

Applying free geotechnologies and offline maps for data collect and logistical support to Caeté S/A Sugarcane Mill, in the municipality of São Miguel dos Campos - AL

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Key words: geoprocessing, GIS, precision agriculture

SUMMARY

Applying free geotechnologies to support decision-making is becoming increasingly common, especially with the use of mobile devices. The objective of this work was to develop a tool through free geotechnologies and to create offline maps that serve as an aid to decision-making in the sugarcane fields. Its main focus was to verify the increase in decision-making power compared to the traditional methods used. The study area for application of the developed tool was Mill Caeté S/A, located in the municipality of São Miguel dos Campos/AL. The methodology was based on the acquisition of data obtained through the smartphones GPS and Google Earth software, to be compared to georeferenced data from rural property limits provided through the electronic tool (SIGEF) developed by the National Institute of Colonization and Agrarian Reform (INCRA). The positional accuracy value was calculated using the set of control and field obtained points to calculate the Standard Error (EP) values, and thus estimate the positioning errors (planimetry and/or altimetry) relating to the data. The results in Table 3 showed that data obtained by these different technologies presented different EP values: 5,34 m (SW MAPS); 4,71 m (MOBILE T.) and 7,50 m (GOOGLE EARTH). However, when verifying the adequacy of these data it was found that they fall as Class A on a scale of 1/50,000 and as Class B on a scale of 1/25,000. The results showed that the use of the tool provided a better performance for official field activities in relation to the traditional methods used and that the techniques do not present high precision. The implementation proved to be an efficient alternative to the proposed goal, making it possible to increase the decision-making power. However, other functionalities need to be better explored, measured and improved, what means these technologies need great evolutions to perform tasks that require high precision for sugarcane field, distance, perimeter and area measurements. Further studies will be necessary to quantify this information, especially when taking into account the diversity of smartphones available in the market today.

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A aplicação do geoprocessamento e geotecnologias livres no suporte a tomada decisão torna-se cada vez mais comum, principalmente com a utilização de dispositivos móveis. O objetivo deste trabalho foi desenvolver uma ferramenta através da aplicabilidade de geotecnologias livres e da construção de mapas offline para que sirva como recurso auxiliar a tomada de decisão no campo canavieiro. Teve como foco principal verificar a ampliação do poder de decisão em comparação aos métodos tradicionais utilizados. A área de estudo para aplicação da ferramenta desenvolvida foi a Usina Caeté S/A, localizada no município de São Miguel dos Campos - AL. A metodologia foi baseada na aquisição de dados em campo através do GPS de diferentes modelos de smartphones e através do software Google Earth, que depois comparados com dados georreferenciados de limites de imóveis rurais fornecidos por ferramenta eletrônica (SIGEF) desenvolvida pelo Instituto Nacional de Colonização e Reforma Agrária (INCRA). A acurácia posicional foi calculada a partir de um conjunto de pontos de controle para obter os valores de Erro Padrão (EP) e com isso estimar o erro de posicionamento (planimétrico e/ou altimétrico) associado aos dados. Os resultados mostraram que os dados obtidos por estas geotecnologias livres apresentaram os seguintes valores para EP: 5,34m (SW MAPS); 4,71m (MOBILE T.) e 7,50m (GOOGLE EARTH). Porém, quando verificada a adequação desses dados (Tabela 1) foi constatado que se enquadram como Classe A para escala de 1/50.000 e como Classe B para escala de 1/25.000. Os resultados mostraram que o uso da ferramenta proporcionou um melhor desempenho das atividades em relação aos métodos tradicionais utilizados e que as técnicas não apresentam alta precisão. A implementação se mostrou uma alternativa eficiente para o fim proposto, possibilitando ampliar o poder de decisão. Porém, outras funcionalidades precisam ser exploradas, mensuradas e melhoradas, ou seja, essas geotecnologias precisam evoluir para que sejam utilizadas em tarefas do setor sucroalcooleiro que exijam alta precisão de medidas de localização, distância e área. Assim, serão necessários mais estudos para uma melhor quantificação dessas informações, principalmente quando se leva em conta a diversidade de modelos de smartphones disponíveis no mercado atualmente.

