Expert System that Assists the Cultivation of Mandacaru Aimed at the Production of Water and Food in the Interior of Northeastern Brazil

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Abstract. The purpose of this research is to provide more comfort in the life of the Northeasterners, more precisely those who live in the interior of the Northeast, using resources already present in their daily lives with the help of technology, and for that, the cactaceae will be studied and used. mandacaru (cereus jamacaru), a wild card from the hinterland and can be used in various ways for food, medicinal or even for handicrafts. The interior of the northeast is composed almost exclusively by the semiarid region, but also has the caatinga, both biomes where the heat is predominant practically throughout the year. The absence of rain in recent years has left the situation severe for many regions and especially for many residents, as the interior of the northeast is isolated from large centers, many places do not have running water, often even basic sanitation, which makes them dependent rainwater or water trucks that go very rarely to them. As an alternative for farmers who have their families and take care of livestock and the countryside, mandacaru comes as a relief to many, since it is not today that many animals die from drought and families are in need since there is no water to grow and generate food. But one solution is the assisted monitoring of the mandacaru, which can mitigate the conditions in which the Northeasterners and the animals find themselves.

Keywords: Cereus Jamacaru · IOT · Notheast · Paraconsistent logic

1 Introduction

This work presents an applied research that seeks to generate knowledge for practical application; with a quantitative approach, which tends to emphasize deductive reasoning, emphasizing the dynamic, comprehensive aspects focused on social and survival experiences. This type of research uses structured procedures with formal instruments for data collection, whose purpose is the collection and analysis of data. The exploratory

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objective of this study aims to provide familiarity with the problem and build the central hypothesis that is the use of the Paraconsistent Decision Method, thus developing a practical solution in the form of a functional prototype.

It is not just today that the Northeast of Brazil has been suffering from drought and forgetfulness, but even though large cities have resources and even places that are automated, the countryside suffers without any forecast of improvement, in some places there is no sanitation or even energy for homes. So how to open a company to generate jobs or how to automate processes when most of them are not even literate, or have access to education even with social advances [1]? People's livelihoods are provided by the government's agricultural assistance, which is approximately R$ 100.00 per farmer , but the main source of income comes from what they produce, the food plantation, the cattle they raise or even an embroidery that makes and manages to sell, this becomes a variable for many to leave schools, when it gets bigger, it is necessary to help with income in some way,

But sometimes living on the fields and livestock can be very difficult, both due to manual labor, but mainly because the Northeast has been suffering from a severe drought for some years [2], so finding a way to obtaining the provision for yourself and your family, feeding the cattle and taking care of the plantation can be an arduous task (Fig. 1).

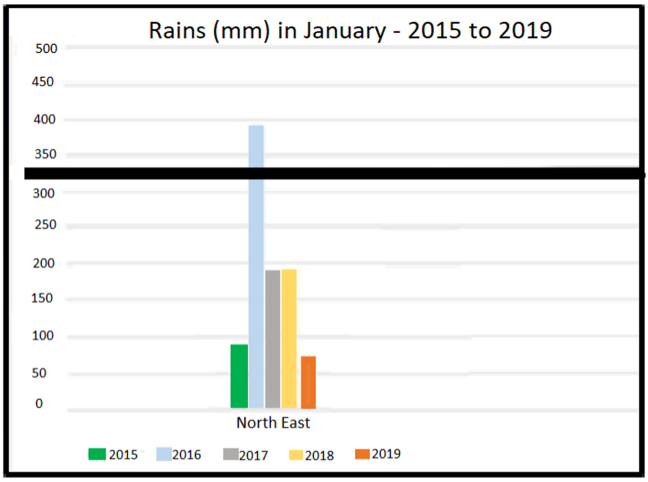

Fig. 1. Cutout of graph: average rainfall in Northeast Brazil [Source: [3]]

And then, as an alternative we use Cereus Jamacaru, which, although it has a slow growth compared to other flowers and cactaceae, it is possible to grow and develop anywhere, there are reports from residents who tell about mandacaru that grew even on top from the house, on the roofs. And because it does not need that much care, mandacaru is perfect for these regions, because, unlike other plants, it does not need a lot of water or constant irrigation, this, in fact, can cause damage to mandacaru, since one of its main pests is humidity.

