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# IoT Enabled Agriculture & Forestry: Development of Water Level Monitoring Model for Efficient Utilization of Water Resource

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*Abstract*

***Agribusiness is confronting a major test these days: supply the requirements of the entire total populace without exhausting the accessible assets of the planet. Without a doubt, innovation and advancement are its most significant partners since they can enable horticultural possessions to be more effective and their creation frameworks more reasonable. In this regard, the advancement of sensors equipped for analyzing the ground conditions with correct precision and giving information to ranchers can be of extraordinary help. We are presently going to introduct the sensors connected to farming purposes that we may not know about.***

***In farming the need to expand generation and the synchronous endeavors to limit the natural effect of rural creation procedures and spare costs find in sensor frameworks the best associated apparatus. The utilization of sensors helps abuse every single accessible asset properly and to apply dangerous items respectably. At the point when supplements in the dirt, stickiness, sun oriented radiation, thickness of weeds and an expansive arrangement of variables and information influencing the creation are known, this circumstance enhances and the utilization of concoction items, for example, composts, herbicides and different poisons can be diminished significantly. Some portion of this information permits additionally checking photosynthetic parameters of high pertinence for photosynthesis. The majority of the related exercises fall inside the extent of what it is called Precision Agriculture, a rising territory accepting exceptional consideration lately.***

*Keywords:* ***Agriculture, Sensors, Crops, Water, Soil, Cloud, Wireless Sensor Networks.***

## 2.0 Literature Survey

In timberland administration, a branch of ranger service, various exercises are situated towards wood creation or backwoods inventories with the points of controlling parameters of intrigue, for example, distance across of trees, stature, crown tallness, bark thickness, overhang, stickiness, brightening, $CO_2$ change among others, generally with the objective of natural maintainability with high social effect. Sensors offer answers for controlling and observing generation in timberland trees while a similar time costs are limited by applying specific medicines because of the blast of these innovations. Furthermore, amid the after generation process, including transportation, stockpiling, pressing, choice, characterization or appropriation, among others, the utilization of sensors is of imperative significance for limiting expenses and negative natural effect, permitting vitality reserve funds or limiting the use of compound items [1].

Ranchers, analysts and specialized producers are joining imperative endeavors. continually attempting to discover more effective answers for taking care of various issues or for enhancing current generation or procedures. The exponential development of sensors capacities and advances permit abusing these abilities and the above objective ends up achievable [2]. The works distributed

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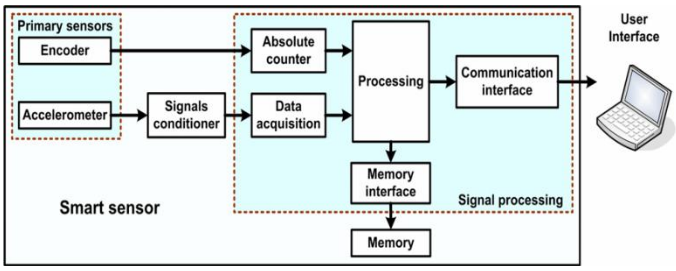
on this exceptional issue are a reasonable show of these statements. In what takes after the important sensor-construct advances and applications proposed with respect to this unique issue are displayed. Picture based sensors are a capable instrument for various purposes, including atmosphere fluctuation and fleeting examination of yield field regions, giving increased the value of harvest generation.

This sort of sensors can likewise be utilized for examination and measurement of product harm. Examination of soil scope by deposits is conceivable and alluring for controlling resulting preparations. Yield and weed division methods in view of pictures are of uncommon enthusiasm for Precision Agriculture. The blend of laser and picture cameras permits controlling the nature of apples under capacity. Picture sensors are likewise utilized for route in orange forests [3].

Three dimensional demonstrating of tea-shoots in light of pictures is likewise conceivable. The utilization of hyper-otherworldly and chlorophyll fluorescence imaging permit dissecting the trustworthiness of contaminated wheat ears. The utilization of stereoscopic pictures caught with angle eye focal points is valuable for timberland inventories. Multi-fleeting is practical in sugarcane by watching TerraSAR-X pictures. Picture based detecting innovations and photoconductive cells are helpfully consolidated for concentrate light fluorescent microspheres as molecule tracers in turbid water streams from the perspective of horticultural applications.




**2.1 Sensor networks** allow collecting different types of in-situ information which can be conveniently exploited for controlling crop production or monitoring ecosystems by analyzing different variables, such as light, temperature, humidity or climatological and anthropological events, among others. This information can be acquired by sensors deployed in different countries or areas and processed remotely, including web technologies. Sensors networks combined with image-based devices allow monitoring pests and diseases in vineyards. Analysis of biomass quality is also possible with sensor networks. Specific and dedicated sensor networks platforms have been applied in Precision Agriculture.

