# **Usability and Accessibility in Agricultural Software: A Systematic Review**

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**Context:**

Accessibility and usability add quality to a digital service or product. The low level of these attributes reason for the user demotivation and in the agricultural field it can result in low use of software that helps farmers control their agricultural activities.

**Objective:**

Performing bibliographic review about accessibility and usability attributes in software turned to agricultural and web applications. Through systematic review is possible to identify the art state in the theme, such as: measurement techniques, users difficulties, the benefits when these concepts are applied , employed tools, solutions to problems found, ways to access software, and the most used agricultural software.

**Method:**

The Systematic Review Technique was performed using four (4) databases. As result and after filters and duplicated removed were selected 6.577 studies such as papers of journals and conference proceedings. Subsequently the application of the inclusion and exclusion criteria 28 relevant studies about the research theme were highlighted.

**Results:**

Among the results it is highlighted the limitations of the current tools: necessity of measurement regarding how much one of the attributes had been applied to the system, necessity of performing qualitative tests, and identifying serious problems rather than the trivial.

**Conclusions:**

Despite the large number of works related to agricultural software, few studies on accessibility in agricultural software were carried out. Also, this research revealed several problems and deficiencies related to this theme and it was possible to verify the need for more research and consequently development of software with more accessibility and usability in agriculture.

**1. INTRODUCTION**

Accessibility and usability increases quality to a product or service in the digital scope (CASARE *et al.*, 2016). The usability is considered a decisive factor to the services success(FLÁVIAN *et al.*, 2004) and the low level of this attribute entails time loss, demotivation to the user(CEAPARU *et al.*, 2004).

# The accessibility represent the relationship between information and communication in context to the individual needs and preferences (NEVILE, 2008).

# The usability is identified as an important factor in the adoption of information systems in agriculture (ALVAREZ *et al.*, 2006). The usability problems in agricultural systems result in unintuitive, complex interfaces, or interfaces with a quantity of resources are greater than necessary for a given context. (NIKKILÄ *et al.*, 2010).

# In relation to Precision Agriculture, usefulness and facility of use are key aspects considered in the adoption of applications, as long as they do not bring substantial increasing to the production costs (PIERPAOLI *et al.* 2013). The evaluation of software usability in the Precision Agriculture is needed in order to meet the requirements of the users (HAAPALA *et al.*, 2006).

Researches have shown that the internet access among farmers has increased. Between 2009 and 2010, 30% of the Brazilian farmers were used to accessing the internet; in the period between 2013 and 2014 this rate rose to 39%. Regarding the access way, 71% occurs through computer, 19% through smartphone, 7% through common cell phone and 4% through tablet (ABMRA, 2013).

The development of this study focused on agriculture has been driven by the need to identify the technological situation in rural areas, specifically in topics of usability and accessibility in agricultural software. This paper performs a systematic review to evaluate and interpret relevant studies on a research subject (PAZ; POW-SANG, 2016). This study used a systematic review method proposed by Brereton *et al.*(2007), Kitchenham (2014) and Pagani *et al.*(2015).

This works consists in seven sections. Section 2 presents accessibility and usability concepts and evaluation means. Section 3 present the related works. Section 4 presents the steps, planning and the systematic review performing. Section 5 describes the related studies and answers to the research questions. The Section 6 reports the results this works. Section 7 presents conclusions and further researches that can be performed after this study.

**2. USABILITY AND ACCESSIBILITY**

Nielsen(1993) defines usability as a set of factors directed to qualify how well a person is able to interact with a system. The author considers as usability factors the learning and remindingfacility, efficiency, safety of use and satisfaction.

Preece (1994) refers to usability as a measure of the facility provided by a systemregarding its learning or use. Holland *et al.* (2012) defend that usability refers to the facility with which the users are able to use a system.

According to ISSO/IEC 9126 (1991), the usability consists of a set of attributes related to the demand of effort on the use of an interactive system, and the individual evaluation made by a specific group of users.

The ISO/TR 16982 (2002) cites as usability evaluation methods, questionnaires, interviews, project techniques, participatory evaluation, or methods which involve the final users.

The web accessibility has as objective allowing users, with or without disabilities, to have a democratic access to information (W3C, 2008). And, in order to guarantee if a page is accessible, it’s needed the use of automatic validation methods along with the human evaluation, besides being important to identify which users will perform the access and their respective disabilities. Few websites have accessible structure and content to all kinds of users, thus the adaptation of those websites is able to build an egalitarian environment (Carmen *et al.,* 2015).

Besides bringing benefits to disabled people, the web accessibility also assists users who have difficulties to interact with the internet and depend on resources which are able to ease the access to these tools(ROCHA *et al.,* 2012). For instance, the elderlies are susceptible to the reduction of their abilities over the years(Cusin, 2010).

There are standards to provide accessible design and methods to evaluate the accessibility, directed principally to web content(TANAKA, 2010). According to Baazem, et al. (2015), the accessibility evaluation regarding web is performed with one, or a combination of the methods: automated verification tools, manual evaluation made by specialists, users’ tests, and surveys aiming to identify reasons relationship inaccessibility problems.

**3. RELATED WORKS**

Paz *et al.*, (2016) applied the systematic review process in order to determine current trends on the use of usability evaluation methods to software development processes. The software categories frequently related in usability tests and the techniques employed by software category were presented. The study was motivated due to the existence of a wide range of techniques used to measure usability, which, on account of its volume, hampers the choice of the most appropriate method to a certain scenario.It was inferred that the most used techniques according to the literature are the questionnaire, the user’s test, the heuristic evaluations, the interviews and the aloud thinking.

Garcés *et al.* (2017) performed systematic mapping about the art state of models and quality attributes, relevant to the Ambient Assisted Living (AAL). It was also approached how these attributes were defined, evaluated and used. The study was motivated by the lack of an overarching analysis related to quality guarantee of these systems.