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1. INTRODUCTION

It is common for the human being to be inserted in situations in which it is necessary to make a decision. Most of the time such decisions are trivial, therefore they require little reflection and time. However, when the resulting consequences are crucial and there is not enough information or analytical capability to offer a set of alternatives capable of leading to a certainty about what should be done, then there is a decision problem.

Deciding on situations of uncertainties that involve high risks requires reflection on possible alternatives of action and on their potential consequences (CONTINI; et al., 1984). Also, technological advances, mainly with the availability of computers, brought the possibility of analyzing numerous alternatives, promoting a broadening of the horizon of possibilities of analysis and conferring decision-making power more efficiently, especially when combined with geoprocessing (ABDEL-RAHMAN and AHMED, 2008; BOLFE, 2019; MOLIN and VEIGA, 2016; TAUFIK et al., 2020; ZANARDO et al., 2016).

The current dynamic in the agricultural system carries with it the need for decision-making efficiently through reflection on several variables, thus requiring technological resources that can assist in planning, management, and decision-making from the analysis of as much available information as possible. In addition, when information is organized and properly analyzed they lead to an optimal set of alternatives for decision-making (MASSRUHÁ, 2018). In this sense, the emergence of equipment that allows great mobility, such as smartphones, together with interoperability, has allowed the achievement of a powerful resource for access and sharing of information when working together with geotechnologies, conferring greater power of analysis and decision in the field (AYAZ et al., 2019; MITTAL and TRIPATHI, 2009; PIVOTO et al., 2018; QIANG et al., 2011; ROSALEN et al., 2019; SAIZ-RUBIO and ROVIRA-MÁS, 2020; SANCHES et al., 2019). However, one of the major challenges faced in the use of these technologies is still the issue of internet connectivity of cell phones. The availability of internet access for the functioning of these tools and instruments of innovation is essential.

Is the possible lack of internet connectivity a factor preventing the application of these tools and instruments of innovation?

Therefore, there is the challenge of finding ways to use these technologies in order to circumvent this problem.

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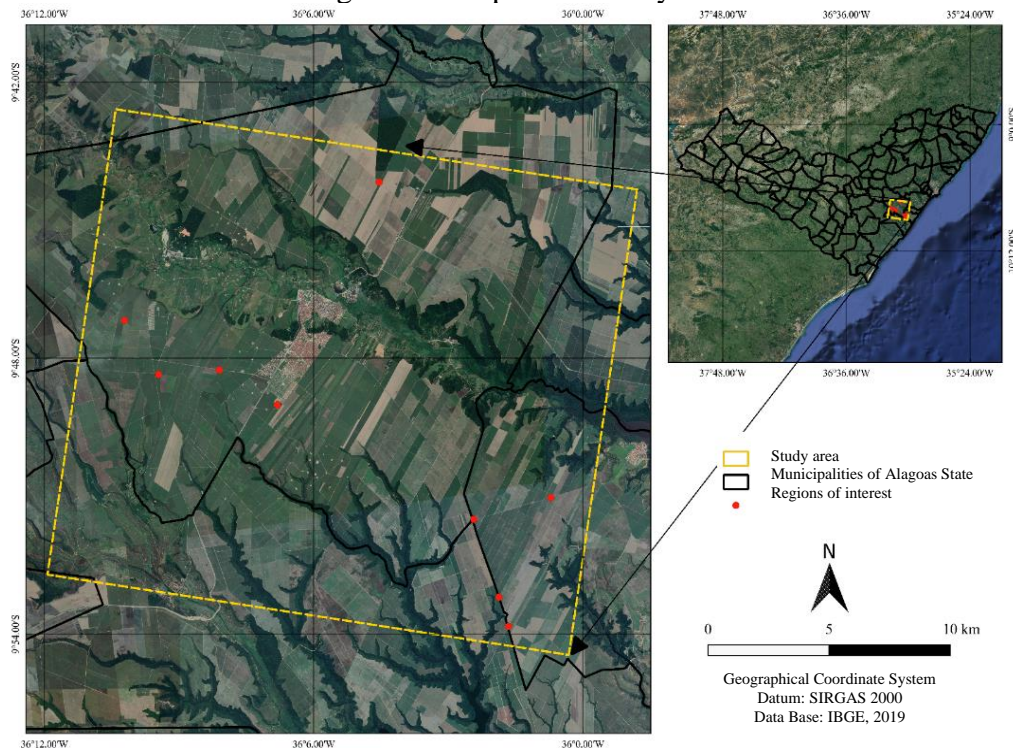
Thus, this work evaluated the applicability of free geotechnologies and offline maps through the development of a tool that serves as a resource for data collection and support to sugarcane logistics of Mill Caeté S/A, located in the municipality of São Miguel dos Campos/AL.

