)
Accuracy	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)
Price Reasonableness	1.186(0.553)	14.659(0.001)	2.097(0.718)	14.858(0.001)	10.028(0.007)	0.036(0.849)	10.245(0.001)
MIS Popularity	3.174(0.205)	7.087(0.029)	1.227(0.874)	15.197(0.001)	3.819(0.148)	14.767(0.000)	3.647(0.056)

NB: ( ) Asymp. Sig. (2-sided)

3.5 Challenges for Agricultural MIS Development

In Senegal, to sum up, the application of ICT for agricultural farm profit still faces some major challenges such as inequality of gender and ethnics in ICT availability, lack of sound official organizational support, poverty of information contents, disadvantages of the remote communities, language incapability, out-of-date information. Without interaction platform for feedback mechanisms, farmers plays a passive role in the market information network. They rely on weak social contacts or one-way media to catch some fragmentary and slippery information, instead of possessing diversified reciprocal channels for information exchange and confirmation. It is a challenge to further diagnosis the constraints of ICT applications and provide a solution of MIS and its specific management needs. Based on the results of this study, it can be suggested a MIS as an interactive decision support systems for farm strategic oriented process. In market information system, the development of ICT application has to be permanently evaluated for better effectiveness. It is important to ensure that the support from the ICTs-based MIS can keep up with the evolution of farms and agriculture food production chains in terms of new management concepts or operational technologies.

The Senegalese national program needs the governance and financial support from the official agencies and farmers' banks as well as the cooperation with local producers' associations and telecenters. Producers should be firstly organized into associations. Then the associations must be more dynamic for looking into production, marketing integration and market information. Since mobile phone industry is powerfully competing with the numerous waning telecenters in Senegal, it could be a great opportunity for telecenters to associate a new business by working with producers' associations to provide vital market information services for farmers in rural areas.

Telecenters can be adopted into MIS as information centers to transmit and relay the market information in the remote communities to overcome the provincial inconvenience of signals and power. Moreover, it is necessary to expand the range of information collected and delivered. Information should include not only prices, but also technical, environmental, financial, strategic policy, and inputs aspects. Information collection teams must spread into at least one in every department of Senegal to obtain the effective and latest information in the main markets and send back to the headquarter for database update (**Figure 5**). Then, information should be gathered, classified into types, processed into proper formats, and issued according to needs priority and urgency.
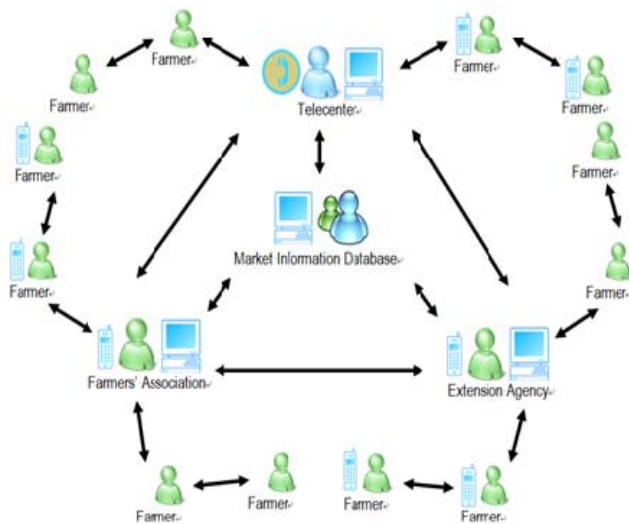

Figure 5. Market Information Network Scheme.

A formal MIS program must ensure the participation of some vulnerable groups, including women and the ethnic minority, by providing information through the media highly available and the languages widely understood for users. Providing vocal services and visual images can explain and illustrate the messages inside of information to help producers bridge over the difficulties in reading or speaking. Daily needed information such as prices should be quickly disseminated to local information centers through email connection and fax, and the managers of producers' associations or individual farmers can retrieve the information from the nearby information centers by paying a certain cost. The members of the producers' associations can also receive the information through convenient media from their managers with a price. The payment to either telecenters or producers' associations can both assist the sustainability of this MIS operation. The institutions and administrative communication structures may allow interaction between information providers and users. Farmers or managers can give feedback to the headquarter through telecenters. Farmers may even be the information collectors in the markets to provide firsthand information. They can play a positive role as information platform and link to the members within the market information network. This platform can help to confirm the reliability of information since the data are gathered from all over the country.

4. Conclusions

In this study, ICT availability and MIS effectiveness to vegetable producers in Senegal have been evaluated. The results show that there are different market information network patterns in the survey areas. These market information network patterns mostly rely on weak personal social contacts of producers and one-way media. It is found in general that the widely available ICTs have not been used effectively for market information dissemination. Format adopted by the current transmitted information in the network is merely oral. Market information network does not provide more diversified information but only price information. Moreover, from the functional features of MIS, the results show practical difference according to the region. In Saint-Louis Region, TV and household telephone are relatively difficult to access compared to telecenter. For Dakar Region, mobile phone has been widely available but not fully utilized for market information network. The speed of information dissemination in the remote areas appears to be slower than in the suburban areas. In both locations, it evidently remarked that there is a wide gap between ICT availability and utilization for market information research by farmers. Nevertheless, the performance of market information network in Dakar Region received fairly positive appreciation from green bean producers while tomato producers were discontented in Saint-Louis Region. From the results of this study, the major constraints of ICT application for MIS in Senegal are the poverty of information contents,

disadvantages of the remote communities, language incapability, out-of-date information. To overcome these difficulties, the study suggests an information network scheme as a key recommendation to improve the current poor market information system for Senegalese farmers.