Among the identified quality attributes are present the usability, learning facility, user aesthetic interface, and accessibility. The authors remark that the AALsystems interface is directed to three different kinds of users: The assisted people, medical and maintenance staff. When the elderly are the public to which the system is directed, the learning facility becomes even more important. The accessibility is especially desired in anticipatory interfaces, which are the mandatory kind on AAL systems, and it is destined to provide direct contact with relatives and healthcare professionals in emergencies.

The study inferred that there is a necessity of major agreement from the interested parts in the AAL systems development. It is approached the importance of developing a model able to define quality attributes, considerate its variability according to the assisted life environment domain, analyze the dependence among the attributes, offer indicators and measures to perform measurement, and offer means to evaluate and predict the quality of AAL systems.

Fernandez *et al.*, (2011), developed systematic mapping for surveying the usability evaluation methods used by researchers on the evaluation of web applications in the last 14 years. The motive of the research arose because the applications developed not always fulfill the usability expectations of the customers, despite the existence of methods to survey the usability.Approximately 39% of the analyzed studies used specific evaluation methods designated to web. The User’s Test is the most used method, applied to 59% of the studies. Among the subtypes of the user’s tests which were identified, it is highlighted the Aloud Thinking Protocol, Interviews, Performance Measurement, Log Analysis, and Remote Test.

The inspection methods were applied to 43% of the analyzed studies, and it is highlighted among them the Heuristic Evaluation, Cognitive Course, Inspection Based on Perspective, and Guidelines Review. Inquiry Methods were present in 35% of the articles, and the Analytical Modeling, in 21%.

About 90% of the studies applied evaluations during the implementation phase of web development, and since it is the most expensive phase to perform changes, the evaluations were usually performed in a unique step of the application development. It was also noticed that the usability evaluation methods are based on different concepts, therefore they might not evaluate the same aspects, and this characteristic turns the comparison among them into a complex task.

The majority of the methods were projected to generate a list of usability problems. This list doesnot include guidelines about how they may be fixed. There were no results thatcould be generalized for web; these studies are specifics in the domain.

There is few methods specifically created to the web domain and which may be applied on the initial stage of the development. The automation the methods may reduce efforts and resources, however it doesnot consider the perceptions and condition of the user and this is a disadvantage. The authors suggest that the methods to be applied in a combined form in order to provide better results and consider as many usability dimensions as possible.

**4. REVIEW PROCESS**

Systematic approaches of literature review have appeared due to the necessity of locating, evaluating and adding results from a number of empirical studies related to a specific topic of interest. This necessity has been approached in many areas, including: clinical medicine, social policy, education and information (SACKETT *et al.*, 2000).

It may be defined as a research method used to identify, evaluate and synthetize substantial studies about a specific area. As a result, it is aimed finding evidences about specific questions of a research or gaps which need definition (DYBA *et al.*, 2005).

The systematic review method approached in this work is based on Brereton *et al.*(2007), Kitchenham (2014) and Pagani *et al.*(2015) studies, being the biggest part of the process based on Pagani *et al.*(2015).

The contributions of Brereton *et al.*(2007) and Kitchenham (2014) are related to the process documentation which has occurred with the elaboration of the Review Protocol document. The application of the Kitchenham (2014) study takes place, specifically, on the Review Protocol content making. The Figure 1 identifies review process steps applied to this works.

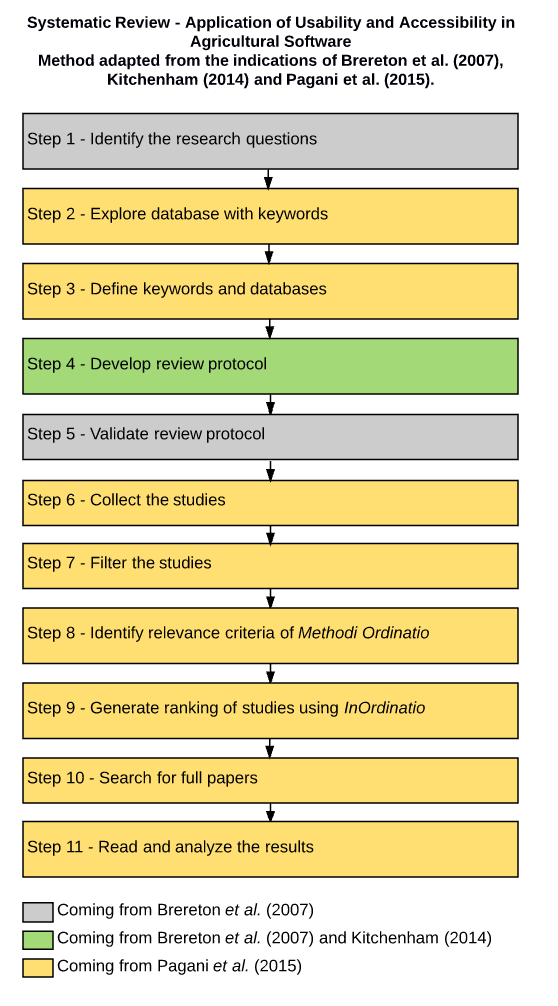
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Figure 1 – Proposed systematic review method.

(colocar Phase from Brereton et al. (2007))

In the first step specifying the research questions and defined the data to be extracted (BRERETON et al., 2007). The Brereton et al (2007) method does not propose the grouping of questions, so it was used the approach of Queiroz et al. (2015) to group the questions by objective. An adaptation of the Queiroz et al. (2015) method was performed. The grouping used the GQM (Goal/Question/Metrics) Basili et al. (1994). The GQM framework consists of the following three steps:

1. Generate a set of goals
2. Derivate a set of questions
3. Develop a group of metrics that provides necessary information to answer the questions.

The GQM framework may be applied is based in the premise that, in order to measure, it is necessary to firstly specify the objectives.