2. METHODOLOGY AND MATERIALS

2.1 Study area

The study area map is presented below (Figure 1).

Figure 1 – Map of the Study area



Source: Authors (2020)

Mill Caeté S/A, located in the municipality of São Miguel dos Campos, Alagoas State, was the first industrial unit acquired by the Carlos Lyra Group in 1965. Investing in the most advanced production techniques, in its activities of production of sugar, ethanol and other derivatives of sugarcane, the Carlos Lyra Group made the Matrix a model plant. The sugarcane plantation of Usina Caeté S/A has among its advanced production technologies mechanized harvesting, with transshipment stations, linear irrigation systems, fertigation with vinasse /truck, since 1993, in addition to a soil management system, with careful use of fertilizers (GRUPO CARLOS LYRA, 2020).

São Miguel dos Campos is situated between coordinates 09° 40' 24.6" and 09° 52' 58.8" latitude S and 35° 59' 14.6" and 36° 14' 58.08" longitude O, in the southeast region of the State of Alagoas, ~~inserted in the mesoregion of Eastern Alagoas and in the microregion constituted by the~~ Applying Free Geotechnologies and Offline Maps for Data Collect and Logistical Support to Caeté S/A Sugarcane Mill, in the Municipality of São Miguel Dos Campos – Al (11066)

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municipalities of Anadia, Campo Alegre, Junqueiro, Teotônio Vilela, Coruripe, Jequiá da Praia, Roteiro and Boca da Mata, whose name is microregion of São Miguel dos Campos. Its area is 335,683 km² and its estimated population is 61,251 people (IBGE, 2019).

Access to the municipality is possible through paved highways: BR-101, AL-105, AL-215, AL-220, AL-415, AL-420 and AL-450, with a route of around 74.3 km to the state capital taking as access to BR-101 (ONTL, 2018).

2.2 Material Resources

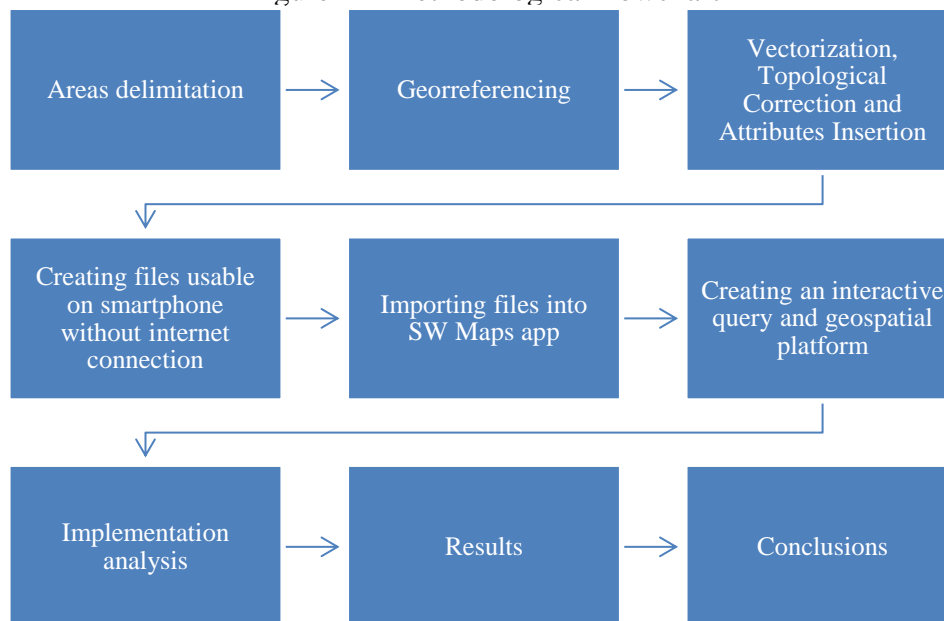
For the development of this tool, the following materials were used:

