Agriculture 4.0 the advance in models and new knowledge to improve production.

F González-Salazar
Electronic Engineering. Seedling leader in Agriculture 4.0 – GiosTIC Research Group.
Services Technician at Netux Tecnologia. University Institution of Envigado
Email: ferdinan7@gmail.com

Abstract. This article presents Research on the design and application of a model that allows controlling agroecological variables and conditions based on inductive-deductive methods supported by qualitative and quantitative tools such as metadata, trend tools and comparison graphs. This Model represents the knowledge of the farmer in a different kind of applications that allows the continued progress of the agriculture. The model has been tested with some agricultural, plant and animal species in controlled in real environments, where the quality of the cultivated species can be measured to determine improvements in nutritional quality, this measure is made by sensors of temperature, pH, lumens and humidity then we have a mathematical model that allows the simulation of the variables that we want to control that includes monitoring and control times. From here, concepts of agriculture 4.0 are associated, which consists in mitigating the risk in different in the environments. Currently, the integration of concepts and technologies associated with the fourth industrial revolution is evaluated through the simulation of variables and comparison between ideal and real models.

1. Introduction
To contextualize the space of the research carried out, some aspects of the agricultural plans that Colombia has and the elements of interest for the agriculture 4.0 project, its development and the possible elements of application are described.

“In Colombia, the National Development Plan proposes as a transversal strategy the transformation of the field and green growth to strengthen the competitiveness of the agricultural sector, seeking to modernize processes and projects” [1]. Colombia, like most Latin American countries, is a country of regions, so its diversity of climates benefits it for the growth of various plant and animal species. However, climate changes has caused problems of drought for long periods and instability in climatic conditions, in addition, the erosion caused by deforestation and the little technification implemented in agricultural practices, complicate the greater expansion of this type of crops Precision agriculture (PA) discourses this problem, “the term occurs in the early 1980s, with the use of sensors and positioning systems, the use of data from all types of sensors, both in-situ and remote, together with positioning via GPS / GNSS offers the possibility of generating useful recommendations for farmers to make informed decisions about what actions to carry out in their plots ”[2], since then developments have been generated where agriculture concepts are applied 4.0, which has managed to introduce not only electronics, but the convergence of different knowledge as if stemas, mathematical modeling and agro-
biotechnology, seeking a better production process through the joint innovation of technological and agronomic sciences.

"All the techniques are already being introduced in our territory as evidenced by the fact of the number of companies that offer different products and services of precision agriculture"[2], the implementation of technologies to improve agricultural production and efficiency processes, together with the diversification of Colombian and foreign species, establish the initial conditions that allow developments in agriculture 4.0.

“Now, with information and communication technologies (ICT), unprecedented ways have emerged to generate, store, transmit and distribute information, causing important changes not only in formal and non-formal education, but also in social relationships, work, economy, politics, culture and daily life”[3], the electronic signal conditioning models establish ideal growth conditions; Agriculture 4.0 manages to concatenate the information that nature gives us and converts it into data that allows its management, in the same way it includes metadata analysis that determines trend lines and behavioral graphs that make constant comparisons with the actual measurement for maintain ideal conditions as much as possible.

“The application of optimal quantities at the right time and in the right place allows a reduction in time, costs and impact on the environment, as well as an increase in yields obtained in crops”[2]. Although Colombia It is a country with the optimal agro-ecological conditions for cultivation, it is located below the world average of agricultural production, due to the insufficiency of land for agriculture. Agriculture systems 4.0, generate optimal conditions regardless of the availability of the land or external environmental conditions, the only thing required for its implementation is a space dedicated to cultivation.

Information and communications technologies (ICT) have begun to be used and implemented throughout the crop's life cycle”[1]. “It is a strategic initiative for the industrial sector, triggered by the development of communication and information technologies (ICT), which results in a transformation of traditional production systems”[4]. Food is defined as one of its strategic focuses. It is from here that the objective of this research project is inspired, which seeks to generate sustainable production models for the cultivation of agricultural species, innovating in its growth process and final result for its consumption and/or transformation, improving the productivity of Colombian agriculture.