**2.1.1. Specific sensors** for soil moisture in both, agricultural and forest environments are also of special interest for analysis of plants.

Unmanned Aerial Vehicles (UAV) [4], equipped with different sensors, in collaboration with ground-based sensors have become a powerful tool for early fire forest detection and posterior monitoring. This combination of sensors has also been applied for crop monitoring under a wireless sensor network architecture.

**2.1.2. LIDAR sensors** are used to obtain dynamic measurements to estimate fruit-tree leaf area and combined with GPS have been applied for 3D map generation in vine plantations.

**2.1.3. Laser and hyperspectral** data are used for tree classification, including coniferous and deciduous trees. 3-D modeling of tomato canopies is obtained through high-resolution portable scanning LIDAR. Airborne LIDAR data are processed for estimating biomass in alpine forests.

**2.1.4. Agricultural robotics systems** are continuously expanding and the design of efficient sensor architectures for task classification, communication and control results of great relevance. The communication can be established among different vehicles or between different sensors mounted on a unique ground or aerial mobile unit, where sensors must be conveniently integrated.

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An interesting area is the one related to **autonomous or remotely guided agricultural tractors [5]**. For positioning a tractor in the field only GPS can be used as the unique sensor if the receiver is placed ahead of the tractor. Sensors based on augmented reality technology are useful from the point of view of autonomy. Guidance of a tractor by means of an electromiographic-based human-machine interface is vital for disabled people.

**2.1.5. Raman and Fourier Transform Infrared spectroscopy** has been used for assessment of structural differences of celluloses of various origins.

**2.1.6. Soft water level-based sensors** for characterizing the hydrological behavior in agriculture catchments have been used with promising prospects.

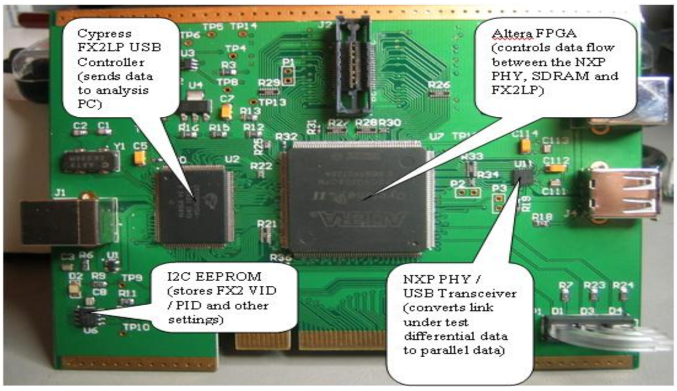
**Capacitance probes** are suitable for measurement of soil moisture in tropical areas.
The use of **methodologies** for boom sprayer regulation has been successfully applied; this was intended to guarantee that the dose of the product applied per surface unit is similar across the field.

**Reflectometers** can determine moisture content in oil palm fruits.
**2.1.7. Ultrasonic ranging sensors** are used for analyzing apple tree canopies.
**2.1.8. Optoelectronic sensors** for weed detection in wide row crops have been analyzed in terms of accuracy and feasibility [6].
**2.1.9. pH soil-based sensors** allow measurements of variables in the soil oriented toward crop productivity.
**2.1.11. Eddy covariance sensors** are applied to quantify carbon metabolism of peatlands and also regional and global analysis of observations from micrometeorological tower sites.

A solar energy powered **autonomous wireless actuator** has been designed for irrigation systems in agriculture.
**2.1.12. Fluorescence-based optical sensor** for plant constituent assessment was used to monitor grape maturation by specifically monitoring anthocyanin accumulation.

The measurement of the leaf temperature of forests or agricultural plants is an important technique for the monitoring of the physiological state of crops. The infrared thermocouple is a convenient device due to its fast response and nondestructive measurement technique.

Classification of seeds through an acoustic sensor is possible analyzing sound absorption spectra [7].




An **FPGA-based fused smart sensor** for real-time plant transpiration monitoring is possible.

Automated point **dendrometers** to analyze tropical treeline stem growth has been applied in forest inventories.