In the northeast, Cereus Jamacaru is a symbol of resistance, as it remains firmly dry and has water storage as one of its main characteristics, which can make it resist years without the need for water. Its structure helps it to survive beyond the drought to the cold climate also true, not only droughts, but also to the cold climate, however the mandacaru found mostly in the Northeast due to the dry climate.

The physical characteristics of the Cereus Jamacaru are its long thorns, although the cactaceae has a variation without thorns, the thorns serve as a protection by acting so that no predator approaches the Cereus Jamacaru or its fruit. Its size varies, but it can reach up to six meters in height, possessing an edible stem and interior with a lot of liquid due to the storage of water, it is very well-known flower and present even in the local folklore for blooming at night and withering at dawn. day has medicinal properties, in addition to the regeneration ability that the mandacaru has, it has a fruit that has a characteristic abundance of water in addition to being very sweet, it is usually protected by the thorns of the Cereus Jamacaru, making the only animals that have access to be small birds, which eat the fruits and end up spreading the seeds, which helps in the multiplication of Cereus Jamacaru. These elements present in everyday life that can help in the life of the Northeast.

When the time comes to use Cereus Jamacaru (with thorns) and you need to remove it, sometimes they occur by burning the Cereus Jamacaru, where only the thorns are affected, or by cutting off a piece of Cereus Jamacaru together with the thorns, as they can serve by hand (Fig. 2).



Fig. 2. Cereus Jamacaru [Source: [4]]

The research will act to make his life easier, the Cereus Jamacaru can provide wonderful things for the population, using the paraconsistent logic and the IOT we will be able to reach an average of time that the Cereus Jamacaru develops, or the percentage of water it stores so that thus, let us have an average so that the population always has everything mandacaru has to offer.

2 Social Impact

By retaining water, in the driest season it becomes essential for the feeding of animals, because, when given, in addition to quenching hunger, it can quench thirst as well. Another way of using Cereus Jamacaru is in the medicinal area, and the roots and stem are commonly attributed to diuretic action and benefit from heart, respiratory and kidney diseases. The entire plant is used for scurvy and for respiratory tract disorders. Its flowers can also be used for the treatment of headache and body.

Cereus Jamacaru can contribute to the improvement of the quality of life of the people of the interior of northeastern Brazil, when it is possible to make a living through planting, many who live on it do not know how to continue taking care of cattle now that there are no resources to use as food or how to buy food for him and when using Cereus Jamacaru for this, the need to buy food for cattle does not exist, thus preventing the sale of the same or even that the cattle die of hunger.

3 Internet of Things (IoT) in Agriculture

The Internet of Things (IoT) can transform the world in which we live; more efficient industries, connected cars and smarter cities are all components of the IoT equation. However, the application of technology such as the internet of things in agriculture can have the greatest impact. The global population is expected to reach 9.6 billion by 2050. Thus, to feed this population, the agricultural industry has adopted the internet of things [5].

The challenges, such as extreme weather conditions and increasing climate change, and the environmental impact resulting from intensive agricultural practices, the demand for more food needs to be met. Intelligent agriculture, based on IoT technologies, will allow producers and farmers to reduce waste and increase productivity, from the amount of fertilizer used to the number of trips that agricultural vehicles have produced [5].

Smart farming is a capital-intensive, high-tech system for growing food cleanly and sustainably for the masses. It is the application of modern ICT (Information and Communication Technologies) in agriculture. In intelligent agriculture based on the internet of things, a system is built to monitor the crop field with the help of sensors (light, air humidity, temperature, soil moisture etc.) and automate the irrigation system. Farmers can monitor field conditions from anywhere [5].

The applications of intelligent IoT-based agriculture are not only intended for large conventional agricultural operations but can also be new levers to raise other common or growing trends in agriculture such as organic farming, family farming (complex or small spaces, private livestock and/or cultivation, preservation of particular or high-quality varieties, etc.), and to improve highly transparent agriculture [5].

4 Method

The process of developing this research was divided into three parts (Fig. 3).