2. Methodology

Agricultural production processes require models and processes that that allow their reproduction, regardless of changing agroecological conditions and the different environments associated with them, for this the model of agricultural production applied to the technification of their processes, starts in agriculture models precision (AP), which have the ability to increase the productive efficiency of a crop in turn managing in a more efficient way the resources required for it. In the agriculture of precision, different technologies are observed such as satellite geo-positioning systems, both physical and digital geographical processes of agronomic conditions, performance monitors, sampling and fertilization management, automatic nutrient management, agroecological conditions sensors such as temperature, humidity, lumens and pH, the convergence between these technologies establishes a more precise production model but lacking human conditions that allow decisions to vary according to the terrain, and types of planting.

“In agriculture, water quality is of great importance because it is a factor to be considered for obtaining high agricultural yields”[5], precision agriculture models are today a combination of technologies applied in order to increase, preserve and evolve agricultural management techniques, it is there that the convergence of current schemes nested in a single production model based on concepts of agriculture 4.0, manage to develop disruptive models and schemes of intakes of Critical decisions for agricultural production, through manual and semi-automatic processes, human expertise is included according to the ideal production conditions.

"Due to the impacts of climate change (increase in temperature, increase in CO₂ and variation in the acidity of the soil) agriculture has been affected during the cultivation process”[6] current models
establish technological models while Agriculture 4.0 establishes conditions of convergence that can be scaled over time. These allow a number of applicable solutions, which in the Colombian planting process generate conditions of evolution towards new exploitation processes and, above all, the conservation of our environment.

3. Developing

“A third of the global population derives its livelihoods from agriculture, and in emerging economies it can represent up to 30% of GDP” [1]. Conventional exploitation processes in agriculture make it difficult for them to be repeatable and used in time and space independent of the agro-ecological conditions to which it is involved, that is where agriculture 4.0, with each of the technological systems at the service of the controlled exploitation of agriculture, allow "ideal" and "variable" conditions of production, always within the framework of conservation and quality of the final product.

"Precision Agriculture means the differentiated application of inputs, taking into account the characteristics and needs of each specific area of the field or land, through the use of geo-computer techniques and other technologies" [7]. Agriculture 4.0, in all its definition applied to our developments, manages to concatenate technology at the service of nature, where it gives us valuable information that, through mathematical models and microelectronic control and automation schemes, generate a formula for the acquisition of information that will become metadatas, which will be adjusted in time by the agronomist of the present and future, a person with a high knowledge of the environment and agro-industrial with a great sense and competence of textual information analysis, which will allow guiding their knowledge towards controlled equipment, establishing more demanding and efficient agricultural administration models according to environmental and market needs.

Apply mathematical models and prospective techniques that control the conditions of the environment and its variables such as humidity, light, temperature, pH among others; It achieves environments adjusted to agricultural needs.

The incorporation of vibro sensor systems and microelectronic devices are a fundamental part so that the conditions of the plant are optimal and the climate is not a determining factor for its growth obtaining efficient and effective results in agriculture 4.0.

“We want to describe the possibilities of applying these tools to decision making in agriculture” [8], it is ideal to test management tools under the “Block Chain” scheme that allow the implementation of models using tools of risk management and determination of critical points in the process.

These tools are based on a production model, the systems are reflected in the low productivity and quality in most crops, "perhaps due to the lack of a system of instruments that allow the farmer to know when and how to produce according to the climate” [6], a method applied to agriculture 4.0 was generated, which has been consolidating throughout the world since 2016 a few years after the 4.0 industries boom exploded, of which it is part. For the integration of these two branches such as systems and electronics to control the variables of each system, it is necessary to be clear about which are the variables to be controlled, that is, which of the thousands of variables will be the selected ones, In this case, the project team considered that the lumens, relative humidity, pH and temperature are variables specific to each system and that in some variation of it can affect the entire system and cause imbalances with dire consequences and potential loss of this one.