**Optical and microwave sensors** are suitable for characterizing olive grove canopies.

**2.2. Smart Agriculture Sensors: Helping Small Farmers and Positively Impacting Global Issues, Too**
Shrewd horticulture, otherwise called accuracy agribusiness, enables ranchers to augment yields utilizing negligible assets, for example, water, manure, and seeds. By sending sensors and mapping fields, ranchers can start to comprehend their harvests at a smaller scale, preserve assets, and decrease impacts on nature. Keen horticulture has attaches backpedaling to the 1980s when Global Positioning System (GPS)

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[8]capacity ended up available for non military personnel utilize. When ranchers could precisely delineate yield fields, they could screen and apply compost and weed medicines just to zones that required it. Amid the 1990s, early accuracy agribusiness clients received harvest yield checking to create compost and pH redress proposals. As more factors could be estimated and gone into a product display, more exact suggestions for compost application, watering, and even pinnacle yield collecting, could be made.

In this work, we will investigate how these detecting advances have been woven into present day extensive agribusiness and talk about how movement of the innovation both to little homesteads at home and also comprehensively can expand our ability to bolster the world.

### 2.3. Agricultural Sensors

A number of sensing technologies are used in precision agriculture, providing data that helps farmers monitor and optimize crops, as well as adapt to changing environmental factors including:

**Location Sensors** use signals from GPS satellites to determine latitude, longitude, and altitude to within feet. Three satellites minimum are required to triangulate a position. Precise positioning is the cornerstone of precision agriculture. GPS integrated circuits like the NJRNJG1157PCD-TE1 are a good example of location sensors.

**Optical Sensors** use light to measure soil properties. The sensors measure different frequencies of light reflectance in near-infrared, mid-infrared, and polarized light spectrums. Sensors can be placed on vehicles or aerial platforms such as drones or even satellites. Soil reflectance and plant color data are just two variables from optical sensors that can be aggregated and processed. Optical sensors have been developed to determine clay, organic matter, and moisture content of the soil. Vishay, for example, offers hundreds of photodetectors and photodiodes, a basic building block for optical sensors (**Figure 1**).

#### 2.3.3 NJR NJG115xP GPS, GNSS, and GLONASS Front End Modules

NJR NJG115xP Front End Modules are designed for GNSS including GPS, GLONASS, BeiDou, and Galileo applications. These FEMs [9] provide low noise figures, high linearity, and high out-band rejection characteristics supported by a high performance pre-SAW filter and low noise amplifier (LNA). These devices can operate from 1.5V to 3.3V. Features include a stand-by mode to save current consumption and a very small mounting area. two external components, and small package sizes.

#### Features

- Low supply voltage 1.8/ 2.8V typ.
- Low current consumption
- High gain
- Low noise figure
- High out band rejection
- Small package size
- RoHS compliant and Halogen Free, MSL1

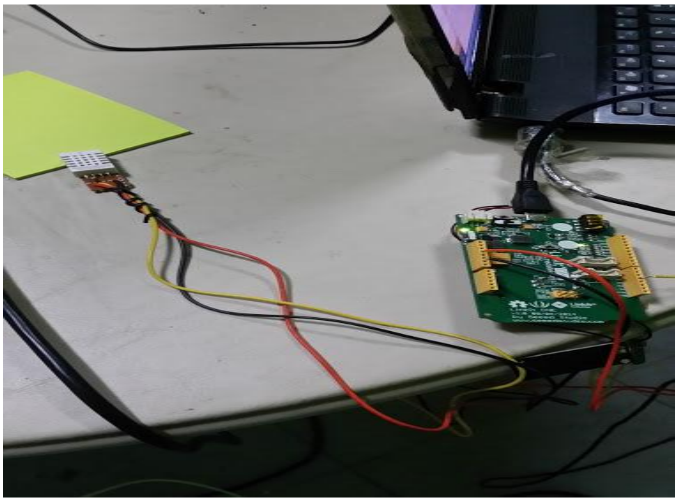
| Part Number | Operating Frequency | NF - Noise Figure | Operating Supply Voltage | Operating Temperature Range | Gain |
|---|---|---|---|---|---|
| NJG1156PCD-TE1 | 915 MHz to 2.5 GHz | 1.6 dB | 1.5 V to 3.3 V | - 40 C to + 85 C | 18.5 dB |
| NJG1159PHH-TE1 | 1.575 GHz to 1.606 GHz | 1.7 dB | 1.5 V to 3.3 V | - 40 C to + 105 C | 16 dB |
| NJG1157PCD-TE1 | 1575 MHz to 1606 MHz | 1.7 dB | 1.5 V to 3.3 V | - 40 C to + 105 C | 18.5dB |

