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HAS COVID-19 AFFECTED SOFTWARE USABILITY: MOBILE ACCOUNTING SYSTEM AS A CASE

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ABSTRACT

The importance of electronic systems has increased due to COVID-19 because of the mobility constraints which stimulates businesses to look for remote work supporting systems. So, businesses either rapidly adopted off-the shelf software or demanded the development of new software solutions. This causes usability concerns including new difficulties to businesses because of the low usability of the off-the shelf systems that were not designed to address the challenges during the pandemic. Also, the development of new software usually requires much time and may not produce usable software if all requirements are not sufficiently addressed. Furthermore, the factors affecting usability after the COVID-19 have not been identified in related studies. Therefore, this research empirically investigates the usability of software by developing a mobile accounting system and conducting qualitative analyses to evaluate the system and identify the usability factors in the post COVID-19 era. This research contributes the Rapid Application Participatory Development (RAPD) method which is used to develop the system because this method enables rapid development, sufficient requirements elicitation by allowing users to participate in the design process, and usability testing during the development. The results show that the RAPD method can be used to develop usable software and mobile applications. Also, in addition to the traditional usability factors, COVID-19 has created new usability factors including remote work, user experience, security, privacy, artificial intelligence and internet speed.

Keywords: *Mobile Accounting System, COVID19, Rapid Application Participatory Development, Usability testing.*

1. INTRODUCTION

This COVID-19 has made the need for electronic systems that support remote work more urgent [1]. Many companies and organizations have realized that remote work is necessary and can last even after COVID19 since work productivity can be maintained at a satisfying level [2]. Unfortunately, the fast adoption of off-the shelf software or the fast upgrading of existing ones worsened the situation because the resulting solutions are not usable. In most cases, the resulting solutions impose a new workflow and require complicated professional skills adding new burdens to businesses [3].

The transition from on-site work to remote work has to be through usable systems that preserve workflow for enabling employees to adapt to new work environment quickly, efficiently and securely [4]. Usability of software systems has been the focus of many studies, for example [5]–[8]. These studies identified the factors affecting usability. Although different terms are used to describe these factors, these terms can be grouped into fundamental ones including efficiency, learnability, memorability, visibility, flexibility, decision-support, accuracy, usefulness, satisfaction, simplicity, security and reliability. However, few research has studied the usability of electronic systems developed for COVID-19, for example [3], [4]. While several systems that can work during COVID-19 have been developed (e.g. [9], [10]), they do not show how the systems maintain usability, workflow or captures requirements. Further, few research has discussed the usability of these systems after the end of the pandemic.

To answer the question of whether COVID-19 has affected electronic systems usability or not, this research firstly developed a mobile accounting system for the Jericho Central Vegetable Market. The system was developed by the method proposed in [32] with some modifications because this method allows for rapid development, user participation in the design and usability testing. Secondly, the usability of the developed system was evaluated by conducting qualitative usability analysis and interviewing users after they used the system. The results show that the system is usable and accepted by users because the system satisfies all usability factors. Furthermore, the results show that COVID-19 has created new usability factors in addition to those discussed in the previous fundamental studies [5]–[8]. So, the contribution of this research is:

- Modifying the RAPD method for supporting the development of mobile applications,
- Showing that the RAPD method, which was proposed to be used during COVID-19, can still be used to develop usable mobile based systems that support remote work after COVID-19,
- Showing that in addition to the traditional usability factors that are efficiency, learnability, memorability, flexibility, accuracy, and user satisfaction, COVID-19 has created new usability factors including remote work, user experience, security, privacy, artificial intelligence and internet speed.

2. METHOD

This section presents the method used to develop the mobile accounting system.

2.1 System Development

We used the RAPD method proposed in [32] to develop the system as this method enables the development of usable systems rapidly. We made some modifications to RAPD to enable a more rapid development. The modification includes removing the comparison testing from the RAPD stages and using all electronic artifacts of the desktop system. This modification is justified because an electronic system that is a desktop application with all required functionalities is available. So, the comparison test, which was used to find alternative solutions, is not necessary as the main focus becomes converting the desktop system to a mobile one.

