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# An Overview of Smart Farming Production Technology for the Advancement of Home-grown Farmers in the Philippines

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## ABSTRACT

This article explores the technologies that can be used to establish smart farming in the Philippines, as well as the various smart systems that have been used to aid home-grown farmers. The emergence of smart agriculture and farming is a method that heavily integrates digital technology in order to increase food production while minimizing input costs. The importance of this technology has a significant effect on farmers and investors as a result of technological advancements. It should also be recognized that numerous promotions requiring government funding for the establishment of smart farming technology in the Philippines has been addressed.

***Keywords:*** Smart Farming; Hydroponics; Aquaponics; Aeroponics

## INTRODUCTION

In the Philippines, almost half of the population lives in rural areas and relies on agriculture for a living; among them are indigenous people, landless farmers, and fishermen [1]. In general, farmers on different islands in the Philippines operate independently using conventional methods, and their management of farm produce to end-users is facilitated at low prices by middlemen. Micro-propagation protocols for bananas, coconuts, legumes, and oilseed crops are well known [2].

In the first quarter of 2021, the value of agricultural output fell by -3.3 percent at constant 2018 rates. This was attributed to a decrease in livestock and poultry demand. Crops and fisheries, on the other hand, also increased productivity [3]. Despite this condition, the Philippines is working to modernize and improve its agriculture industry, with both the government and private firms encouraging the use of advanced technologies and smart farming practices to raise harvests and reduce losses [4].

Agriculture's creation was a watershed moment in human history. The willingness of fully modern humans to change the atmosphere to produce enough food to support population growth is the first major improvement in the relationship between fully modern individuals and society. Agriculture ushered in a slew of new developments, ranging from the use of fire and cooked food to self-driving machinery [5].

Hence, smart farming is seen as the agricultural future because it produces higher quality crops by making farms more intelligent in sensing their controlling parameters [6].

## SIGNIFICANCE OF SMART FARMING TECHNOLOGY

Agriculture routinely uses sophisticated technologies such as robots, temperature and moisture sensors, aerial images, and GPS technology. These cutting-edge devices, precision agriculture, and robotic systems enable businesses to be more profitable, efficient, safe, and environmentally friendly [7].

Thus, technology is critical to the development of the farming industry and the improvement of agribusiness. Researchers have successfully grown crops in deserts and other harsh environments using genetic engineering, which involves inserting traits into established genes in order to produce pest-resistant, drought-resistant, and plant pathogen-resistant crops.

Moreover, this technology will enhance insect or pest resistance, herbicide or drought tolerance, and disease resistance, providing farmers with a new tool for increasing crop yield. Farmers have used plant breeding and selection techniques to increase crop yield with the assistance of researchers. Technology is also used to protect crops by tracking growth and detecting plant diseases. Without the physical involvement of farmers, automation allows for the consistent distribution of fertilizers, pesticides, and water throughout fields [8].

Lastly, innovative agriculture ensures that new farming and agricultural development models emerge, introducing innovative techniques on how food is produced and distributed. These methods allow more economies and regions to keep up with changing trends and meet the demands of modern living while ensuring sustainably grown food. [9].

## SMART FARMING TECHNOLOGY

### Hydroponics Farming

Hydroponic farming is a method of growing plants in water without soil using mineral nutrient solutions. The hydroponic gardener controls the nutrient content of the liquid solution used to water the plants [10].

### Common Types of Hydroponics System

### 1. Nutrient Film Technique (NFT)

A method of cultivating plants in which plant roots grow in shallow and circulating hydroponic nutrient layers, allowing plants to receive adequate water, nutrients, and oxygen. Plants grow in layers of polyethylene, with plant roots immersed in nutrient-rich water that is constantly pumped by a pump [11].