### 3.0 Existing Model

### 3.1 Water level Monitoring Sensor

### Design Model of Prototype 3

| Item | Description/Specification | Material cost in USD |
|---|---|---|
| Casing | Custom 3D Printed ABS Plastic Heat Insulation to Protect Electronics | < 30 USD (1 ABS plastic cartridge) + Printing Cost |
| SeeedStudio Linkit-One | MT2502A (Aster, ARM7 EJ-S (TM) ) 5V Operating Voltage 3 Analog Input 16 Digital I/O (6 PWM Output, 1 I2C, 1 SPI, 1 UART) Built-in SD Card Reader, Audio Output, GSM, WIFI, BLE, RTC and GPS | 59 USD |
| Distance Sensor | Sharp GP2Y0A21YK 3V - 5V Operating Voltage Infrared Based 10cm - 80cm Detecting Distance | 13.95 USD |
| Evaki Solar Power Pad | 4.95W, 5.5V Solar Panel with Built-in 3000mAh Battery | 25.62 USD |
| Backend System | Ubidots Google Sheets | Free for low data number of data points |



A temperature and humidity (DHT22) sensor on the Linkit One

### 3.2 General Findings

#### 3.2.1 Adopting the water level sensors requires fields to be properly leveled in large plots.

The water level sensor is only useful if the field is leveled. Using the water level sensor in a field that is not properly leveled will lead to misinformation or an ineffective use of the system. Having multiple plots requires more water level sensors and hence, rice field plots need to be consolidated and leveled to make the use of water level sensors economically. Consolidating multiple plots may require association of farmers to cooperate with the use of tractors with leveling attachments.

#### Farmers have strong conservative attitudes for adopting AWD.

Some farmers are taking change as a risk. They are skeptical in adopting the AWD because it deviates from what they were taught by their ancestors or their "experience". AWD was met with resistance because the farmers' livelihood is tied to the yield of their crops.

#### Entrepreneurial farmers are more willing to adapt AWD and water level sensor.

Entrepreneurial farmers manage the risk of trying new things and are more open to new methods. Farmers who have a secondary business see the benefit of adopting AWD with an automatic irrigation control to save time so they could spend on other activities.

#### Stealing water from neighboring irrigated ricefield is adding complexity in automated irrigation control.

Farmers mentioned that they needed to monitor the irrigation control gates since some farmers will close the irrigation gates of other farms so they can get more water in their farms. Because of this occurrence, introducing water level sensors and irrigation control may not be feasible in some irrigated rice paddies.

#### Security of the device is an unresolved issue.

The strategy for security was to have a GPS module to constantly check if the device has been moved but the code to implement this was not trivial. The GPS module was planned to double as an accurate clock for the system. Placing the sensor in the middle of the rice field is already a deterrent since it is quite difficult to reach especially if the rice field is flooded. Tracking of the device is possible from the radio gateway but this requires collaboration from the provider or a system needs to be designed to track the device.

**Underdeveloped communications network infrastructure is a hindrance to adoption.** SMS is expensive for two-way communication and will be limiting in terms of ability to control. Recently, congested networks also limit the reliability of this communications means. GPRS communications are

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limited but could be adopted provided adequate power is provided and the software is properly architectured. Because of unreliable network communications, it would be more practical to use the water level sensor to directly control the irrigation and use radios to communicate events (i.e. irrigation gate is open/close) to farmers.

**Power management could problems could be easily solved by using complete integrated systems instead of putting together separate components.** Arduino's GSM shield was not stable in the operation of the device and consumes a lot of power. When the team used SeeedStudio's Linkit One Platform, the power management issue was resolved. Open hardware is at an disadvantage in this stage of prototyping because of the lack of integration of different components. The Linkit One platform has the advantage of following the Arduino framework, making it easier to program on a proprietary system.

**Farmers were also interested in using the water level sensor to detect flood water level in their houses.** Farmers gave us a feedback whether the water level sensor can be used in their houses to inform them if their home is flooded during the rainy season.

Water administration situation portrayal Scenarios for water administration think about common habitats, urban communities and country districts. Frameworks sent in these situations are controlled by applications that entrance to subsystems. It is important to consider different conditions, running from the quantity of subsystems to be sent to the plans of action that must be considered for subsystem control, abuse administrations and data trade. This Section depicts the organization situation we have characterized for approving the MEGA model[4], that is created in Aula Dei, a trial station in Zaragoza, Spain[4].