- Mobile Topographer FREE application;
- QGIS for Desktop data processing software, versions 2.18.28 and 3.10.8 long-lasting;
- QuickMapService plugins, QTiles, qgis2web;
- SW Maps application;
- Google Earth for satellite image visualization;
- Acer Intel® Core™ i3 CPU M380 @2.53 GHz computer, 06 GB memory and 1 TB storage;
- Galaxy J2 Prime smartphone with Android 6.0.1, 1.5 GB memory and 16 GB storage;
- Xiaomi Redmi Note 7 smartphone with Android 10, 04 GB memory and 64 GB storage;
- Maps of Mill Caeté S/A in PDF file.

2.3 Methodological Procedures

The methodological flowchart is presented on Figure 2.

Figure 2 – Methodological flowchart



Source: Authors (2020)

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Area delimitation: Through a field visit, in each of the areas of interest some points were collected through the Application Mobile Topographer FREE. Subsequently, lists were generated with the coordinates of these points in the TXT file format and exported from the smartphone to the computer. These lists were used as support in the georeferencing process.

Georeferencing: Through the lists generated in the delimitation process of the areas, the georeferencing of the maps made available in the version was performed. This procedure was performed in the long-running QGIS version 3.10.8 software. Once in possession of the lists, the maps in PDF file format were imported into the QGIS software. For georeferencing within this software, the 'Georeferencer' tool was used in the 'Raster' tab. The results generated the georeferenced files, which were exported in the TIF file format. It is important to note that this procedure differs from the georeferencing of rural properties, with a high positional accuracy required.

Vectorization, topological correction and attributes insertion: Georeferenced vector maps were developed in the shapefile format from georeferenced files and supported by the QuickMapServices plugin. The topological correction was made through the tool 'check the validity', in the item 'Geometries', in the 'Vector' tab of the QGIS software. Subsequently, the attribute 'farm number, field number and area referring to each field that composes it' was added to each farm's shapefile.

Creating files usable on smartphone without internet connection: Once the areas have been properly vectorized, georeferenced and with all desirable attributes inserted, the 'QTILES' plugin available in the 'Complements' tab generated the files for offline use on smartphone.

Importing files into SW Maps app: After developing interest areas files for offline use, they were imported to the smartphone and later to the SW Maps app.

Creating an interactive query and geospatial platform: It was used qgis2web, a QGIS tool, to visualize the shapefiles generated in the previous procedures as add-on available on the 'WEB' tab. An interactive web map was produced so that both the smartphone and the computer were able to access the data produced.

Implementation analysis: The tool analysis was based on field monitoring for a period of time considering the sugarcane harvest 2019/2020 to evaluate its performance obtained by comparing to the traditional methods used until then. The accuracy of the smartphone's geographic location device was also verified, in relation to the georeferenced information of rural, public and private property limits, provided by the electronic platform of the Land Management System (SIGEF) developed by the National Institute of Colonization and Agrarian Reform (INCRA) to subsidize the land governance of the national territory.

3. RESULTS AND DISCUSSION

As result of the data geoprocessing carried out in the QGIS software, all the shapefile maps, for each of the selected farms, were selected being ready for offline use by the SW Maps app, in the smartphone (Figure 3).