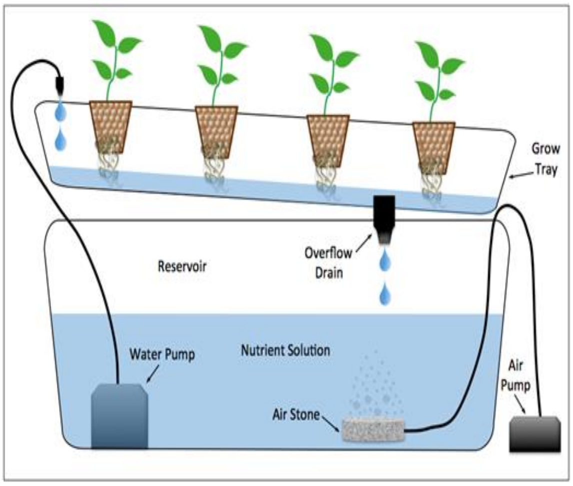


**Figure 1. Diagram of the Nutrient Film Technique (NFT) hydroponic system [12]**

### 2. Wick Systems

It is considered the most basic hydroponic device. The Wick system is classified as a passive system, which means it has no moving parts. Your unique Growth Technology nutrient solution is drawn up into the expanding medium through a number of wicks from the bottom reservoir. This device will work with a number of mediums, including perlite, soil, and coco [13].

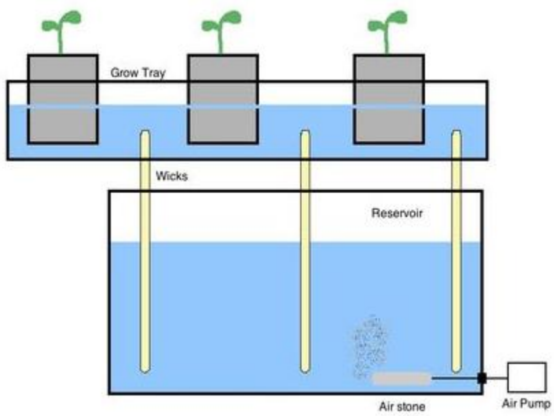


**Figure 2. Diagram of the Wick System [14]**

### 3. Deep Water Culture (DWC)

It is a hydroponic method of plant production by suspending the roots of the plant in a solution of oxygenated, rich in nutrients. This system uses rectangular tanks of less than one foot deep filled with a nutrient-rich solution and plants floating on

Styrofoam panels, also known as Deep Flow Technique (DFT), Floating Raft Technology (FRT), or Raceway [15].

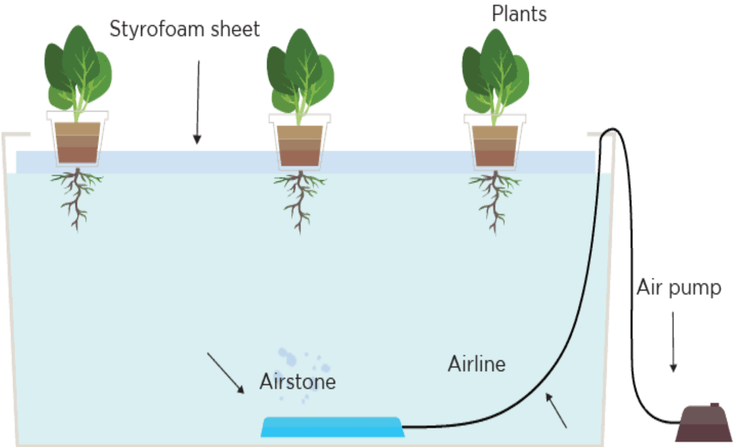


**Figure 3. Diagram of the Deep Water Culture [16]**

## 4. Ebb and Flow (Flood and Drain)

It is a hydroponics technique that involves flooding the growth media with nutrient solution for a set period of time, after which the unabsorbed nutrient is returned to the tank. Normally, this hydroponics device uses a timer to fill the water, resulting in inefficient usage of nutrient solution [17].