The second step consists of the exploration of databases by using keywords, and its main goal is evaluating and testing the terms adhesion to the available filters. In the third step are defined the combination of keywords with substantial databases (PAGANI *et al.*, 2015).

The fourth step has a documental aspect, and by means of the Review Protocol creation is defined how the process will occur, as well as the conditions required to its execution. This document has to be constantly reviewed, just as the changes have to be controlled through versioning (BRERETON *et al.*, 2007). In the fifth step the protocol has to be approved by an external member of the development team(BRERETON *et al.*, 2007); doctoral students, for instance, must present the protocol to their supervisors (KITCHENHAM, 2004).

The review is executed in the sixth step, in which the data have to be exported to a reference manager. The seventh step performs the studies filtering procedure, by eliminating duplicated data or articles which do not belong to the designated area; to this end the title, the abstract and the keywords are examined. Subsequently, in the eighth step, it is calculated the relevance of each study through the application of the InOrdinatio method. The ninth step generates a ranking of the most relevant works (PAGANI *et al.*, 2015).

In the end of the process, there are the tenth and eleventh steps, which are responsible for performing the search for the complete version of the documents, and the final reading by obeying the InOrdinatio order, respectively.

**4.1. SYSTEMATIC REVIEW PLANNING**

The systematic review planning starts in the first and it ends in the fourth step of the Systematic Review Process, which has been exposed in the Figure 1. As the final product, it is generated the Systematic Review Protocol document.

This document has to include the justification, research questions; studies search strategy, selection criteria definition, quality criteria definition, extraction strategy, data synthesis, and timeline elaboration (KITCHENHAM, 2004). Subsequently it will be shown the way each one of these requirements has been developed in this work.

**4.1.1. JUSTIFICATION AND RESEARCH QUESTIONS**

The systematic review has developed to perform survey about usability and accessibility, emphasizing the web applications and agricultural domain.The Table 1 presents the defined research questions, and this activity corresponds to the first step of the systematic review process. The development of these questions has taken place by basing itself on the observation of other studies regarding Systematic Review, some of them being Fernandez (2008), Fernandez et al.(2011) and Ribas et al. (2015).

Table 1 - Research questions

|  |  |
| --- | --- |
| **Researsch questions** | |
| Question 1 | Is there an indication of problems caused by the lack of usability and accessibility? Are there problems specifically mentioned for the agricultural domain? Is the device by which the software accessed? |
| Question 2 | What are initiatives, evaluation methods or products designed to promote usability and accessibility of software?What are the limitations? Are they specific to the agricultural domain? Who is leading the initiatives? |
| Question 3 | Are there records on the benefits of applying accessibility and usability? Are ways of measuring these attributes pointed out? |
| Question 4 | What are the most used agricultural software? Are they geared toward Precision Agriculture (AP)? Are they aimed at family or business agriculture? |

**4.1.2. SEARCH STRATEGY**

In order to select databases, it has been considered notes in systematic review studies; more specifically Dyba *et al.* (2005), Brereton *et al.* (2009), Kitcheman *et al.* (2009), Pagani *et al.* (2015) and Ribas *et al.*(2015). It has been conducted exploratory research about 15 databases which were indicated in those studies cited above, which corresponds to the second step of the review process. As the result, 4 databases have been selected to the execution of the Systematic Review, all of which are in Table 2. This activity corresponds to the third step of the review process.

Table 2 - Research bases

|  |  |  |
| --- | --- | --- |
| **Base Number** | **Search Base Name** | **Available in** |
| 1 | ACM Digital Library | http://dl.acm.org |
| 2 | Science Direct | http://www.sciencedirect.com |
| 3 | Scielo | http://www.scielo.org/php/index.php |
| 4 | Web Of Science | https://login.webofknowledge.com |

As well as the databases, it has been also conducted explanatory research in order to select the keywords. After the procedure execution, the defined keywords are: “Usability”, “Accessibility”, “Agriculture”, “Software”, “Farming”, and “Tillage”.As palavras-chaves foram procuradas em inglês, espanhos e português.

The searches have occurred after the combination of two or more keywords by using the logical operator “AND”; its details are shown in Table 3.

Table 3 –Keywords combinations

|  |  |
| --- | --- |
| **Number** | **Keywords** |
| 1 | Usabilidade AND Acessibilidade |
| 2 | Usability AND Agriculture |
| 3 | Accessibility AND Agriculture |
| 4 | Usability AND Accessibility |
| 5 | Usability AND Accessibility AND Agriculture |
| 6 | Usability AND Farming |
| 7 | Accessibility AND Farming |
| 8 | Usability AND Software AND Agriculture |
| 9 | Accessibility AND Software AND Agriculture 0 |
| 10 | Acessibilidade AND métodos AND avaliação |
| 11 | Usability AND evaluation AND methods |
| 12 | Accessibility AND evaluation AND methods |
| 13 | Usabilidad AND métodos AND evaluación |
| 14 | Usabilidade AND métodos AND avaliação |
| 15 | Accessibilidad AND métodos AND evaluación |

**4.1.3. SELECTION CRITERIA**

In order to take part of the review, the study, besides being returned by the search in the database, has to possess all the characteristics defined in Table 4.