We additionally count the rundown of capacities that we will test in this station. [4]The Aula Dei trial station is engaged in the water administration cycle, particularly in water system. A total water system framework is demonstrated, from the water admission to the dissemination to the most recent components (i.e. hydrants). One water system framework works by gravity and the other one works by manufactured weight, to cover every one of the circumstances that can be introduced in a genuine setting. From the perspective of the mechanization and control components, the execution of different methodology is permitted in the same water driven component. In particular, the establishment is separated into:

1. Upper system with two water tanks at various levels and a lifting station with two pumps in parallel and level control work.
2. Weight coordinate with programmed pumping station, three pumps in parallel. Two of them with variable speed drive. The system is formed by 20 hydrants, gathered into 4 lines that arrival water to the tank, shutting the cycle. 3. Control focus with the fundamental PC gear for appropriate control and establishment, and in addition for leading a few tests over the administration applications.

## 4.0 Proposed Work

**Design Model of Prototype 4**

Should an opportunity arise to continue the development of the water level sensor, the following could be considered to improve the system.

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### 4.1. Low Maintenance Design

1. Designing for ranchers ought to be the primary thought. The gadget should be anything but difficult to send without the requirement for devices or configuration—we can't anticipate that agriculturists will accomplish more than convey the gadget to the field and plant it on a decent spot in the field to screen the water level. The framework configuration should be anything but difficult to adjust.
2. Factoring in how to introduce the framework where the zero level or ground level can without much of a stretch be set up. Adjusting the tube to the zero level and extra alignment of the separation sensor should be considered for simple organization.
3. Distance sensors with glides bring a wide range of issues so an elective sort of sensor that utilizations resistivity because of hydrostatic weight (utilized as a part of auto fuel tanks) could be considered.
4. Should GSM network be utilized, SIM card should be stacked remotely and uncommon game plans with the telco should be made. Thought for mishandle (i.e. somebody taking out the sim card and utilizing it for their own telephone) should be considered in.

### 4.1.2 Autonomous Irrigation Control

1. Being ready to screen the water level and send cautions to the rancher is a zone where the framework would breakdown be able to dangers the framework not being broadly embraced. On the off chance that the SMS or call isn't gotten in time, or the agriculturist has another thing to do could prompt rice fields not being appropriately flooded.
2. It is imperative to execute an entire framework that incorporates estimation and robotized control of water as to limit the danger of the framework being reprimanded for fizzled crops.
3. Water level sensors with manual alarms, for example, a banner being raised when water isn't sufficient could likewise be another thought as opposed to depending on interchanges arrange for data purposes. This should be said something versus information gathering for inquire about purposes.

### 4.1.3 Efficient Data Gathering

- Send data only when the data changes. This will reduce the amount of data collected should the system be widely deployed.
- Water level does not change significantly over a couple of hours.

### 4.1.4. Low Powered Wide Area Networks (LPWAN)

- Telcos do not have an incentive to improve the rural communications infrastructure since there is low usage in these areas.
- The GSM network was not designed for the water level sensor use case as this protocol is power hungry especially for long distances.
- Recently, LPWANs have become popular with Sigfox and LoRaWAN as two emerging standards for this use case. Both are low-powered and long-range communications systems but need to be weighed by obsolescence of the standard.
- The cost structure will change with an LPWAN radio system since managing the radios would be another thing to consider. Should this be pursued, partnerships with other institutions who can use this radio system need to be considered.

### 4.1.5 Mass Production

- The prototypes are all made with prototype boards. The cost per unit can be lower since many components of the prototype boards will not be used in the final product.
- The main problem of mass production of the sensors would be to have a large volume of at least 1,000 units.
- Should mass production be considered with an LPWAN radio system, new radios circuits need to be tested and studied.

### 4.1.6 Alternative Business Model

- Selling sensors to farmers who pay close to zero for water does not make sense. In irrigated rice fields, the farmer has a fee to pay. The Duterte administration has already indicated that irrigation fees will be removed.

- Farms that pump water from deep wells need fuel and if we can minimize pumping water, this can lead to some cost savings ~2,000 PHP per season.
- One possible business model is to bundle the water level sensor together with a rice insurance package. Insurance companies have a problem of monitoring whether the farmer has done all that can be done to grow rice. If a sensor is able to validate that the farmer is able to grow properly, this can make way for insurance. The other side of the story is that other insurance companies who tried providing crop insurance end up having farmers who grow a good harvest, sell it, and also tell the insurance company that they were not able to harvest—this is plain cheating and a reason why crop insurance is not taking off.

## 5.0 Future Scope

Other issues such as cooperation among farmers, education of farmers about AWD, the confidence of farmers to adapt AWD, leveling of rice field, proper implementation of irrigation systems, etc. need to be addressed before automated irrigation control can be feasible.

Level sensor must work with irrigation control autonomously. If we rely on communications networks for relaying a message with the purpose of controlling the system, there are chances these instructions will not be communicated. Managing communications risk is key to successfully implementing this system.

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