The RAPD method integrates Rapid Application Development (RAD), Participatory Design (PD), and usability testing to enable rapid user centered development [32]. RAD, PD, and usability testing were integrated in research before for developing different types of software applications (e.g. [20]–[24]). RAD is used to enable fast development and fast delivery of the system [15], and process in RAD consists of the following [32]:

1- Requirement planning stage: The designers meet with clients and form a team to analyze requirements, identify all entities, draw action diagrams, and define all interactions between functions and data.
2- Joint application development (JAD): the team revises the requirements for determining the core ones, develops the entities collected in the requirements planning into a data model and diagrams, develops test plans, and creates layouts and design for the system based on object oriented programming.
3- Construction stage: the team iteratively develops and tests the system, refines the requirements until the system is complete. The developers convert the data model into a functional prototype which is tested by the construction team using test scripts developed in JAD. During this stage, the designers meet also with users to refine the design.
4- Implementation stage: the system in deployed and the end users are trained on using the system.

The PD enables the participation of users for capturing all requirements, and the design process in PD passes through three main stages [13]:

1- Pre-design stage: designers and users decide the project plan, objectives and schedule, and they select representatives to perform the coming design tasks.
2- Requirement analysis and design stage: this stage is divided into three sub-stages:
   - Stage 2-A: designers and user representatives analyze the organizational workflow and feed the design with the output resulting from data collection and analysis. Documents are created to maintain the focus of all participants in the design process.
   - Stage 2-B: Then, developers build a prototype based on the earlier analysis, and each update is also documented.
   - Stage 2-C: After that, further technical issues are determined and the design can be revised to include new technologies.
3- Post-design stage: the prototype is implemented and tested against the project plan and

objectives. The final specifications are also identified and documented.

The usability testing enables the evaluation of the system usability at all design stages [18], [19]. Usability testing includes different types of tests which are performed during different design stages, and these tests include:

- The exploratory test is carried out early to test preliminary design concepts,
- the prototype test is used during requirements gathering to provide iterative feedback into evolving design of prototypes or systems,

the validation test is conducted to ensure that completed software products are acceptable regarding predefined acceptance measures.

2.1.1 Stage 1

This is a predesign stage in which designers meet with end users to identify the system and sign the contract. The first meeting in this research was physical as it is necessary to meet with end users face to face and make agreements. The procedures of this stage are shown in Fig. 1. To analyze the requirements, the designers collected artifacts including user stories, documents, and a video of workflow. The designers found that the existing desktop system can be consider as an electronic artifact. So, the e-system is an input for this stage. During this stage, the designers categorized the users into direct users and indirect users. The direct users of this system are the auctioning store owners and their employees, and they have different privileges for accessing the data entry, data inquiry and setting screens. The indirect users are the farmers, traders, and supply stores owners, they have limited access, and they can make inquiries to view their accounts, bills, and balances only.

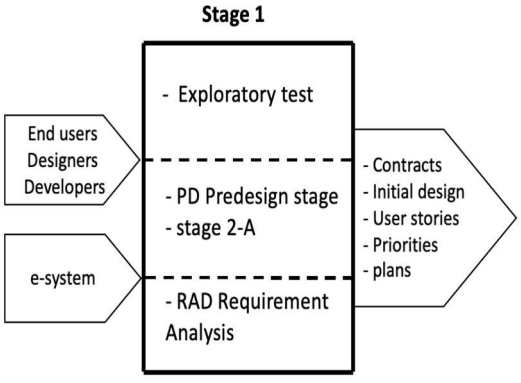

Figure 1: The first development stage for the mobile accounting system

Based on the requirement analysis of RAD, the PD pre-design stage and PD stage 2-A, the designers put the initial design including all needed diagrams, entities, and initial interfaces. The designers and the direct users met virtually and cooperated on performing exploratory usability testing to refine the requirement. The designers decided to develop a mobile-based system providing different services supported by cloud computing to enable remote work. Most systems tasks are identified in this stage and prioritized according to dependency, as shown in Table 1. This means the developers started building the services that serve the other ones. For example, the data entry service should be developed before an inquiry service which depends on the data entry. All details in this stage were documented to enable further design follow up.

Table 1: The dependencies of services developed in stage 1.