Table 4 - Selection criteria for primary studies

|  |  |
| --- | --- |
| **Criteria for Selection of Primary Studies** | |
| 1 | The studies should be articles from periodicals or annals of congress. |
| 2 | The material must have been published in thebases presented in Table 2 |
| 3 | The study should be written in English, Portuguese or Spanish. |
| 4 | The study should have been published between the years 1993-2016. |
| 5 | The studies must be available through the web. |
| 6 | The studies should contain one of the keywords in their titles, abstract or keywords |
| 7 | Studies should address usability or accessibility |

**4.1.4. QUALITY CRITERIA**

|  |  |  |  |
| --- | --- | --- | --- |
| It has been opted to use the MethodiOrdinatio, which was defined by Pagani *et al.* (2015), as a form of measuring quality. By calculating the InOrdinatio index, this method defines the scientific relevance of a publication. So that it is been used three criteria: impact factor, year of publication and quotation amount. The variables present in the calculation may be extracted from a number of indexes, among which are JCR (*Journal Citation Reports*) and SJR (*Scientific Journal Rankings*). It was opted by the use of SJR because it analyzes both magazines and conferences publications.The InOrdinatio calculation is done by using the formula (1):   |  |  | | --- | --- | | *InOrdinatio* = (FI/1000) + FP \* [10- (Year of research – Year of publication)] + (∑ Quotation amount) | (1) | | (1) |

where:

* FI is the impact factor,
* FP is the weighting factor which varies from 1 to 10 and has to be provided by the researcher.
* Year of research is the year in which the research was developed,
* Year of publication is the year in which the research was published,
* ∑Quotation amount is how many times the article was quoted.

The needed values to fill the calculation variables have been extracted from the SJR index.The Figure 2 presents an example of the InOrdinatio index calculation.

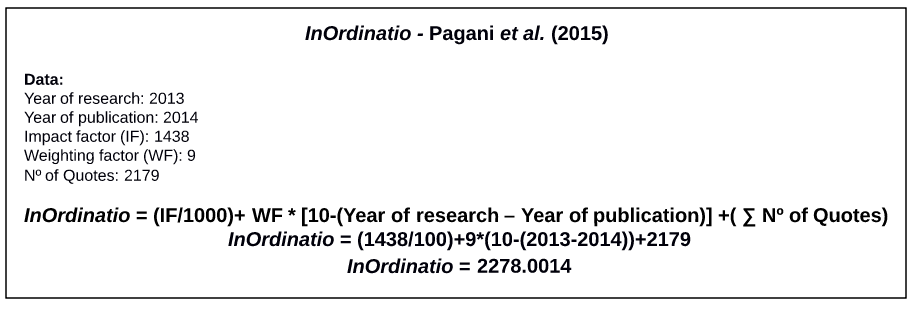


Figure 2 - Example of application of the *InOrdinatio* index

**4.1.5. EXTRACTION AND DATA SYNTHESIS**

In order to perform the selection of primary studies, it has been read the title, abstract, keywords and conclusion, and after the selected studies has been thoroughly read. It has not been applied any specific technique to synthetize the data.

**4.1.6. SCHEDULE OF THE PERFORMING REVIEW PROCESS**

The schedule of the systematic review is detailed in Table 5.After surveying the results from the steps 4.1.1 to 4.1.6 it has been made the Review Protocol, and such activity corresponds to the fourth step of the adopted review process. Its validation, fifth step of the adopted review process, has been executed by an external member.

Table 5 – Schedule of execution of the systematic review

|  |  |  |  |
| --- | --- | --- | --- |
| **Schedule** | | | |
| **Month** | **09/16** | **10/16** | **Hours** |
| Step 1 - Identify research questions | X |  | 4h. |
| Step 2 - Explore database with keywords | X |  | 16h. |
| Step 3 - Define databases and keywords | X |  | 4h. |
| Step 4 - Developing review protocol | X |  | 4h. |
| Step 5 - Validate review protocol | X |  | 4h. |
| Step 6 - Finding the studies | X |  | 16h. |
| Step 7 - Filter the studies | X |  | 160h. |
| Step 8 - Identify Relevance Criteria with *Methodi Ordinatio* |  | X | 4h, |
| Step 9 - Generate ranking of studies using *InOrdinatio* |  | X | 1h. |
| Step 10 - Obtaining for full papers |  | X | 4h. |
| Step 11 - Read and analyze the results |  | X | 145h. |
| **Total amount of hours** | **378h.** | | |

**4.2. SYSTEMATIC REVIEW EXECUTION**

The studies collection, sixth step of the adopted review process, has occurred by using the Zotero reference manager (HARDING, 2014.). It has been obtained a total of 6.577 studies as a result.

Subsequently, the seventh step of the adopted review process, it has been performed the results filtering by eliminating duplicated studies as well as those which are not related to the research topic. The outcome has been 28 out of 4.975 studies, which have been selected to be completely read.

Based on Queirós *et al.* (2015) and GQM (Goal/Question/Metrics), the resulting studies have been grouped by objective, being the first group related to Review and Surveys in the Accessibility and Usability area, the second associated to Tools which provide Usability and Accessibility and the third group related to Accessibility and Usability Initiatives in Agriculture. More details about the source of the articles may be observed on Figure 3.

**Figure 3\_refazer**

The *MethodiOrdinatio* calculation needed data were surveyed by using the SJR index, which corresponds to the eighth step of the adopted review process. It has been applied the InOrdinatio significance calculation and it has been generated the ranking of the studies reading order as a product, corresponding to the ninth step of the adopted review process.

It has been performed the acquisition and complete reading of the 28 selected studies to end the process, corresponding to the tenth and eleventh steps of the adopted systematic review process.