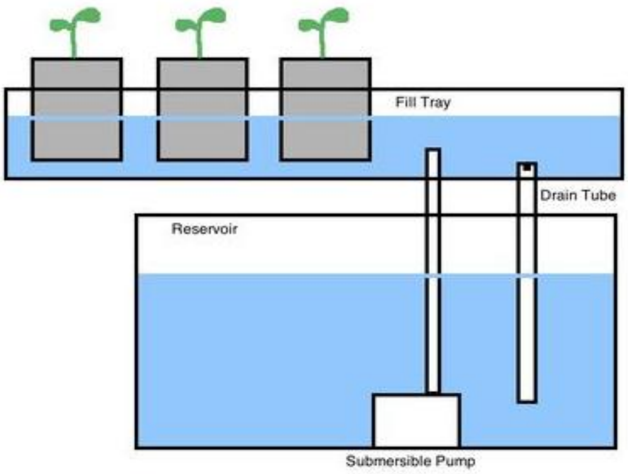


**Figure 4. Diagram of the Ebb and Flow [18]**

## Aquaponics Farming

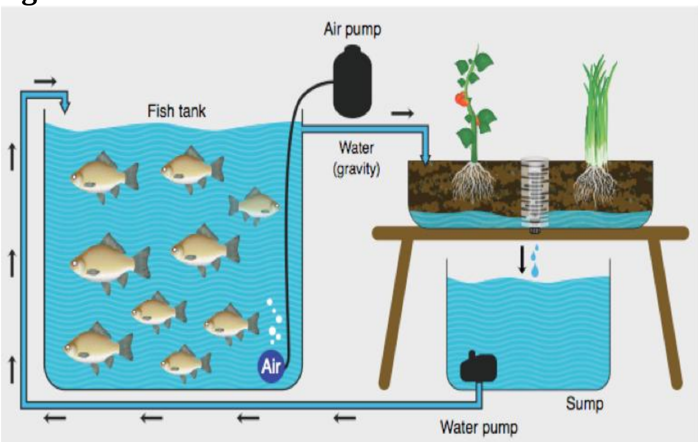


**Figure. 5. Diagram of the Aquaponics [19]**

In an aquaponics system, water from an aquaculture system is fed into a hydroponic system where by-products' are broken down by nitrifying bacteria first into nitrites and then into nitrates, which are used as nutrients by the plants [19]. A symbiotic relationship between two food production disciplines: (1) aquaculture, the farming of aquatic species, and (2) hydroponics, the cultivation of plants in water without soil. Aquaponics is a closed recirculating device that incorporates the two. A typical recirculating aquaculture system filters and eliminates organic matter ("waste") that accumulates in the water, ensuring that the water is safe for the fish [20].

### Aeroponics Farming

In Aeroponics, the nutrient solution is sprayed onto the roots by moving it through misters inside the root region, either continuously or several times per hour [21].

The plant you want to develop is suspended in an air space with an atmosphere that is either completely closed or semi-closed. As a result, it is best achieved in a closed, regulated environment where you can monitor the amount of light, air, and nutrient-rich water spray that is fed into the plant [22].

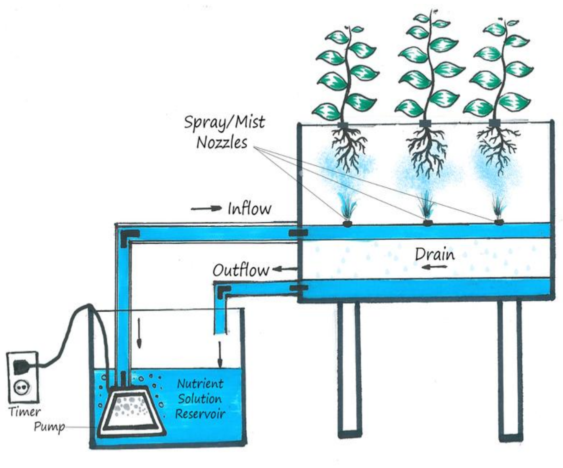


**Figure 6. Diagram of Aeroponics [22]**

## GOVERNMENT SUPPORT TO SMART FARMING

In the Philippines, the local government, led by the Department of Agriculture, is aiming for a 2.5 percent growth this year through further incorporation of technology in agriculture to increase productivity, connectivity, and service delivery to beneficiaries. By focusing on and closely implementing 'Agriculture 4.0,' or the fourth agricultural revolution that encourages the use of smart farming technology, the country would have a better chance of having a better 2021 in terms of agriculture [23].

Agriculture Secretary William Dar released a memorandum to all DA executives, attached agencies and companies, services, and regional offices directing them to "pursue an inclusive approach on these main strategies to accelerate the transition into a new and industrialized Philippine agriculture." [24].

Another agency distinguished in its Labor Market Intelligence report "Soils to Satellites," the Technical Education and Skills Development Authority (TESDA) has been published covering practical topics such as automation in smart greenhouses, agricultural drones, IoT solutions to agricultural problems, and case studies in selected ASEAN countries in smart agriculture applications [25].