Measuring points are specified, which indicate that parts of the process are considered more vulnerable, after having clarity on this, a mathematical model based on statistical concepts such as trend lines, graphs of behavior of agroecological variables that are fed by sensors was generated which in turn feed the metadata. With this, a 4.0 integration model is generated based on a “PHVA” (plan to verify), and the recurring need for models that allow greater efficiency in the management and quality of agricultural products. This means that in Colombia and in much of Latin America, it is not easy to find models that generate greater efficiencies in the final product and that also offer a higher quality in agricultural production. This creates the need to generate their own production model for agriculture 4.0.
The design plan begins, based on knowing in detail the agricultural process that is to be intervened, which generates an impact mitigation plan, in addition to a change management system to ensure that it is effective. At this stage of the process, the sensors that will be used for the data collection of the different variables are specified, the way in which the data is quantified and its processing, based on metadata and data science, in order to submit this information under a continuous improvement system, which indicates that the system can always be improved in each of its versions, until it is considered to comply with the necessary standards of ISO 9001/2015.

When this level was reached, they proceeded to implement, which resulted in a demo version of a functional and viable system and by repeating the process several times the productive version was reached.

Research is complemented with simulation of automatic control for irrigation systems. Methodologically, the Penman-Monteith and water balance models were used to analyze the water requirement of the crop” [9].

As a control strategy, the water systems could be associated according to the type of controller according to the system designed proportional, integral and derivative (PID) and diffuse type controllers were used to compare comportments and establish the best option in the face of crop water resource difficulties under climatic conditions. See Figure 1.

“Adopting the concept of 4.0 is the opportunity to make the country’s production more competitive, mainly in exportable goods” [4]. For the generation of this model, the inductive-deductive method was applied, which allows transcending from a general idea to a final product, applying quantitative tools that facilitated decision making and data mining, and the use of qualitative tools that allowed the differentiation of each of the systems and how optimal was their intervention in the processes. With this, improvements were achieved in growing times in both crops and animal species and in quality standards to make it faster in growth, without losing nutritional quality.

The uses of micro-electronic systems on planting allow cultivation in unproductive or very small spaces, where it would normally not be possible to cultivate.

Finally, the last component of the model, the administration and management of the integrity of production or what was called traceability according to ISO 28001. It is a strategic initiative for the industrial sector, triggered by the development of communication technologies and information (ICT), which results in a transformation of traditional production systems” [4]. "An agricultural company is made up of the natural, human and capital resources it has and the external and internal factors that condition production; where management plays a very important role in the efficient control of internal factors” [10]. Inspired by these concepts, the administrative component for the management of all the systems implemented and the decision making of the projects is carried out, it was defined at what moment the possible vulnerabilities, risks and the identification of the critical points can be presented, control points at each step of the system. Eight fundamental schemes of an organization were evaluated:

![Figure 1. Block diagram of the controller. [9]](image-url)
Human, Economic and Financial Resources, Information, Corporate Image, Environmental, Operation, Customers and Suppliers.

The Joiben matrix is shown where the risk is analyzed with respect to its severity and its probability of occurrence and how each of these factors can be managed or mitigated its impact so that the severity is lower or minimum after its management. This is achieved by means of a matrix which is responsible for making these qualitative variables take a quantitative value with respect to the severity and the probability of occurrence after each of these risks are outlined in some technical sheets which will mitigate this risk from foresight, prevention, protection, attention, control, transfer, recovery; this to attack the risk before it occurs and implement. A contingency plan for this so that its probability of occurrence is low.

To replicate the model it is necessary to make a study of the natural phenomena of the space that is desired to intervene since all the areas do not have the same conditions, therefore for each intervention their own indicators or natural values of each variable are generated; This implies that this condition must be added to the model every time one wishes to implement.

“While additive manufacturing presents greater precision in the terms that define it, this is not the case with Industry 4.0, as it does not have a standard terminology as such, rather it refers to a wide
spectrum of technologies, processes and applications in the framework of digitalization, autonomy and networking” [11]. The strategies allow us to have a large number of information available to the industry because of the influence of the 4.0 industries and in turn the data mining and the possible applications of these tools.