# **5. SELECTED STUDIES AND ANSWERS TO THE RESEARCH QUESTIONS**

# The Table 6 brings the description of the 28 selected studies, which are organized by group. Primarily,9 studies belonging to group 3, Accessibility and Usability Initiatives in Agriculture, are presented, followed by the 11 studies belonging to group 2, Tools to provide Usability and Accessibility, and finally are presented the 8 studies belonging to group 1, Reviews and Surveys in the Accessibility and Usability Area.(começar pelo grupo 1 e não o 3)

Table 6 - Description of usability and accessibility studies.

|  |  |  |
| --- | --- | --- |
| **Group 3 - Tools to provide usability and accessibility in agriculture.** | | |
| **Study** | | **Description of the study** |
| 1 | Medhi-Thies *et al.*(2015) | They developed, implemented and evaluated social network, aimed at farmers of low education in the rural context of India. The network was designed to utilize audio-visual resources and access occurred through eight mobile devices delivered to workers, called mediators, and a non-profit organization. Over 4 months, 306 farmers were registered and made use of the system, the evaluation of the network occurred with the application of interviews.The research showed that the intervention of the mediators had a strong influence on the content that the farmers posted in the social network, as future work points to the realization of the experiment in an unmediated way and the application in other contexts. |
| 2 | Simek *et al.*(2014) | They optimized agrarian portal content and ergonomics, these modifications include the implementation of a responsive layout with a focus on information and accessibility.For the evaluation of the portal was applied user experience test and automated test.The portal has been used comfortably but one of its disadvantages is that the responsive layout needs a permanent connection. |
| 3 | Simek *et al.* (2015) | They performed three distinct methods of User Experience testing for web applications in the agricultural, food industry, forestry, water management and rural development scenarios. The tests applied were: five-second test, thirty seconds and user test in a predefined scenario.  Among them, the 5-second test was not adequate to evaluate agricultural information, the 30-second test followed by questionnaire presented useful data and the user test proved to be the most effective for the sector. |
| 4 | Jeong *et al.* (2013) | They developed and evaluated a web interface for rural tourism planning. Users' suggestions were collected to refine the interface, analyze possible impacts on tourism, and identify spatial models.  In the evaluation a questionnaire was applied to different groups, the unification of the data was done with analysis of variance, ANOVA, and analysis of main components, PCA. A partir dos resultados obtidos inferiu-se a possibilidade de unificar as recomendações de planejamento com as sugestões fonecidas pelos usuários. |
| 5 | Bali *et al.* (2013) | They evaluated and discussed the usability of a Hindi speech module intended to enable voice navigability in a mobile video search application. The validation occurred by observing the interaction of the users with the application. It was noticed less precision in the recognition of the words and greater rejection on the part of the women than on the part of the men. |
| 6 | Gupta (2012) | They have studied the usability of computer technology input artifacts by Indian rural dwellers. They claim that any input device takes more effort to be used in rural areas which implies less usability. As alternating the authors indicate the use of touch screen devices, they say that this type of device provides a more understandable, friendly and relaxed interface, allowing consequently greater development for the agricultural sector. |
| 7 | Briteli *et al.* (2013) | They developed an educational geographic information system, named MGIS, which uses an audio monitor in combination with a tablet and pen for the same. The system is aimed at ensuring accessibility for blind users. The use of the system was successful, however the individual performance of each user differed significantly. As future work is the identification of the behavioral and demographic variables that influence the performance of the users and the search for improvement in the user's performance through adjustments in the interface design. |
| 8 | Li *et al.* (2013) | They developed a browser, called TroTro, aimed at maintaining the navigability of the internet in scenarios of floating connectivity. It was carried out a survey of the difficulties of users with Internet users test in schools and cybercafes in rural Ghana. It has been found that in addition to connectivity, challenges such as a lack of computational knowledge, poor usability of interfaces, and alienation from technology are faced. The TroTro validation occurred through usability tests with predefined scenarios, users were encouraged to explain their thoughts aloud, sections were recorded and post-test interviews were conducted. |
| 9 | Brown *et al.* (2013) | They developed a usability assessment process for geographic information, called PEGI. It is an adaptation of pre-existing usability processes, the authors state that the method was developed due to the fact of usability assessment methods is not a good analysis in the geographical analysis.  The PEGI process consists of seven steps: definition of the context of use analysis, definition of use scenarios, application of cognitive pathway test, application of heuristic evaluation test, compilation of data, prioritization of problems and report development. The heuristic evaluation used is specific to geographic information analysis. |
| **Group 2 - Tools to promote usability and accessibility.** | | |
|  | **Author** | **Title** |
| 1 | Holland *et al.*, (2012) | Present methods for automated segmentation and classification of ranges in Visual Search. For this classification techniques based on mouse / keyboard events and eye movements are applied. The results show that automated classification has a loss of precision compared to manual classification, but this loss is not significant, making automated classification an effective tool to reduce the amount of data recorded and analyzed by IHC experts. |
| 2 | Scarr *et al.*, (2014) | They presented two implementations of the Command Map's interface technique. In the first study it was observed that the use of Command Map's generated higher performance in tasks applied to the real scenario, in the second study the interaction of users with Command Map's, qualitative data of interviews, questionnaires and conversations was observed, the results show that this technique are received positively by users. |
| 3 | Kieffer *et al.*, (2016) | They developed a questionnaire and strategic usability evaluation model, called Stratus. The questionnaire was used by both the novice group and the usability group. The dependence between usability and experience in the usability scenario was inferred. |
| 4 | Dingli *et al.*, (2014) | Developed a web usability evaluation framework, this framework uses heuristic evaluation techniques and performs automated testing. The tool was able to detect usability violations effectively, but presents a limitation regarding the number of guidelines used in the inspection. |
| 5 | Kremer *et al.*, (2015). | They developed a framework to evaluate the user experience. For this, the main theoretical models of the area were integrated in a tool capable of allowing understanding, communication and evaluation of the user experience. |
| 6 | DIAS *et al.*, (2014). | It proposes a questionnaire, called HEUA, to measure how much a web system needs to be improved to reach usability and accessibility. The questionnaire consists of 93 attributes that were classified in one of the ten heuristics proposed by Nielsen (1995). The questionnaire was validated by tests performed in two systems, as future work indicates the indication of elements of the system that need to be modified to satisfy the given heuristic. |
| 7 | Moraveji *et al.*, (2012) | They proposed 10 heuristics of usability that aim to identify the stress factors in the users of systems, were planned for application with other tests of heuristics. They can be applied before studies with users. |
| 8 | Torrente *et .al.* (2013). | They defined a usability evaluation framework, called Sirius, based on heuristics. This structure performs analysis of the site according to its type. Evaluation criteria are provided, metrics that quantify the level of usability reached and list of criteria to be corrected in the site ordered according to the importance. |
| 9 | Crabb *et al.*, (2016). | They have developed a framework to collect and analyze user experience data in relation to subtitles. Specifically aimed at ensuring the same experience of users who do not make use of the caption. |
| 10 | Afonso *et al.*, (2014). | They presented an evaluation model of the interface, called Usa Web, aimed at detecting usability problems and presenting solutions proposals. The model is formed by methods and techniques such as preliminary evaluation, interview with users, usability test, questionnaire and heuristic evaluation. |
| 11 | Corrêa *et al.*, (2012). | They discussed the semiotic inspection method to evaluate systems that use audio resources in their interfaces, precisely evaluating the communicability of these sound resources and evaluating aspects of accessibility. It proposes to evaluate the communicability of the system and the quality of the message being transmitted. |
| **Group 1 - Usability and accessibility initiatives.** | | |
|  | **Author** | **Title** |
| 1 | Casare *et al.*, (2016). | They addressed the relationship between usability and accessibility through mapping between the WCAG 2.0 guidelines, specifically their four principles, and the Nielsen Heuristics. t was noted that there is no consensus between the definition of usability and accessibility in IHC, the authors argue that these are complementary concepts. |
| 2 | Queirós *et al.*, (2013) | They carried out a systematic review of the literature on technology and products used in AAL assisted living systems. Among the selected studies, 87% were related to a specific technology, 13% referred to complete systems, it was also discussed how a certain technology can be used in AAL systems, leaving the users' needs in the background. |
| 3 | Paz, *et al.*, (2016) | They performed systematic mapping to identify the usability evaluation techniques most used in software development. The study aimed to serve as a contribution to decision making in the choice of a technique. It was inferred that the questionnaire, user test, heuristic evaluation, interview and thought out loud are respectively the most commonly used techniques in the literature. |
| 4 | Baazeem, *et al.*, (2015) | They analyzed the methods of evaluating the accessibility of the web used in the last five years, the results revealed a lack of significant evolution of the techniques. The methods were: automated tests, user tests, expert tests or a combination of them. Although there are new forms of evaluation, these have not been widely used. |
| 5 | Pretorius *et al.*, (2015) | They described the scenario of using user experience activities in South Africa to raise awareness of the field and assist professionals and organizations in the environment. For this, a virtual questionnaire was carried out with 105 interviewees in the period of 6 months, among the results the identification of challenges for application of user experience activities. Challenges are: time constraints, lack of qualified professionals, process challenges and budget constraints. |
| 6 | Al-Badi, *et al.* , (2012) | They presented usability and accessibility tools through an overview of previous research and literature related to usability, accessibility, cultural differences and aspects of globalization. |
| 7 | Lima *et al*., (2012) | They reviewed the literature to investigate the current accessibility initiatives applied to the web and to identify their characteristics and trends. It was noted that in Brazil 47.8% of developers have access to practical accessibility tests, but only 7.76% of the tests include people with disabilities in the process of creating content on the Web. The need to develop tools to identify accessibility gaps and metrics in assessments was emphasized. |
| 8 | Ramos *et al.*, (2011) | They developed course planning to assess accessibility in web applications aiming to produce quantitative and qualitative diagnosis on the subject. For this, accessibility issues were defined in three ways: from the user, analyzed through his / her satisfaction, to the specialist, analyzed through the measurement of user performance, and the accessibility community, analyzed through product compliance inspection with standards. |