## CONCLUSION

Some technologies will need to be developed specifically for agriculture, while other technologies already developed for other areas could be adapted to the modern agricultural domain such as autonomous vehicles, artificial intelligence and machine vision and smart farming.

Moreover, as farming in the Philippines faces several problems, proactive solutions like ICT must be implemented together with the full support of the government. Similarly, other major players, such as multinational companies, agricultural and fisheries industry leaders and organizations, and agricultural state universities and colleges (SUCs), should work together to elevate home-grown farmers in the country.

Lastly, if modern agriculture is applied widely in the near future, millions of farmers will be able to benefit from the acquisition and development of smart farming production technology.


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# The Dawn of Digital Coins: A Literature Review on Cryptocurrency in the Philippines

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**Abstract:- This analysis of the literature aims to shed light on the Philippines decision to follow the alternative currency scheme. Limited knowledge of cryptocurrencies, as well as knowledge of where to find required block chain wallets on the internet, is now a challenge. Philippines has legalized the used of cryptocurrency approved by the Bangko Sentral ng Pilipinas (Central Bank of the Philippines). It is also used for banks especially by the money transfer outlets that are established in the country. There are popular crypto coins in the Philippines it includes the Bitcoin, Ethereum, XRP, and Bitcoin Cash, this cryptocurrency accepted from various embellishments. Study found out that the prices of cryptocurrency are volatile in nature and it is expected to be at high peak exchange or low peak exchange. It is also noted that central organization of this currency adopt in this technology thru centralized establishments.**

***Keywords:-** Cryptocurrency; Bitcoin; Bitcoin Cash; Etheruem; Ripple; Exchange.*

## I. INTRODUCTION

The Philippines, officially the Republic of the Philippines, is a Southeast Asian unitary archipelagic nation. The Philippines is the world's 63rd largest nation by area and 12th by population. The Philippines is the world's 63rd largest nation by area and 12th by population. The Philippines is one of the most ethnically mixed countries in the world, with a wide range of religious denominations. At the end of 2018, the Philippines had a gross domestic product of $348 billion, making it the 34th biggest economy in the world. Electronics, transportation machinery, petroleum and its derivatives, and agricultural goods make up the majority of the economy. Despite the fact that the agriculture sector employs 30% of the population, the Philippines' economy is becoming increasingly tech-oriented. Circular No. 944, which developed rules for Virtual Currency exchanges on June 2, 2017, made cryptocurrency legal in the Philippines. The Central Bank of the Philippines is in charge of Bitcoin transactions in the Philippines [1].

Cryptocurrency in the Philippines is delivered thru bank transfer transaction, this deemed necessary to use this kind of currency. Some investors invest thru this technology, the popular cryptocurrency is Bitcoin, Ethereum, Bitcoin Cash and Ripple (XRP). These literature reviews try to provide solutions to address the adoption of this alternative mode of currencies in the Philippines. Now a day's limited knowledge of cryptocurrency has been an issue such as the knowledge in providing necessary block chain wallets available in the internet. Security as an issue, these wallets may be address to enhance the idea and capability of one's account or investors. The main issues with the adoption of cryptocurrencies include an early track record of illiquidity, high volatility and potentially nebulous uses. Most of the issues surrounding the successful adoption of cryptocurrencies is marred in the confusion of whether they are digital or virtual currencies, and as such, how their values are determined [2].

Within recent years, internet-based currencies and payment systems have emerged that do not require banks to process payments. The first, and still the largest, of these so-called crypto currencies was Bitcoin [3] [4]. Unlike most other currencies normally held by the central bank in their international reserves, the supply of cryptocurrencies is not controlled by a central bank but by a highly complex iteration of a mathematical proof. Network users, known as miners, gather blocks of transactions together and vie to verify them. In return, these users receive a new supply of the currency as well as any transaction fees. Several businesses around the world at present accept Bitcoins as a means of final payment [5].

Data Journalist, Statista the World Economic Forum, recent data shows the usage and adoption of countries in cryptocurrency (Fig. 1).