The first stage had the objective of designing how the prototype would be monitored. For this purpose, mandacaru was planted from the seeds, with the chosen locations it

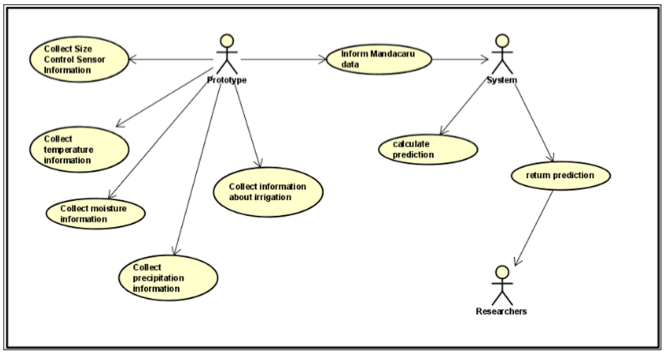

Fig. 3. Use case [Source: Authors]

will be possible to follow how growth occurs with Cereus Jamacaru exposed to different climates (Fig. 4).

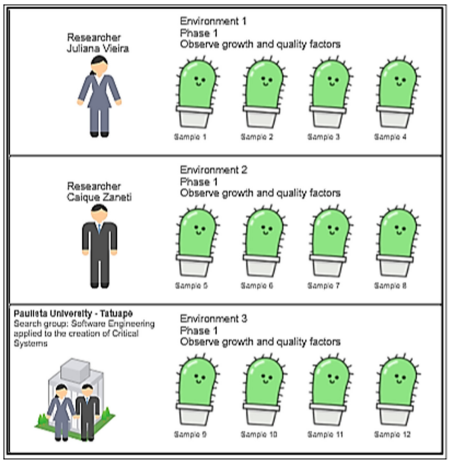

Fig. 4. Description of the first phase [Source: Authors by cacoo]

After the seedlings are placed, manual monitoring is started, it consists of noting the average temperature of the day, if there was rain or sun and if they received water during the day (either from rain or irrigation) [5] (Fig. 5).

With the factors already extracted, in the second stage the seeds will be accompanied by sensors to validate phase 1, and calibrate the sensors more efficiently, already making it possible to remotely observe the samples using prototyping plates (Arduino) interconnected through a system via internet, using Wi-Fi module and being observed by a web observation system (Fig. 6).

With the sensors calibrated and the data starting to be obtained and stored in the previous phases. Phase three will consist of collecting the data and making a prediction of the mandacaru, using the paraconsistent logic of the average that each seed in each

Date D/M/Y:	Average temperature of the day	Sun:	Rain:	Water:
22/03/2020	20,5°C	Yes	No	No
23/03/2020	21,5°C	Yes	No	No
24/03/2020	20,5°C	Yes	No	No
25/03/2020	20,0°C	Yes	No	No
26/03/2020	21,0°C	Yes	No	No
27/03/2020	22,5°C	Yes	No	No
28/03/2020	23,0°C	Yes	No	Yes
29/03/2020	23,5°C	Yes	Yes	Yes
30/03/2020	23,0°C	Yes	No	No
31/03/2020	23,5°C	Yes	No	No
01/04/2020	23,5°C	Yes	No	No
02/04/2020	24,5°C	Yes	No	No
03/04/2020	22,5°C	Yes	No	No
04/04/2020	20,0°C	Yes	No	Yes
05/04/2020	21,5°C	Yes	No	No
06/04/2020	24,0°C	Yes	No	No
07/04/2020	20,5°C	Yes	No	No
08/04/2020	17,0°C	No	No	No
09/04/2020	18,0°C	No	No	No

Fig. 5. Manual Monitoring [Source: Authors]

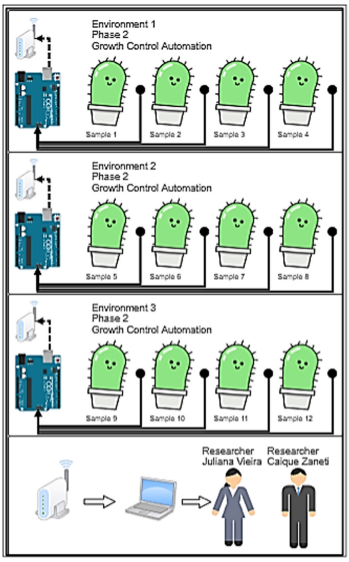

Fig. 6. Description of the second phase [Source: Authors by cacoo]

environment took to arrive at the right moment and with a significant amount of water, thus predicting how the future of the plant, in terms of the amount of water in it, age of the plant, frequency of the fruit and flower, size control and obtain data on humidity, rainfall and temperature at which it is found. The information will be presented on a dashboard to better illustrate the situation (Fig. 7).