Stage	Priority	Service
1	1	Data entry of accounts for customers, such as farmers, traders, suppliers, and employees
1	2	Settings to conFig.all needed parameters, such as tax, commission, box prices, employee's month salary, and others,
1	3	Data entry for daily transactions: inputting daily sales, daily payments, and daily receipts,
1	4	Data Review screens for Daily auditing of all transactions,
1	5	Basic query
1	6	Report view and printing services customized to end user formats (language, size and shape),
1	7	Billing and balancing accounts,
1	8	Inquiry service including daily or accumulative customer balance, daily or accumulative bill, store daily and accumulative balance, commissions, taxes,

2.1.2 Stage 2

The purpose of this stage is allowing developers to develop an initial prototype based on the output of stage 1. As shown in fig. 2, the input to this stage is the artifact, initial design, and priorities of services. The designers, developers and end users work according to PD 2-B, PD 2-C and RAD JAD to convert the initial design to an initial prototype. The meetings in this stage were virtual. The designers then met virtually with the direct users and representatives of indirect users to run usability prototype testing using predefined test cases. This assisted the designers in refining the requirements and the prototype. Then, the developers refined the prototype and uploaded it to the cloud.

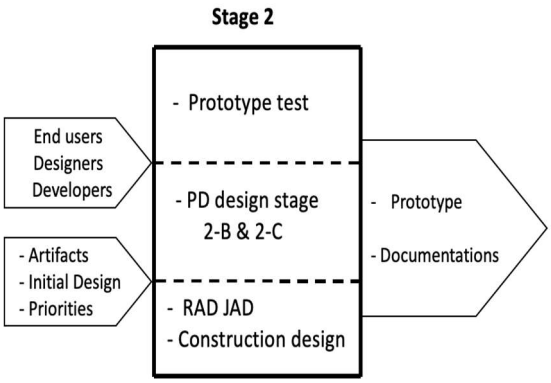

Figure 2: The second development stage of the mobile accounting system

The dependencies were also refined and new dependencies were identified, as shown in Table 2. The system was distributed to direct users to let them try its services and give feedback. During this period, the participants conducted comparison testing to check for alternatives. All documents related to the refined requirements, user stories, and design were collected and maintained for future modifications.

Table 2: The dependencies of services developed in stage 2.

Stage	Priority	Service
2	1	Direct users: service to create user authentication credentials
2	2	Direct/indirect users: Log in service with defined user privileges
2	3	Indirect users: Services such as viewing bills and balances, requesting changes, and modifying entries
2	3	Indirect users: billing and balancing inquiries
2	3	Direct users: advanced inquiries

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2.1.3 Stage 3

The input of this stage, as shown in Fig. 3, consists of the prototype developed in stage 2 and the documentations. According to PD post design and RAD implementation, the developers implemented all refined requirements resulted from stage 2. Then, the designers met virtually with the direct users and representatives of indirect users to run usability validation testing for ensuring that all objectives and plans were considered. The result of this stage is a mobile-based system consisting of responsive web supported by the cloud, and detailed documentations.

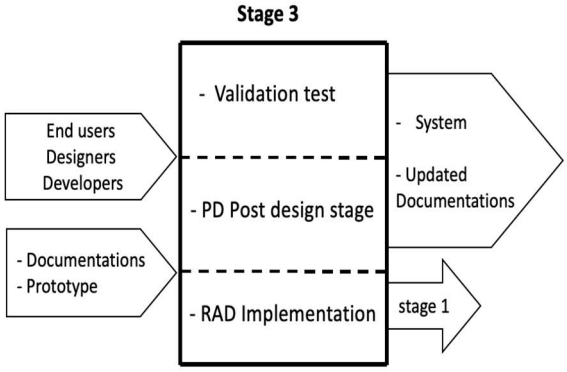

Figure 3. The third development stage of the mobile accounting system

2.2 Usability Analysis

We used the RAPD method proposed in [32] to develop the system as this method enables the development For usability analysis, we depended on cognitive walkthrough which is for understanding usability factors associated with the performance of each system task using a specific interface [25], [26]. We conducted qualitative usability tests through interview because we focus on users who interact with the system to identify their problems and challenges during each work session. We interviewed 16 users: six direct users, five traders, and five farmers. During the interviews, we focused on the factors affecting usability which are shown in [6]–[8]. We also asked users to compare between the developed system and other systems used previously in the market.

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All interviews including those conducted during the design process and those after the completion of the system were transcribed for analysis and coded by the coders who are the researchers and one developer. The coders had two meetings in which they used thematic analysis, described in [27], [28], for grouping codes that have similar factors. By the end of these meeting, the coders could identify the factors affecting the usability of an electronic system used after the end of COVID-19.