**QUESTION 1 – Is there any indication of the problems caused by the lack of usability and accessibility? Are there problems specifically cited to the agricultural domain? Is the device used to access the software portrayed?**

The most substantial indications related to problems are listed in the Table 7. The pointed problems to the agricultural domain are specified in the problem description.

Table 7 – Problems related to usability and accessibility

|  |
| --- |
| **Study: KrishiPustak: a social network system directed to low-literate farmers (MEDHI THIES *et al.* - 2015)** |
| **Problems:** |
| - Internet high cost and the bandwidth hamper the online participation.  - Audio output applied to graphic and Touch Screen systems do not foster relevant impact to low-literate farmers.  - Information which is not consolidated in the same screen foster less use facility to the farmers.  -Photographs or abstract icons are less well understood than images including hand drawing representations.  - Illiterate publics have difficulty to read and comprehend numerical digits. However, these characters are well accepted by the low-literate public.  - Numerical passwords might cause difficulties to low-literate users.  - There is a necessity of using non-textual resources to users who are unable to read texts.  - Nonlinear navigation structures reduce the user performance. |
| **Study: Cross-platform of user interface applied to agricultural sector (ŠIMEK; VANĚK; PAVLÍK, 2014)** |
| **Problems:** |
| - Unconsolidated information annoys the users. |
| **Study: Usability of UX Methods in the Agricultural Sector – Verification (ŠIMEK; VANĚK; PAVLÍK, 2015)** |
| **Problems:** |
| - Traditional graphics may be commented by final users. Nevertheless it is a common and expected practice among the majority of final users. |
| **Study: A Hindi language recognizer directed to search of agricultural video (BALI *et al.*, 2013)** |
| **Problems:** |
| - The application used to language recognition presented lower level of accuracy and acceptance to women farmers than men farmers. |
| **Study: Relation among Input Gadgets Usability of Computing Technology and the Rural development in India (GUPTA, 2012)** |
| **Problems:** |
| - The data input through keyboard was considered a hindrance to farmers.  - It is necessary to reduce the use effort of input devices in order to increase the life standard of rural areas residents.  - Farmers reported difficulty in finding the web portal homepage when the link was placed in the system logo.  - Difficulty in distinguishing the interface elements.  - By proposing that the farmers performed an action and subsequently undid the same action, it was noticed that they wanted the undo button to be in the same position as the button which executed the action.  - Any input device in rural area demands bigger effort to be used, which results in less usability.  - The Touch Screen use provides more use facility to unskilled people.  - The most common reasons to failure are occasioned by visibility problems. |
| **Study: Introduction to PEGI: A usability process for practical evaluation of Geographical Information (BROWN; SHARPLES; HARDING, 2013)** |
| **Problems:** |
| - Traditional usability heuristics are not appropriated to evaluate Geographical Information.  - Application presenting translation failure.  - Lack of information about the last data update.  - Lack of clarification about abbreviations used in the documentation.  - Inconsistent technical terms, the same technical term has received more than one related technical term.  - Difficulties to represent geographical information when the available layers granularity is fewer than 4.  - Product presenting complex appearance.  - Inappropriate description to cartographic physical characteristics.  - Non-intuitive symbology.  - Differences between the terminology used on the product and the user guide.  - Difficulty to download files which refer to certain geographic region.  - Use of abbreviation in the names of files entailed the users to consult the user guide constantly.  - Traditionally, usability concentrates just on interface, disregarding the data usability. Among the unwanted results coming from this scenario, well projected data presented in a low usability interface, or appropriate interface with low usability data, are examples.  - The Geographical Information designers have minimum control about the interface matters because the various Geographical Information Systems that will present and manipulate this information have different interfaces.  - The wide range of kinds of users is a challenge to the Geographical Information conception. |