And then, as all the steps done, and calibrated sensors will be possible to estimate the amount of food and water that the population will have in each period.

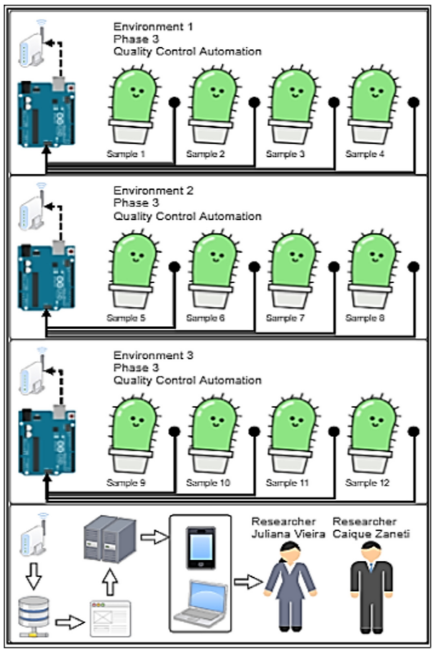

Fig. 7. Descriptive third phase [Source: Authors by cacoo]



Fig. 8. Dashboard for monitoring [Source: Authors by Adafruit Platform

You can access Mandacaru's real-time tracking. A prototype was assembled, which has a Wi-Fi connection that, together with sensors, collects information and communicates with the Adafruit interface (Fig. 9).

By reading the Qr Code it is possible to access the research Dashboard and monitor the growth control and the climate situation in real time (Fig. 10).

The prototype was assembled using the ESP8266 which is a microcontroller just like the Arduino, however, it also has an integrated wifi card for communication and

Fig. 9. Qr code dashboard [Source: Authors]

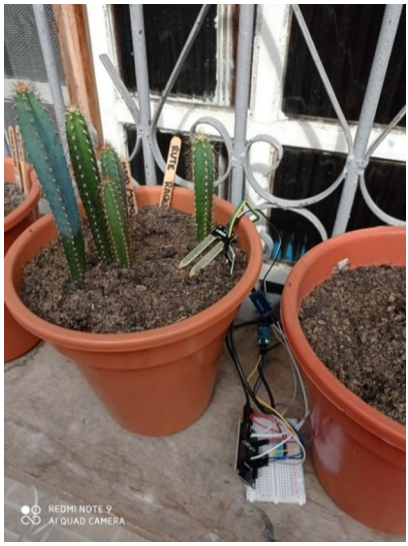

Fig. 10. Prototype in state of the work [Source: Authors]

different from the Arduino too, it only has an analog port which resulted in a change in our plans using two hygrometers, being used one to measure soil moisture and the other rain. The DHT11 sensor was also used, which collects information about the current temperature of the environment and also has an air humidity sensor, communicating with the dashboard via a wifi module as shown in the Fig. 8 (Fig. 11).

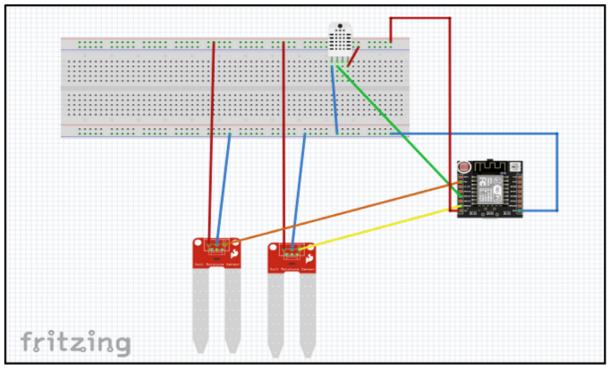

Fig. 11. Electrical scheme prototype [Source: Authors by Fritzing]

5 Paraconsistent Logic

The Paraconsistent Decision Method was developed by the study by Carvalho [6], with the objective of identifying factors that influence the success or failure of an enterprise, that is, that end up influencing the decision to carry out certain projects or not. Its analysis made it possible to identify that the attributes may, in some cases, indicate favorable conditions, in others, unfavorable and, in others, indifferent. These factors can be of different orders: economic, social, legal, environmental, technical, political, among others [7] (Fig. 12).