3. RESULTS AND DISSCUSSIONS

This research aims at developing a usable mobile accounting system that supports the entire business life cycle in the Jericho Central Vegetable Market. The system is cloud based with responsive web design that can run on different mobile devices to support remote work. The users of the system are the owners of the auctioning stores in the market, 120 farmers who sell their products in the four stores, 70 traders who buy from the market and distribute to other cities, and nine agriculture supply stores who provide farmers with plants, fertilizers and other materials. This section shows and discusses the results of the development stages and the results of the usability analysis.

3.1 System Functionality

The main components of the system are classified into authentication screen, data entry screens, data review/editing screens, inquiry screens, report view screens, and setting screens. The system has a menu that helps users navigate from screen to screen, and the users stated that the menu should be displayed on the top of the active screen to make the navigation easy. In this section, we present examples of the main screens.

3.1.1 Data entry screens

There are several data entry screens in the system including the main entry screen, the payment screen, the receipts screen, and the screen for material supply stores. Fig. 4 shows the main data entry screens which appears after a user logs in to the system. In this screen, the user inputs the daily auctioning transactions. Each transaction contains the name of the farmer who sells the product and its parameter, and this needs to be specified in the area with orange background. Also, the name of the trader who buys the product and its related parameters, and this needs to be specified in the area with dark blue color.

Fig. 4. The main data entry screen for the daily auctioning transaction

The parameters associated with each transaction include the commission rate, price of empty box, cost of renting a box, cost of transportation of each box. The business model in the market allows the farmer to rent empty boxes and return them back filled with vegetables. The trader who buys vegetables may not return back the boxes and in this case, the trader has to pay for the boxes. If boxes are returned back, the trader only pays the cost of renting them. The bottom of the screen contains the places when the user enters the product name, price, quantity, and weight if the product is sold by weight not quantity. Each transaction is displayed as a row in the table at the bottom of the screen for enabling the user to review and modify if a mistake occurred. The system calculates the total prices and prepares the data for billing.

The usability of this screen depends on the way how the users input the data to the system. During stage 1 and stage 2, the users stated that for each farmer, there are several traders who buy his/her products. So, the system should allow the users to select a farmer name, and while the farmer name is displayed on the screen, a different trader can be selected and changed continuously until all transactions corresponding to the farmer finish. Also, for enhancing the usability, the user does not need to type the entire name. Instead, the user only types the first alphabet and then select the name from a list. Also, the users selected the colors in the

backgrounds to enable them distinguish between the fields. Further, the screen allows the users to modify the transaction in case something is missing or inputted incorrectly. In stage 3, the designers and users refined these requirements and ensured that this screen makes the required computations without errors. The other data entry screens follow the same style.

3.1.2 Data Review Screens

These screens enable the user to review all transactions for a specific date and modify if needed. The purpose of these screens is allowing the user to run a complete and comprehensive check of all transactions although these transactions were reviews at the entry stage. Also, the user stated that customers may come after one day or more asking for modifying a transaction due to some changes. Each data entry screen is associated with a review screen and Fig. 5 shows an example of the daily auctioning data review screen which is associated with the main data entry screen.

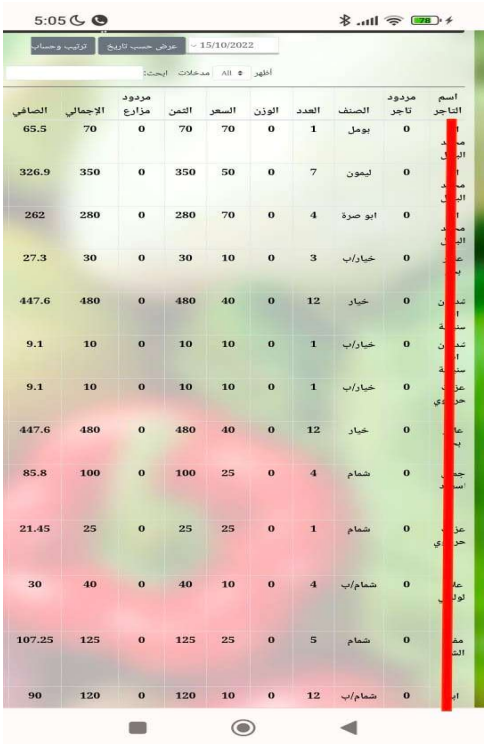

Fig. 5. An example of data review and editing screens. This screen enables the user to review the daily auctioning transactions.