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References:

[1] S. Mehta, M. Kalrab, Information and Communication Technologies: a Bridge for Social Equity and Sustainable Development in India, *The International Information & Library Review*, Vol. 38, 2006, pp. 147-160.

[2] M.M.D. Yunus, M.A. Lubis, C.P. Lin, Language Learning via ICT: Uses, Challenges and Issues, *Wseas Transactions on Information Science and Applications*, Vol. 9, No. 6, 2009, pp. 1453-1463.

[3] H. Lucas, Information and Communications Technology for Future Health Systems in Developing Countries, *Social Science & Medicine*, Vol. 66, 2008, pp. 2122-2132.

[4] G. Schiefer, ICT and Quality Management, *Computers and Electronics in Agriculture*, Vol. 22, 1999, pp. 85-95.

[5] M. Kummerow, J.C. Lun, Information and Communication Technology in the Real Estate Industry: Productivity, Industry Structure and Market Efficiency, *Telecommunications Policy*, Vol. 29, 2005, pp. 173-190.

[6] P. Breathnach, Globalisation, Information Technology and the Emergence of Niche Transnational Cities: the Growth of the Call Centre Sector in Dublin, *Geoforum*, Vol. 31, 2000, pp. 477-485.

[7] S. Usun, Information and Communications Technologies (ICT) in Teacher Education (ITE) Programs in the World and Turkey, *Procedia Social and Behavioral Sciences*, Vol. 1, 2009, pp. 331-334.

[8] N. Wang, N. Zhang, M. Wang, Wireless Sensors in Agriculture and Food Industry—Recent Development and Future Perspective, *Computers and Electronics in Agriculture*, Vol. 50, 2006, pp. 1-14.

[9] S. Geng, T. Ren, M. Wang, Technology and Infrastructure Considerations for E-Commerce in Chinese Agriculture, *Agricultural Sciences in China*, Vol. 6, No. 1, 2007, pp. 1-10.

[10] N. Niederhauser, T. Oberthur, S. Kattnig, J. Cock, Information and Its Management for Differentiation of Agricultural Products: The Example of Specialty Coffee, *Computers and Electronics in Agriculture*, Vol. 61, 2008, pp. 241-253.

[11] R. Bertolini, Making Information and Communication Technologies Work for Food Security in Africa, In *Making Information and Communication Technologies Work for Food Security in Africa*, International Food Policy Research Institute (IFPRI), 2004.

[12] J. Paul, R. Katz, S. Gallagher, *Lessons from the Field: an Overview of the Current Uses of Information and Communication Technologies for Development*, World Resources Institute, 2004.

[13] J. Leary, Z. L. Berge, Trends and Challenges of E-Learning in National and International Agricultural Development, *International Journal of Education and Development using Information and Communication Technology (IJEDICT)*, Vol. 2, No. 2, 2006, pp. 51-59.

[14] A. Nedyalkov, V. Borisova, Internet penetration in Agricultural Markets: the Pattern of Bulgaria and Ukraine, In I*AMO Forum 2005: How Effective is the Invisible Hand: Agricultural and Food Markets in Central and Eastern Europe?*, Institut für Agrarentwicklung in Mittel- und Osteuropa (IAMO), Halle (Saale), Germany, June 16-18, 2005.

[15] X. Jin, Research on E-business Intelligent Examination System, *Wseas Transactions on Information Science and Applications*, Vol. 1, No. 6, 2009, pp. 21-30.

[16] Senegal National Agency of Statistics and Demographic (ANSD/Sénégal), *Social-Economic Situation of Saint-Louis Region Year 2007*, Republic of Senegal, 2008.

[17] Senegal National Agency of Statistics and Demography (ANSD/Sénégal), *Social-Economic Situation of Dakar Region of Year 2007*, Republic of Senegal, 2008.

[18] Senegal National Agency of Statistics and Demography (ANSD/Sénégal), *Social-Economic Situation of Senegal: 2007*, Republic of Senegal, 2008.

[19] FAO, *Information System on Water and Agriculture (AQUASTAT)*, http://www.fao.org/nr/water/aquastat/data/query/index.html, 2009.

[20] FAO, *Statistical Databases (FAOSTAT)*, http://faostat.fao.org/, 2009.

[21] E. Hodgkinson, Senegal: Economy, In *Africa South of the Sahara 2005*, I. Frame, K. Murison, ed., Europa publications, 2004, pp. 960-964.

[22] Senegal Direction of Horticulture, *Bilan de la Campagne Horticole 2007-2008*, Republic of Senegal, 2009.

[23] A.W. Shepherd, *Market Information Services: Theory and Practice*, Food and Agriculture Organization (FAO), 1997.

[24] J. Kiplang'at, D.N. Ocholla, Diffusion of Information and Communication Technologies in Communication of Agricultural Information among Agricultural Researchers and Extension Workers in Kenya, *South African Journal of Library and Information Science*, Vol. 71, No. 3, 2005, pp. 234-246.

[25] O. Shatberashvili, A. Maru, Development of Agriculture Information Services in Central Asia and Caucasus, In *World Library and Information Congress: 74th IFLA General Conference and Council*, International Federation of Library Associations and Institutions (IFLA), Québec, Canada, August 10-14, 2008.

[26] S. Cecchini, C. Scott, Can Information and Communications Technology Applications Contribute to Poverty Reduction? Lessons from Rural India, *Information Technology for Development*, Vol. 10, 2003, pp. 73-84.

[27] C. Poulton, L. Mukwereza, W. Chaonwa, R. Loader, K. Mariga, P. Masanganise, D. Sanyatwe, J. Piesse, Providing Marketing Information to Smallholders in Zimbabwe: What can the State Usefully Do?, *Agrekon*, Vol. 39, No. 4, 2000, pp. 718-729.