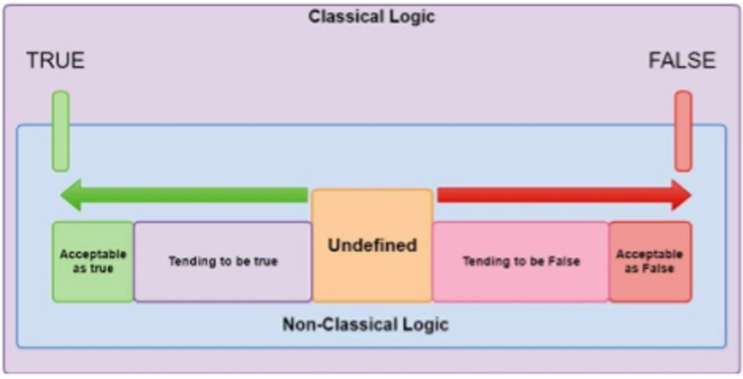

Fig. 12. Classical logic versus non-classical logic [Source: [8]]

The paraconsistent logic uses as input the experience of the participants in the decision-making process, the so-called experts, as a fundamental assessment tool on a given issue, making any situation feasible or unfeasible.

Starting from a problem, question or note, which receives the name of proposition, the method determines the need to end the so-called factors that, as the name says, are the factors that impact on the viability or unfeasibility of the present proposition [7].

The factors can be sectioned, to increase the accuracy of the analysis of a given factor. The created sections can extract more of the knowledge of the specialists who are evaluating them.

The paraconsistent logic, as an aid tool in decision making based on paraconsistent logic, has a fundamental role in the treatment of the opinions of its participants, considering its contradictions, which, in certain cases, is of extreme importance for more informed decision making exact [8] (Fig. 13).

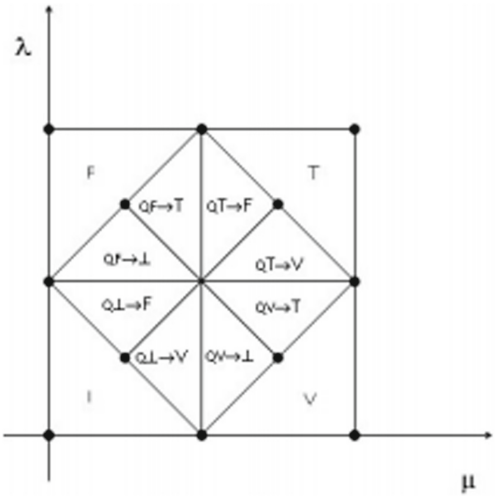

Fig. 13. Extreme and non-extreme States [Source: [9]]

6 Result and Discussion

Even with the slow growth of Cereus Jamacaru from the seed it is possible to observe that even though it is in a small size (about five centimeters), it stores a significant amount of water for its size.

As much as technology is advancing exponentially worldwide and processes that previously took a long time and a lot of labor, are now being carried out quickly and with less or even no labor, in the interior of the Northeast in Brazil this is something very scarce, it seems that the place has been forgotten. Simple resources of large cities can become difficult for people who still live in the countryside and livestock.

The research is still being developed slowly, her current situation is step two of the procedure, all data was collected manually, and the prototype is being developed, the growth of Cereus Jamacaru from seedling and seed is being monitored up close, but because it is a plant that has a firm structure to resist a long time without water it takes a while to develop (Fig. 14).

Because the research is not being developed precisely in the climate and native region of the Cereus Jamacaru, he ends up suffering more from the plagues that he normally would suffer in the northeast.



Fig. 14. Photo collage, Cereus Jamacaru before and after almost eight months [Source: Authors]

Like mealybugs, which occur when the mandacaru is exposed to too much moisture (Fig. 15).

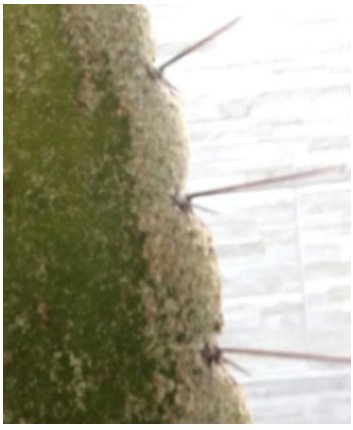

Fig. 15. Appearance of mealybugs [Source: Authors]

The mealybug looks like dirt in the mandacaru, which leads us to think it could be that or earth, but it is a fungus that corrodes the mandacaru, sucking its nutrients, leaving it yellow and weak, so that the mandacaru will rot and release all the water stores and withers (Fig. 16).