These same shapefiles were also used to develop an interactive system of geospatial consultation aimed at computer use, thus creating a common visual reference for all sugar cane

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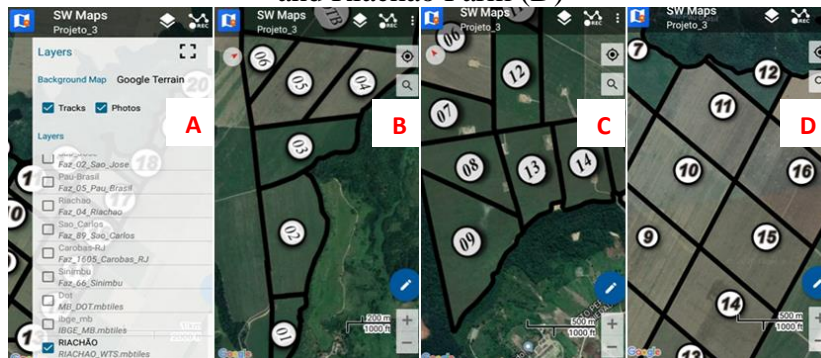
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farms on different platforms (smartphone/computer) and without the need to connect to the Internet.

To check the tool performance and usability on different platforms, two smartphones of different models and with different versions of the Android operating system were used in the tests. The different cell phone models showed a slight change in the size of the visual components, in the labels of the areas and in the degree of smoothing of the geometries, however, the tool functionality was maintained.

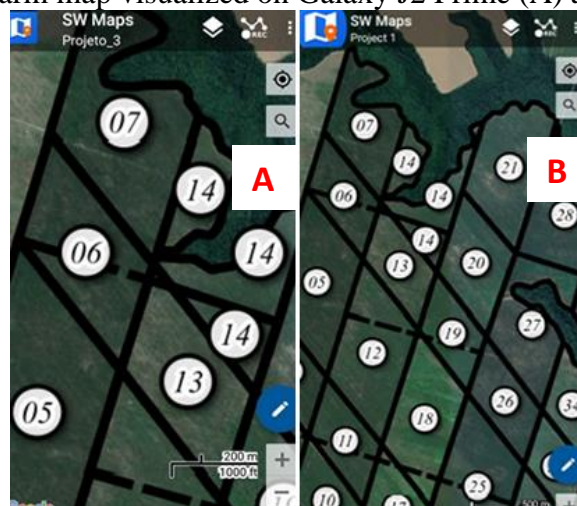
The changes described above may be related to Android operating system version or the screen size configuration inherent to each of the devices used (Figure 4).

Figure 3 – Maps loaded in the SW Maps app: (A), Tomada Farm (B), Conceição Farm (B) and Riachão Farm (D)



Source: Authors (2020)

Figure 4 – Utunga Farm map visualized on Galaxy J2 Prime (A) and Redmi Note 7 (B)



Source: Authors (2020)

In addition, divergences were found between the values of the areas and distances measured by the device's GPS in relation to the actual values reported on the farm maps in PDF file format that were made available by the Mill Caeté S/A.

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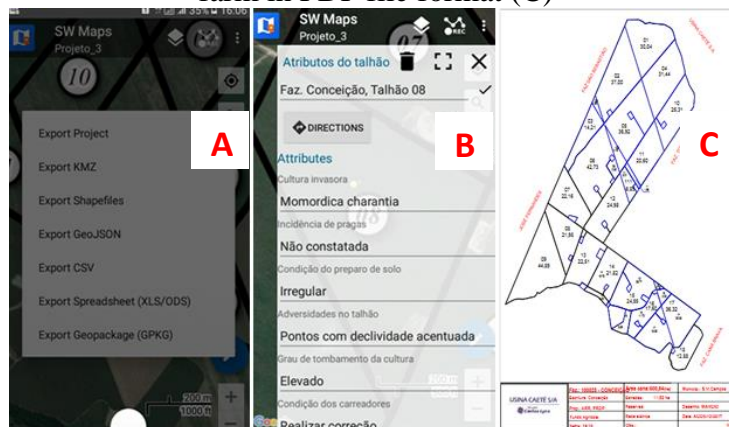
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It was already expected because it is necessary to be cautious about the use of applications on mobile devices that offer the possibility of working with GPS, since the values related to the calculation of the area and distance do not have very high accuracy in Alagoas state (SILVA and FELIPE, 2018). However, the use of this system for the prior recognition of the area is acceptable, as long as it is kept in mind that the results obtained in this way will not come very close to the real value.