4. Results
Once the production model has been established, the work team applied the control of agro ecological variables to potato crops and the clean production of pigs whose processes and results generated two patents: (Ref. File No. NC2016 / 0005923) entitled “irrigation system by aeroponics for controlled production in potato variables” which in its productive model manages to increase starch production per unit of potatoes by 35%, decreasing its final production from 4 months to 3 months, and the second patent (Ref. File No. NC2017 / 0004296) entitled “automation of the livestock production process” which mitigates the proliferation of epidemic swine diarrhea in each stage of semovient growth, thus generating optimal traceability and prolificacy conditions for its production, and commercial development

The patents were evaluated by the Superintendence of Industry and Commerce of the Republic of Colombia under resolution No. 37606 and No. 37358.

These patents attest that the model is functional and meets the academic and productive objectives set for the development of this. Currently working on new projects such as the incorporation of new species and aquaponics systems among others in the field of agriculture, focused on systems that optimize growth times in both animal species and plant species under the generation of microclimates and Microelectronics tools that act on agricultural species.

5. Discussion of the results
“The benefits of agricultural production for society and its interaction with the environment; they are subjective and inaccurate, so it is suitable for the application of mathematical models of fuzzy or fuzzy logic ” [8], this as a cause has a social component under agribusiness projects and the export of these raw materials to other countries since around 12 million people in Colombia have a livelihood through the countryside. This model of Agriculture 4.0 has a significant impact as it improves the efficiency and productivity of these areas, which will help economically the people who join these processes.

"The technification of crops, although it improved productivity against crop pests and diseases, deteriorated the environment, increased deforestation, decreased wildlife and damaged the soil” [12]. The author states that the techniques they are currently using do not favor the environment, which is why it is important to make planting systems in favor of the environment with the use of clean energy and good water management Residual crops, so a solution for deforestation is the conditioning of agricultural spaces and tend to be more productive, thus minimizing the interaction with wildlife is where the microelectronics application model proposed when controlling Irrigation systems reduce water consumption and prevent damage to the soil. In this way, agriculture 4.0 generates a solution to the problem posed by Osorio & Alberto by implementing the technification of agriculture to reduce space, harvest time and water consumption and not to deforest areas with traditional crops and make a revolution technological technology that can meet the demand for food without affecting it irreparably.

“Some research has included different aspects of inter-organizational relationships in their models or empirical work, including areas of organizational behavior”[13]; This depends on the level of expertise of him who is in the execution or usually group different types of models in order to set the parameters that best fit and thus generate their own models. The innovative thing about this implementation is that it generated its own model that has been tested in several species and is currently advancing the planting of a non-native species such as the blue tomato of European origin and whose habitat was replaced by a space which does not It is suitable for agricultural production.

Currently, the new crops are tested in real environments in the La Heliodora Linear Nature Reserve in the Municipality of Envigado, where it is expected to observe the effectiveness of the model by growing the blue tomato in a controlled space.
Figure 4. Germination of the Blue Tomato in the nature reserve Parque Lineal La Heliodora. Photo taken by the author.

6. Conclusions

The processes of Agriculture 4.0 in Colombia and Latin America are at a fundamental moment so that the acquisition of 100% organic products is accessible to all socio-economic strata. Innovation in production, where the amount of land is not a requirement for the development and production of quality agricultural products, will allow countries with “ideal” planting conditions, position their processes and planting models of generations in enduring models in time thanks to the technological convergence between agriculture and technical sciences.

Multidisciplinary work generates more robust models; this model is the result of combining microelectronics, mathematics, the new concepts of the fourth revolution and the standards that allow continuous improvement.

Thanks to the application of mathematics, it was possible to strengthen the statistical techniques and the analysis of agroecological variables that determine the trend lines and expose behavior graphs of these variables, allowing more precise and reliable adjustments in the application of the Agriculture 4.0 model.

The administrative management model is a complement that will strengthen the industry and the adverse factors that are related to the production, times and quality of the agricultural industry.

It is possible to grow crops in unfit or unproductive spaces through the generation of controlled conditions so that the species to be cultivated has optimal growth, in addition to reducing production times and achieving the introduction of non-native species that diversify food for consumption, better quality of life and export opportunities.

7. References

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