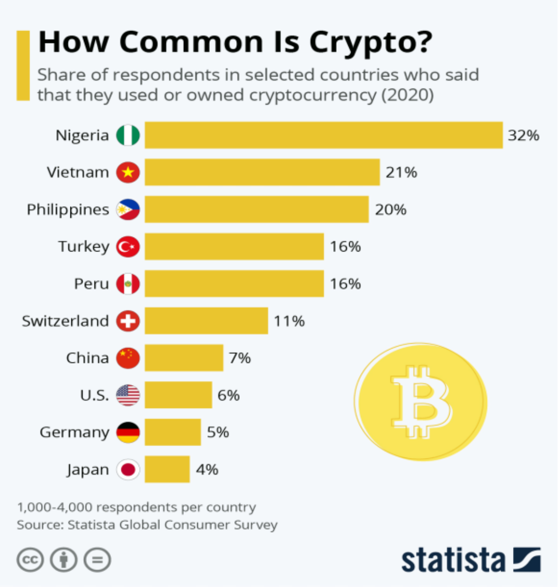

Fig. 1. Statista 2020 Who owned cryptocurrency

The second and third highest rates of cryptocurrency use in the survey were recorded in Vietnam and the Philippines, respectively. Again, remittance payments play a role in the widespread use of cryptocurrency [6]. According to Helms (2020), the Philippines' Central Bank has approved several crypto exchanges to operate as "remittance and transfer companies" in the country [7].

## II. OVERVIEW OF CRYPTOCURRENCY

Cryptocurrency is a form of virtual money that is focused on cryptography and electronic communication concepts. There have been hundreds of cryptocurrencies launched in recent years, with Bitcoin being the most common. Cryptocurrencies have gained a lot of coverage in recent years [8].

Cryptocurrencies are classified as "a digital representation of value that a.) is intended to serve as a peer-to-peer alternative to government-issued legal tender, b.) is used as a general-purpose medium of trade (independent of any central bank), c.) is protected by cryptography, and d.) can be converted into legal tender." [9].

Cryptocurrencies are digital tokens created using cryptographic algorithms. This token is then sent around the internet through protocols like peer-to-peer networking. Its worth is extracted mostly from the demand and supply for such tokens, and the decentralization of the environment in which they operate is an integral part of their appeal [5]. Cryptocurrencies have made their way through the economy as a source of alternative currency, speculative assets, and utility tokens for revolutionary service platforms. Regulators are increasingly scrutinizing cryptocurrencies, and a literature on cryptocurrency regulation is emerging. Regulators are considered to be most likely to trigger protocol shifts by interfering with operators' choices. Regulation may encourage the creation of regulatory-compliant cryptocurrency protocols, but it may also encourage the development of protocols that are specifically intended to avoid regulation [10].

Digital currencies have become increasingly popular around the world. Facebook Credits, Microsoft Points, and Amazon Coins are examples of these [5]. These currencies, unlike Bitcoins, are distributed by corporations and are not tied to any demands on physical estate, as previously stated.

In comparison to the years when the technology was seen as a speculative asset or a fleeting fad, blockchain and crypto in Southeast Asia have definitely matured. From a chronological standpoint, the emphasis in 2016 was on all things blockchain. Initial coin offerings (ICOs) were all the rage in 2017, but 2018 was the year of stablecoins. Decentralized finance (DeFi) became the talk of the town last year. Government-backed coins and business coins are expected to rule and take center stage this year, with the focus on China's Digital Currency Electronic Payment (DCEP) and Cambodia's "Project Bakong." [11].

As the second most populous country in Southeast Asia (SEA), the Philippines offers a fertile ground for blockchain growth. With a population of over 107 million people and a 71 percent internet penetration rate, the Philippines is one of the strongest blockchain markets in Southeast Asia. With its massive population, though, comes the task of banking the unbanked, which accounts for a concerning 77 percent of the population. Thankfully, there is Project i2i, which seeks to offer banking services to people living in rural areas, who account for a substantial portion of the archipelago's unbanked population [12].

## III. POPULAR CRYPTOCURRENCY COINS IN THE PHILIPPINES AND MARKET VALUE

### *A. Bitcoin (BTC)*

Bitcoin first gained traction in the Philippines in 2017, when its price soared from $1,000 to over $19,000 in a matter of months. Since then, BSP has built a dependable network that protects cryptocurrency consumers whilst still encouraging bitcoin adoption, which is still in its infancy [13].

Fig. 2. Market Value of Bitcoin

Fig. 2. shows the current market value for Bitcoin in the Philippines amounting to 2.7 million pesos. It also indicates that 643.10% increase of total value from last year.