Regard to navigation aspect and considering that the dimensions of the plots in each farm are sufficiently large, the tool satisfactorily fulfilled the purpose, since the degree of precision and the accuracy offered by it leads to an acceptable error (SILVA and FELIPE, 2018). However, one must take into account the limitations of the accuracy of the GPS system (05-15 m) for civil use (EMBRAPA TERRITORIAL, 2020; MARTINS; et al., 2017).

Systematizing this information increased the power of making decision and provided to reduce the time wasted by errors of location when compared to the map model traditional format used by the company in PDF file format, by associating a new perspective on the wide view of the field with a better understanding with respect to the position in space (Figure 5).

Figure 5 – SW Maps export file formats (A), Collected attributes (B) and Map of Conceição farm in PDF file format (C)

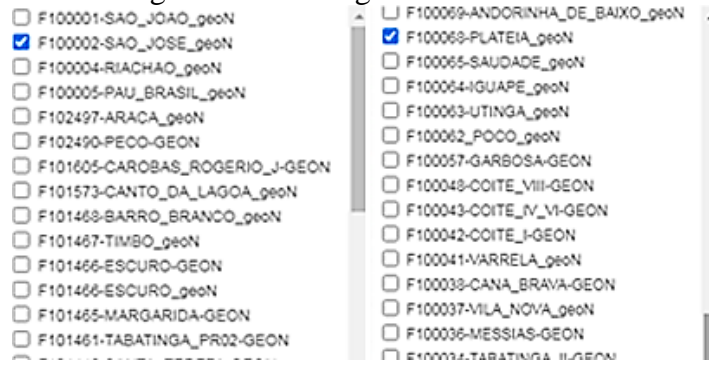


Source: Authors (2020)

In turn, the interactive platform for geospatial query offers the possibility of improving interaction between the user during field work and the user in the office. The possibility of an intercommunication via for the same visual data source, the mobile device and the interactive platform, allows minimizing errors resulting from the misunderstanding caused by verbal communication. This understanding expansion about spatializing information maximized several tasks. Data images from interactive platform are shown in Figures 6, 7 and 8.

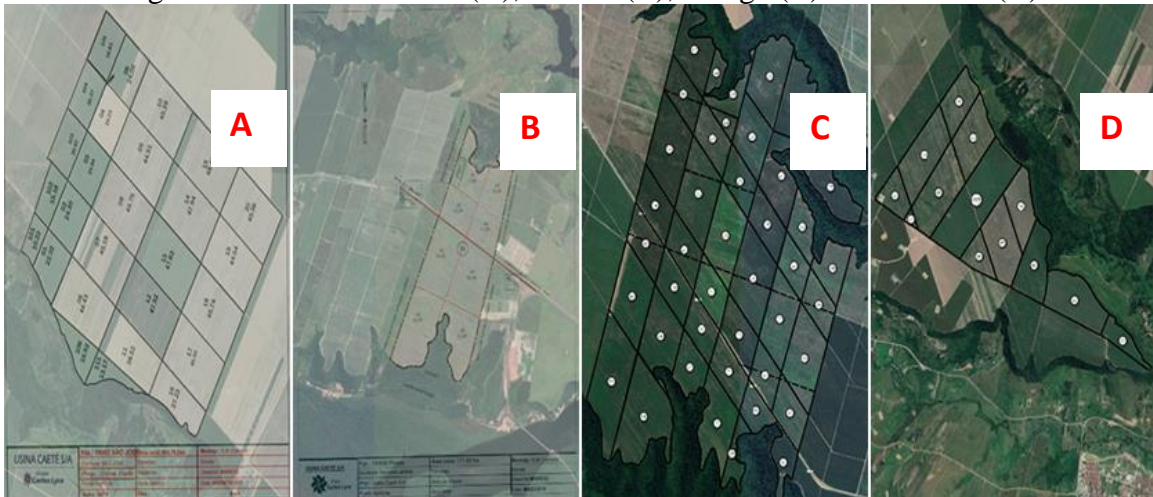
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Figure 6 – List of georeferenced areas