Fig.5 also shows that the user can select one transaction for modifications by clicking a specific row which opens a new screen that allows the user to change the parameters of the selected transaction. The user can also display data from previous dates and can print the contents in case the user wants to review on papers. The color, font size, number of rows per pages, and review style were selected based on user preferences identified during stage 1 and stage 2 and refined during stage 3. Other data review screens follow the same style of usability.

3.1.3 Data Enquiry Screens

In fact, these screens are the most difficult part in the system and costed much of the development time. This is because the users maintain creating new forms of necessary inquiries and they want each inquiry very customized to what they look for. For example, a general inquiry form can display the name of the farmers, traders and all other parameters in one report. But, the users stated they need to show the farmer only, the trader only or a specific transaction. They sometimes need the total balance or details of the balance. Fig. 6 shows the inquiry screen related to the billing part, and this screen enables the user to inquire about a daily bill or a bill in a specific date. This style is based on user preferences because the bills for the day are requested more often than older ones. So, the user can view all the daily bills in one clock, and he can also select a bill for a previous date. The bill is associated to traders or farmers.

Fig.6. The main inquiry screen where the user can make inquiries about most of the data.

The colors, font, date format, and size of screen objects are selected based on user preferences which were identified during stage 1 and stage 2 and refined during stage 3.

3.1.4 Report View Screens

These screens are associated with the data inquiry screens. Each inquiry button opens a new report screen based on the information specified in the inquiry, such as the names, dates, and types. The reports imitate real artifacts used in the market. If a new format or style of report needs to be generated, the users have to agree on that format or style. Fig. 7 shows an example of report associated with the bill of a trader in a specific day.

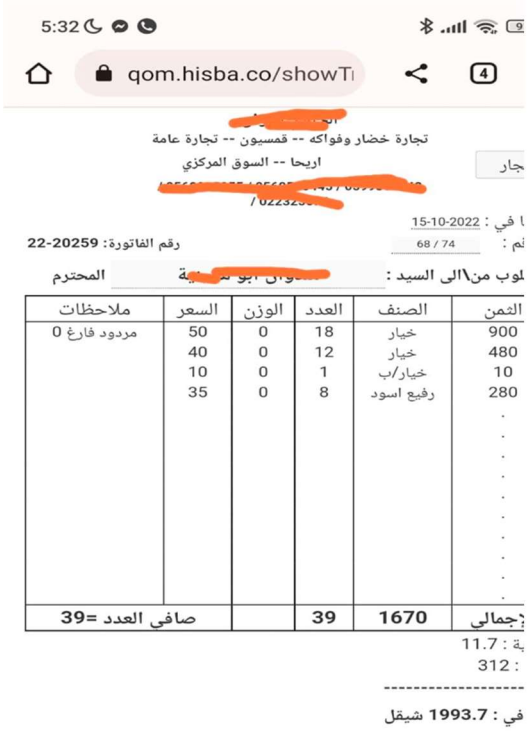

Fig.7. An example of a detailed bill of one trader showing four transactions and their associates parameters.

3.2 Usability Results

The results of the qualitative analysis show that the usability of system is very high. According to users, the high usability of the system is justified by:

- This system was designed according to the user instructions through user participation,
- users were allowed to input their requirements in each stage, and they could refine their requirements in the next stage by experiencing a running prototype,
- the users compared the time required for learning the system and mastering its screens, and they stated the time is smaller than learning the other accounting systems used before in the market,
- the users compared the time required to complete a task related to one transaction; entry, reviewing, printing, and other related queries with other systems, and they stated this time is smaller which makes the system more efficient.

Furthermore, this study identifies the usability factors affecting the acceptance of an accounting system after COVID-19. These factors are:

1- Remote work: the users stated that electronic systems after COVID-19 should support remote work by allowing access to data and services at any time from any place. The users emphasized this statement by showing that the mobile accounting system has an important advantage over previous systems; that is supporting remote work. They added remote work benefits all users not only during the mobility constraints but also during the normal conditions. Farmers and traders became able to check their financial accounts online without traveling long distances. So, remote work maintains user safety, saves user time, effort and money in all aspects in the market. According to users, remote work was the most important factor that affects their acceptance of the system.