As access devices were pointed the tablets, mobile phones and mobile devices. There were studies which do not specified the device, however they indicated that the access was made through web system.

**QUESTION 2 – What are the initiatives, evaluation methods or indicated products to provide usability and accessibility to software? What are the limitations? Are they specific to the agricultural domain? Who is conducting these initiatives?**

The initiatives and respective controllers are showed in Table 8.

Table 8 – Existent initiatives in usability and accessibility areas and their controllers.

|  |
| --- |
| **Existent initiatives in usability and accessibility areas and their controllers** |
| **Initiative: Web Content Accessibility Guidelines, WCAG**  **Controller: W3C.** |
| They approach the web content and are used by developers, authoring tools, and accessibility evaluation tools (W3C, 2016).  They were developed in order to create a unique shared pattern to web content accessibility. The guidelines are organized around 4 characteristics, which determine that the interface elements have to be noticeable, operable, comprehensible and robust. Supposing that any of these characteristics is not present, disabled users will be prevented to use the web. The guidelines are written in the form of testable declarations and they do not rely on a specific technology (W3C, 2014). |
| **Initiative: Nielsen Heuristics.**  **Controller: Nielsen Norman.** |
| There are countless lists of heuristic evaluation which may be used, nonetheless it is constant the quotation of the Nielsen Heuristics (1195). They are ten usability general rules: system status visibility, compatibility with the real world, user control and freedom, consistence and patterns, errors prevention, recognition instead of recalling, flexibility and use efficiency, minimalist design aesthetic, support to recognition and errors fixing, documentation and user help system (NIELSEN, 1995). |
| **Initiative: User Agents Accessibility Guidelines, UAAG.**  **Controller: W3C** |
| They show how to make the user agents accessible to disables people. The agent users include browsers, browser extensions, media players, readers, and other applications which process web content (W3C, 2016). |
| **Process of Practical Evaluation of Geographical Information, PEGI.**  **Controller: Study of BROWN; SHARPLES; HARDING (2012).** |
| The Process of Practical Evaluation of Geographical Information, PEGI, consist of usability evaluation methods, which were modified to the use with Geographical Information. Its development occurred because the nature of these information, includes characteristics which make usability evaluation traditional methods to become inefficient or inappropriate (PEGI / BROWN; SHARPLES; HARDING, 2013). |

The accessibility and usability evaluation methods are listed in the Table 9. In the studies, it was noticed that usability and accessibility were measured together, and it was not specified from which strand the results derived.

It was indicated as the most used web accessibility tests, the automated ones, user’s tests, tests of specialists, or a combination of them (BAAZEEM; AL-KHALIFA, 2015). In the usability strand are indicated as the most used tests: questionnaire, user test, heuristic evaluation, interview, and aloud thinking protocol(PAZ *et al.*, 2016).

Table 9 - Usability and accessibility assessment methods

|  |  |
| --- | --- |
| **Methods of assessing usability and accessibility** | |
| 01 | Interview |
| 02 | Questionnaire |
| d03 | User Experience Analysis |
| 04 | Automated Testing |
| 05 | Five-second test |
| 06 | Thirty-second test |
| 07 | Usability test with predefined scenario |
| 08 | Heuristic evaluation |
| 09 | Observation test without a predefined scenario |
| 10 | Context and usage analysis |
| 11 | Cognitive course |

Some studies approached the development of new methods and products to evaluate accessibility and usability, which have been described in Table 10.

Table 10 - New products and methods developed to analyze usability and accessibility.

|  |  |
| --- | --- |
| **Products and methods developed to assess accessibility and usability** | |
| **Author** | **Description of the tool proposed in the study** |
| Dias *et al.*(2014) | It proposes to use the HEUA questionnaire to determine how much a web system needs to be improved to achieve usability and accessibility. However it does not determine how significant the adjustment is for the improvement of the system. |
| Moraveji *et al.*(2012) | They propose usability heuristics, to increase the proposals by Nielsen Norman. It aims to evaluate interface components based on Stress that they are able to generate to users. |
| Torrente *et al.*(2013) | *Framework* for assessing web usability, is based on heuristics. It detects failures, calculates the level of usability, and sorts the criteria to be corrected in order of importance. |
| Kieffer *et al.*(2016) | Develops questionnaire called STRATUS, the same is focused on usability measurement. |
| Dingli *et al.*(2014) | It proposes framework to evaluate the usability of sites. |

By examining the number of problems indicated in each evaluation method, it was realized the importance of examining a scenario with more than one method. It was verified that by performing more than one test in a specific scenario, the usability tests reliability is increased. Experiments verified that scenarios, in which only one usability test was applied, would have as a product the reduction from 19% to 25% in the amount of identified usability problems (BROWN; SHARPLES; HARDING, 2013).