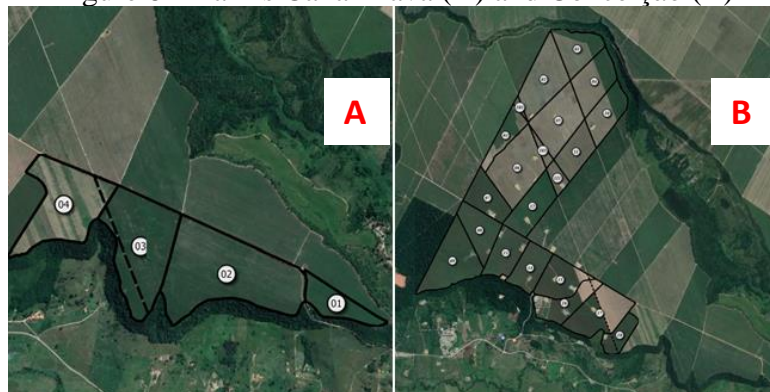
Source: Authors (2020)

Figure 7 – Farms São José (A), Plateia (B), Utinga (C) and Tomada (D)



Source: Authors (2020)

Figure 8 – Farms Cana Brava (A) and Conceição (B)



Source: Authors (2020)

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The positional accuracy value was calculated using the set of control (reference) and field observed points to obtain the Standard Error (EP) values, and thus estimate the positioning errors (planimetry and/or altimetry) relating to the data (SAMPAIO and BRANDALIZE, 2018). More specifically, the values of the Root Mean Square Error (RMSE) were used in this work, as it is more used by international standards to estimate positional accuracy (Figure 9).

Figure 9 – RMSEr calculation

	Tested points (t)		Reference Points (r)		RMSE _x	RMSE _y
	Coord. X _t	Coord. Y _t	Coord. X _r	Coord. Y _r	(X _t - X _r) ²	(Y _t - Y _r) ²
Point 1	X _{t1}	Y _{t1}	X _{r1}	Y _{r1}	(X _{t1} - X _{r1}) ²	(Y _{t1} - Y _{r1}) ²
Point...
Point n	X _{tn}	Y _{tn}	X _{rn}	Y _{rn}	(X _{tn} - X _{rn}) ²	(Y _{tn} - Y _{rn}) ²
					RMSE _x → √(Σ/n)	← RMSE _y √(Σ/n)

$$RMSE_r = \sqrt{((RMSE_x)^2 + ((RMSE_y)^2)}$$

Source: Sampaio and Brandalize (2018)

Depending on the observed accuracy patterns, the methodology used to calculate the RMSE allows that cartographic products be inserted in different classes of EP values (Table 1).

Table 1 – Classes for cartographic products insertion

PEC ^(a)	PEC - PCD	1:1.000		1:2.000		1:5.000		1:10.000		1:25.000		1:50.000		1:100.000		1:250.000	
		PEC (m)	EP (m)	PEC (m)	EP (m)	PEC (m)	EP (m)	PEC (m)	EP (m)	PEC (m)	EP (m)	PEC (m)	EP (m)	PEC (m)	EP (m)	PEC (m)	EP (m)
-	A ^(b)	0,28	0,17	0,56	0,34	1,40	0,85	2,80	1,70	7,00	4,25	14,00	8,51	28,00	17,02	70,00	42,55
A	B ^(b)	0,50	0,30	1,00	0,60	2,50	1,50	5,00	3,00	12,50	7,50	25,00	15,00	50,00	30,00	125,00	75,00
B	C ^(b)	0,80	0,50	1,60	1,00	4,00	2,50	8,00	5,00	20,00	12,50	40,00	25,00	80,00	50,00	200,00	125,00
C	D ^(b)	1,00	0,60	2,00	1,20	5,00	3,00	10,00	6,00	25,00	15,00	50,00	30,00	100,00	60,00	250,00	150,00

Source: Google (2020)

In order to check the adequacy of obtained data by the smartphones GPS and Google Earth, the standard error was calculated according to the procedure shown in Figure 9. The precision parameter considered was the database of certified rural properties made available by the Land Management System (SIGEF).