2- User experience (UX): the users stated that their experience should be incorporated in the design by participating in the design process through planning, prototyping, experimenting and validating. The development of the mobile accounting system allows the user to participate in each design stage and add their perception. The UX factor was clear because users are familiar of using mobile applications, particularly social media apps. This made the users insist on changing colors, objects size, font style, and backgrounds. They also insisted on reflecting the perception related to the traditional workflow in the market on the new system.

3- Security and privacy: the users consider new electronic systems which run on internet vulnerable to attacks and therefore these systems should utilize methods that maintain security and privacy. Security and privacy are

well known usability factors although users of small systems used to ignore them before COVID-19. But, after the pandemic, the users insisted on addressing security and privacy as the systems become more dependent on internet and used remotely. In the mobile electronic system, the users consider their financial data are very sensitive so only authenticated users must have access to the system. To preserve privacy, every user, trader, or farmer can access his/her own data without viewing the data of others.

4- Artificial Intelligence (AI): the users added that the AI methods and technologies should be used in new systems to save effort and time. In the mobile accounting system, the users demanded that the system should minimize their effort of typing data in the screen fields. So, the system uses an AI algorithm that renders the data by typing first alphabet. Also, users demanded voice recognition to enable them input the data by a microphone and image recognition to enable identifying products.
5- Internet speed: the users believe that remote work is vital and the internet speed should be sufficient to enable efficient communication between the system and the servers with minimum delay.
6- Work efficiency: the users stated that an electronic system should reduce the time and effort spend on performing work routing. In the mobile accounting system, the time to submit a request, load a screen and view inquiry results is very short. Also, the system saves user time by reducing the paper work.
7- Easy to learn and memorize: the users stated that electronic systems should be easy to learn and their functions should be easy to memorize. The mobile accounting system imitates the traditional workflow in the market, and the system does not impose new work routines. This made the system simple and enable users to learn how to use it easily and remember its functions quickly.
8- Accuracy: the users emphasized that new electronic systems should be very accurate. The mobile accounting system enables the users to fix mistakes at the entry screens and in the review screens. The users depend on the visibility, i.e. colors and shapes, to distinguish between input fields and therefore reducing the probability of inputting data in the wrong field. Also, several constraints are put on the entry boxes to reduce the error possibilities.
9- User satisfaction: the users stated that electronic systems should be useful, easy to use, customized to their needs, with accepted visible interface, and with suitable content. The mobile accounting systems satisfies these conditions because the users participated in the design and ensured that the system is useful, easy to use, customized to their needs, with accepted visible interface and suitable content.

In comparison with earlier systems adopted in the market, the users added that some of the previously purchased systems were not used for few months because they found them difficult to use, and these systems do not follow the workflow of the market. On the contrary, these systems imposed new work routines, new style of inquiries, and new formats of reports. Also, the users emphasized that the system was delivered to users in a short time (47 days) which enabled them to put it in use quickly and reduce the risk of infection. This was not the case in previous systems because they used to take long time for development or modifications.

4. CONCLUSION

The answer to the question of whether COVID-19 has affected the usability of electronic systems is Yes. This research has answered this question empirically by firstly developing a mobile accounting system for the Jericho Central Vegetable Market to respond to the needs emerged due to COVID-19. The system was developed using the RAPD method [32] which integrates RAD, PD, and usability testing. This development method enables rapid production while allowing users to participate in all design stages. The usability testing allows the development team to refine and validate requirements, designs, and porotypes. Secondly, the usability of the developed system was analyzed by the qualitative cognitive walkthrough method. The results show that the system is usable, and COVID-19 has created new factors that affect electronic systems usability in addition to the factors shown in [5]–[8]. These factors include remote work, user experience, security, privacy, artificial intelligence, and internet speed.

The future work will focus on using machine learning to improve the decision-making process in the market. Such service would assist auctioning shops in planning for new seasons in in terms of crops, land, and number of farmers. We will also use blockchain technology for enhancing the security and integrity of the data, similar to [29]–[31]. Blockchain will be necessary when the mobile

accounting system is connected to all city markets in Palestine.

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