*B. Ethereum (ETH)*

Ethereum is an open-source, decentralized blockchain with smart contract capabilities. The platform's native cryptocurrency is Ether (ETH). After Bitcoin, it is the second-largest cryptocurrency in terms of market capitalization. The Ethereum blockchain is the most widely used [14].

The Ethereum blockchain connects thousands of computers around the world and forms a massive world computer that anyone can access, build, and execute programs on. To operate or execute programs on Ethereum, you need to pay with Ether. Although it is sometimes referred to as a “cryptocurrency”, Ether is not intended to be a currency per se. It is more accurate to say that it is the “crypto-fuel” required to run tasks and transactions on the Ethereum network [15].


Fig. 3. Market Value of Ethereum

Figure 3 shows the current market value for Ethereum in the Philippines amounting to 100,904 thousand pesos. It also indicates that 1044.05% increase of total value from last year.

*C. Bitcoin Cash (BCH)*

Bitcoin Cash was developed by bitcoin miners and developers who were concerned about the cryptocurrency's continued life and scaling ability. Separated witness technology, on the other hand, was a point of anxiety for these persons. They claimed SegWit2x did not sufficiently fix the fundamental problem of scalability, nor did it adopt Satoshi Nakamoto's roadmap, the anonymous community that proposed the blockchain technology that underpins cryptocurrencies [16].

BCH is to increase a maximum block size to process more transactions than BTC. However, even with different block size limits, they have compatible proof-of-work mechanisms with each other. Therefore, miners can freely alternate between BTC and BCH mining to boost their profits [17].


Fig. 4. Market Value of Bitcoin Cash

Fig. 4. shows the current market value for Bitcoin Cash in the Philippines amounting to 32,334 thousand pesos. It also indicates that 153.80% increase of total value from last year.

*D. Ripple (XRP)*

Ripple Inc., a payment solutions firm that also operates the RippleNet cross-border payment network, issues and manages XRP, a digital currency. Ripple started selling XRP in 2012, but in recent years the firm has shifted its focus away from the digital currency and toward its cross-border payment network [18]. Ripple Inc., a payment solutions firm that also operates the RippleNet cross-border payment network, issues and manages XRP, a digital currency. Ripple started selling XRP in 2012, but in recent years the firm has shifted its focus away from the digital currency and toward its cross-border payment network [18].


Fig. 5. Market Value of XRP

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Fig. 5. shows the current market value for XRP in the Philippines amounting to 53.30 pesos. It also indicates that 427.93% increase of total value from last year.

## IV. POPULAR CRYPTOCURRENCY EXCHANGE IN THE PHILIPPINES REGISTERED WITH BSP

According to Fintech News Philippines [19], as of 2019 these are the licensed virtual currency exchanges in the Philippines:

- Coins.ph - a mobile wallet that allows users to access financial services from their phone. The company provides services including remittances, mobile air-time, bill payments, online shopping at over 100,000 merchants, and cryptocurrency exchange services.
- ABA Global Philippines - the latest to receive the nod from Bangko Sentral Ng Pilipinas (BSP). Details on the company are still scarce at the moment.
- Bexpress- a crypto trading platform supporting Bitcoin, Ethereum and XRP. The company provides a mobile app that allows users to transact at anytime and anywhere.
- BloomSolutions (Bloom) - builds blockchain-based products and services to reduce the cost and improve the customer experience of money transfer. Incorporated in Singapore with operating entities in the Philippines and Australia, Bloom acts as a remittance aggregator platform, a foreign exchange broker, and provides consulting, technical, and advisory services on blockchain development.
- Coinville - the latest to receive the nod from Bangko Sentral Ng Pilipinas. Details on the company are still scarce at the moment.
- ETranss' subsidiary GOW Exchange - a cryptocurrency trading platform providing services to institutional investors.
- Backed by Consensys Ventures Philippine Digital Asset Exchange (PDAX) - a cryptocurrency trading platform that is still in private beta mode.
- Rebittance - a wholly owned subsidiary of Satoshi Citadel Industries (SCI). SCI operates several products including Buybitcoin.ph, an exchange service, Bitbit, a peso and crypto wallet, Rebit, a remittance platform, and Citadax, a crypto exchange.
- VHCex - one of the 10 cryptocurrency platforms licensed with Bangko Sentral Ng Pilipinas (BSP).
- Zybi Tech - a cryptocurrency exchange platform that enables the trade of Philippines Pesos to Bitcoin, Ethereum and Litecoin.