The points collected for the comparison of the coordinates (UTM, Datum SIRGAS2000) and the results of the analysis are presented in Tables 1, 2 and 3.

The results in Table 3 showed that data obtained by these different technologies presented different EP values: 5,34 m (SW MAPS); 4,71 m (MOBILE T.) and 7,50 m (GOOGLE EARTH). However, when verifying the adequacy of these data (Table 1) it was found that they fall as Class A for a scale of 1/50,000 and as Class B for a scale of 1/25,000.

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These results differ both from those obtained by Pereira (2015), who observed usability with security of images provided by Google Earth for a scale of 1/30,000 or lower, and accuracy information of 4.9 m for GPS-enabled smartphones in no cloud conditions (GPS.GOV, 2020).

Table 2 – Coordinates of points collected for testing

POINT	SW MAPS		MOBILE T.		GOOGLE EARTH	
	X	Y	X	Y	X	Y
1	810449,04	8916918,75	810448,01	8916918,81	810451,05	8916916,56
2	811819,24	8914740,00	811818,33	8914739,94	811824,61	8914743,55
3	814302,03	8914898,62	814301,61	8914898,30	814299,57	8914902,80
4	816652,93	8913478,13	816652,32	8913477,84	816653,09	8913478,92
5	824625,14	8908819,31	824624,55	8908818,86	824615,86	8908812,20
6	825622,61	8905679,49	825622,08	8905679,15	825611,59	8905681,01
7	825997,66	8904504,56	825997,30	8904503,87	825993,11	8904505,89
8	827767,89	8909654,04	827767,51	8909653,99	827762,66	8909662,61
9	820882,20	8922373,46	820881,57	8922373,00	820882,58	8922376,14

Source: Authors (2020)

Table 3 – Coordinates of points collected as a precision parameter

POINT	SIGEF	
	X	Y
1	810444,05	8916916,56
2	811814,42	8914737,25
3	814297,41	8914896,14
4	816648,24	8913475,39
5	824619,97	8908817,86
6	825617,29	8905679,15
7	825992,54	8904504,09
8	827762,93	8909653,01
9	820876,92	8922372,03

Source: Authors (2020)

Table 4 – EP values (m) checked from the collected points

	SW MAPS	MOBILE T.	GOOGLE EARTH
EP (m)	5,34	4,71	7,50

Source: Authors (2020)

4. CONCLUSION

This work showed that application of free geotechnologies for constructing a solution to sugarcane sector made available functional tools to attend offline activities like data collection, manipulation, storage, export and sharing.

The SW Maps app possibility to collect data and share georeferenced files using the device's GPS in different formats allowed obtaining important data during field works for future attributes insertion as plots of each farm. Combining this functionality with the generated vector

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maps made it possible to acquire data for future analyzes, promoting generated products share and optimization of various tasks related to the production system.

Thus, it is an excellent alternative to optimize certain day-to-day work tasks that do not require a high degree of accuracy, for faster and more assertive decision-making.

However, other functionalities need to be better explored, measured and improved, which means these technologies need great evolution to perform tasks that require high precision for sugarcane field, distance, perimeter and area measurements.

Further, studies will be necessary to quantify this information, especially when taking into account the diversity of smartphones available in the market today.

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BIOGRAPHICAL NOTES

Currently, I am Associate Professor II of the Campus of Engineering and Agrarian Sciences (CECA/UFAL). Has a PhD in Geosciences and Environment with experience in the areas of GIS, Geoprocessing and Integrated Territorial Planning. It has worked mainly on the following topics: automated classification of land use and occupation, application of Neural Network in high and medium resolution aerial images, digitization and recovery of collections of Aerophotogrammetric Surveys, Agroforestry imaging and SAFs with UAV (drone), application of free software (QGIS, Google Earth Pro...) for visualization, mapping and geoprocessing of territorial data. Also coordinate the CNPq Research Group CADEH (Collective for the Improvement of Spatial and Human Data), and LANESA (Laboratory of Spatial and Environmental Analysis) at CECA/UFAL.

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