This is not the only pest that affects the Cereus Jamacaru, there is also Phytophthora spp, a pest that reaches the roots and causes color and rot in the mandacaru, among others that affect it negatively, where the only way to save the Cereus Jamacaru is cutting out the diseased piece, but sometimes even that is not enough.



Fig. 16. Cereus Jamacaru rotting through chowchillas. [Source: Authors]

A study on the main pests and how they act is also being raised, so that in the future, in a way to increase the prototype, using image recognition, it can effectively the main pests, bringing less damage to the mandacaru.

7 Besides Mandacaru

This topic aims to present variations on how this project can be implemented, bringing ease to the daily lives of other people and regions.

7.1 Opuntia Cochenillifera

The research initially focused solely on Cereus Jamacaru, but could be extended to other categories of cacti that, like the mandacaru, develop better in hot weather and can take advantage of this same monitoring and pre-collected data, the Opuntia cochenillifera known in the region like Palma, very common in northeastern Brazil, it is also versatile in their daily lives (Fig. 17).



Fig. 17. Opuntia Cochenillifera [Source: [10]]

In addition to this species, it is possible to list other species in which few or any changes to the prototype would be necessary to be successful, considering that all the cactuses that will be accompanied by the prototype have the same purpose of supplying hunger and thirst for people and animals.

7.2 Pilosocereus Polygonus

Another option for the hot and dry climate is the Pilosocereus polygonus, known locally as xique-xique, which features branches that drag along the ground resembling a crown, as well as the Cereus Jamacaru also has a flower and fruit and can be used for food for people and animals (Fig. 18).



Fig. 18. Pilosocereus polygonus [Source: [11]]

The adaptation of the prototype for this kind would be simple, given the huge similarities between them, with the one of the few differences in the form of development because the Cereus Jamacaru grows vertically and Pilosocereus polygonus develop in scattered form, as said.

7.3 Pilosocereus Magnificus

An option that goes beyond the dry climate and is part of a more humid climate, the pilosocereus magnificus, regionally known as Blue cactus, is named for the bluish green color it has, this color is due to Anthocyanin, being a pigment of plant tissue, which can protect the plant from external environmental factors, due to this fact its development is facilitated in more humid climates. Anthocyanin can be found in blackberries, blueberries, cherries, juçara fruits and many other foods (Fig. 19).

In this case the prototype could fit well too, but with some adjustments, as it is found in wetter climates, it may need a little more water than the others, but that doesn't change the fact that it's still a cactus, and as a cactus, it enjoys the sun and needs it for its development.

The real benefit of the prototype is not just for the cultivation of mandacaru, as the intention of this project is above all to improve the quality of life of the inhabitants of northeastern regions in Brazil specifically, that is, in its development the productive factor was taken into account not imagining financial profits, but environmental and social benefits, which meant that low-cost materials were chosen (given that it is a region by definition more lacking in financial resources), low environmental impact with high-durability devices that use natural resources in a conscious way and return maximum positive results for the environment.



Fig. 19. Pilosocereus Magnificus [Source: [12]]

One of the concerns was also not to impact the environment in a predatory way, that is, so that there is no risk of turning into a worrying and fragile monoculture, since it will be possible to use it in a mixed plantation.

8 Conclusion

In short, although it has the capacity to regenerate, as it was said, it grows slowly, so it is necessary a large space to plant the Cereus Jamacaru so that it can have in greater quantity to supply the needs in greater quantity, because, as was said. In addition to being important to people, Cereus Jamacaru may be even more necessary for farmers who would not need to pay money that would be used for food for the family or something to plant.

The project is still in production more precisely in the second phase, where the software is being produced, so that it acts as a comparison of the information obtained in the manual monitoring with that collected by the sensors, although it is already possible to observe the water inside the mandacaru by unless it is, manual monitoring is of great importance for parameters for the prototype that will perform the procedure alone.

In a cost-effective manner, the purpose of the prototype is to be able to assist non-governmental organizations that operate in the northeast, so that it brings better planning to them and helps them better serve the population, and even, it can be used by people from the countryside, using the dashboard will make the interpretation of the presented data easier.

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