In order to finish the answers in the Question 3, the tools limitations are presented in the Table 11.

Table 11 - Limitations of current tools

|  |  |
| --- | --- |
| **Limitations of current tools** | |
| Dias *et al.* (2014) | They claim that there are no tools to measure how much the accessibility and usability requirements are applied to a web system. |
| Torrente *et al.*(2013) | They assert that the usability tools consider only a few heuristics to perform the tests. Holland et al. (2012) say that the main weakness of usability testing is its qualitative nature that requires detailed and time-consuming analysis by a trained observer. |
| Fernandes *et al.*(2013) | They cite that automatic accessibility checking tools are not able to detect all failures in a system. Brandi (2008) apud Dias et al. (2014) cite as problematic the fact that the WCAG guidelines do not allow the evaluator to distinguish serious problems from trivial ones, regardless of the existence of well-defined priority levels. |

**QUESTION 3 - Are there registers about the benefits of accessibility and usability application? Are indicated measurement means to these attributes?**

There are registers indicating improvements in software, although they are not specified, however, studies directed to specific problems were presented, for instance the reading difficulty due to low literacy level.

In relation to the means of measuring usability and accessibility, two studies, Camenar *et al.* (2015) and Dias *et al.* (2014), indicate means of measuring how much the usability and accessibility attributes are applied to a system, nevertheless none of them are specific on agricultural domain. Camenar *et al.*(2015) generates ranking of accessibility problems by basing on benefits that the correction of them would bring to the system. Dias et. al., (2014) develops a questionnaire to evaluate the usability and accessibility in web systems in order to support the measurement of needed effort to the improvement of a system.

QUESTION 4 - What are the most used agricultural software? Are they geared towards AP? Are they aimed at family or business agriculture?

There were no notes about it.

**6. RESULTS**

Among the resulting studies 62% of them were sourced from conferences (Figure 4). The total of selected studies was 28, being 8 of them from agricultural area, remarking the necessity of more researches. These 8 researches diverge in relation to the approached kinds of users, for instance, farmers, students from rural areas, rural tourists, among others, were cited.

**Figure 4 - Refazer**

The systematic review allowed the survey about some of the difficulties of users. It was inferred that the most common reasons behind the failures, occur because of interface visibility problems. Among the generalized difficulties in systems, it is taken by example the interfaces with complex appearance, lack of usability on the data composing the interface, information presented in a unconsolidated manner, nonlinear navigation structures, translation failures and inadequacy, and inconsistence among the terms used in the software and documentation.

Tests performed specifically with farmers have shown that they have found problems to return to the system homepage when the link was placed in a logo, moreover the farmers desired that the do and undo button to be found in the same place in the system. In the agricultural domain, any input device demands more effort to be used, the keyboard, for instance, is considered a hindrance, what makes the touch screens an alternative to the problem. Regarding the infrastructure, it is approached the internet cost and the bandwidth. As access devices were pointed mobile devices and it was mentioned the web systems use.

Among the initiatives, which aim providing usability and accessibility, were indicated the WCAG recommendations, the Nielsen Heuristics, the User Agent Accessibility Guidelines, and the Process of Practical Evaluation of Geographic Information. The most cited accessibility tests are the automated ones, user’s tests, and specialists’ tests. In relation to usability it is indicated the questionnaires, user’s tests, heuristic evaluation, interview, and aloud thinking protocol. It is recommended joying the use of manual and automatic tests.

In order to measure the accessibility and usability there were initiatives directed to generate a ranking of the problems, based on the benefit which the correction of them would bring to the system, and it was also approached the correction effort. Among the limitations of the tools, it is remarked the qualitative nature of the tests, the measurement of how much the usability and accessibility attributes are applied to systems, the impossibility of identifying serious problems rather than the trivial, and the fact that the heuristic evaluations are not appropriate to evaluate geographical information.

**6.1. THREATS TO THE REVIEW VALIDATION**

The main identified threats to the validation of this systematic review study are specified below:

- *Publication results:* it refers to the fact that positive aspects are more likely to be published than the negative ones. The negative results take more time to be published, or are quoted in less extensive publications (KEELE, 2007). In order to alleviate the problem, the research questions have been defined based on other studies of the area, however the present research might be affected by the fact that only the studies published in magazines and conferences have been considered.

*- Absence of important previous studies:* despite the planned measures used to obtain the most relevant studies, it is possible that primary studies have been lost. In order to alleviate threats, the studies search has been applied to the studies indicated in the Reference Section of the 28 studies resulting from the systematic review.

*- Selection of primary studies:* aiming to guarantee the effectiveness in the studies selection, it has been made the Review Protocol document which allowed the guidelines to the execution of the systematic review to be determined; in spite of that, failures in the first phase might have occurred, due to the lack of information in the title, abstract or keywords of the studies.

*- Inaccuracy in data extraction and improper classification:* it refers to the form that the data have been extracted to answer the questions. There might have occurred failures in this step because not all the information fit precisely on the matter.

**7. CONCLUSIONS AND PROSPECTIVE WORKS**

By considering the systematic review results, it has been identified the necessity of creating application and evaluation methods directed to accessibility and usability in agricultural software, due to the scarcity both of the studies in the area, and the identification of difficulties of these users.

Furthermore, it has been noticed that the studies, regardless of the fact that they have been developed to the agricultural area, cited problems, however they rarely indicated solutions, qualitative measurement means, and the impact that such corrections could bring to the system.

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