## V. ESTABLISHMENTS THAT SUPPORTS THE CRYPTOCURRENCY IN THE PHILIPPINES

The Philippine government has also become involved with bitcoin, partnering with Unionbank to create the blockchain software bonds.ph to sell government bonds. In Makati (Metro Manila), Unionbank has also installed a Bitcoin ATM, demonstrating how cryptocurrencies are increasingly becoming popular in the nation [7].

Fintech Philippines (2020), Fintech Philippine Association is the most inclusive financial technology trade association in the Philippines. Established in 2017, it consists of over 100 institutional and individual members and is partnered with technology associations in Denmark, Israel, Japan, Malaysia, Singapore, and Thailand. It is also a founding member of the Asia Pacific Fintech Network and support various companies that support cryptocurrency in the Philippines [20].

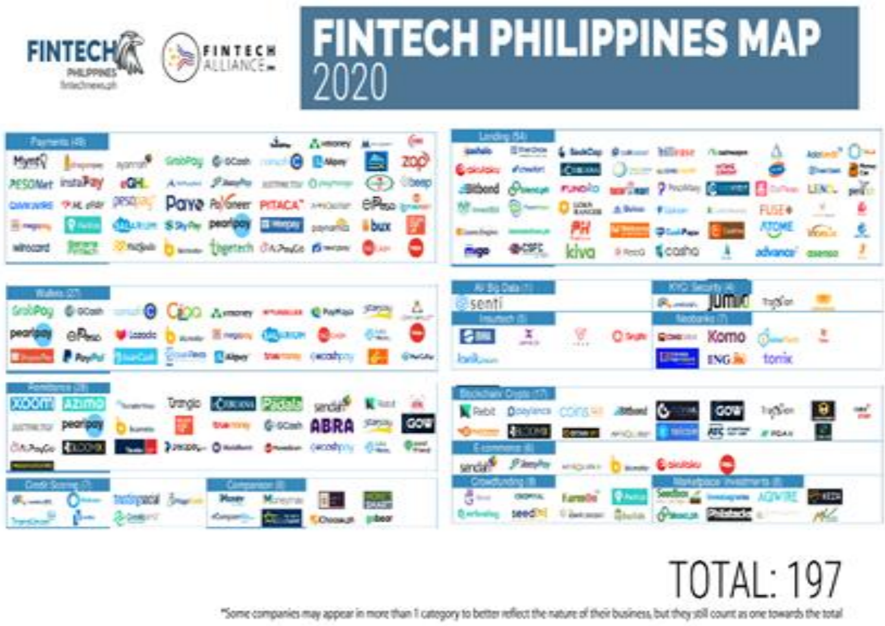


Fig. 6. Fintech Philippines Map 2020

Fig. 6. shows the Fintech Philippines map that support variety of digital coins. There is a total of 197 different types of digital support that is categorise in payments, wallets, remittance, credit scoring, comparison, lending, AI / Big data, KYC / security, neobank, block chain/ crypto, e-commerce, crowdfunding and market place / investment.

## VI. CONCLUSION

In the Philippines, cryptocurrency is legal. This cryptocurrency is not only legitimate, but the country is also really crypto-friendly. Aside from Bitcoin, the Bangko Sentral ng Pilipinas has registered some other approved cryptocurrencies. It also invests in a variety of crypto initiatives and looks at opportunities to enhance the support it offers to the public. Moreover, different establishments and investors using cryptocurrency come with the ease of registering their business in the Philippines. It is also noted that the volatility of the crypto currency still at stake for the invertors. None the less industry of crypto coins in the Philippines is growing rapidly approximately surpass Vietnam in the near future.

## ACKNOWLEDGMENT

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# Internet of Things in the Philippine Agribusiness

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**Abstract:** *This article focused on the benefits, drawbacks, and present state of IoT in farming in the Philippines. Aligning agriculture with readily available technologies to improve production has been identified to have a significant impact in the inclusive growth and rural development of a nation. This literature review clearly suggests that a comprehensive framework of IoT in agribusiness is imperative and worth exploring in order to completely amass its numerous advantages. Relatively, the Philippines could be considered to be on the right track, having been able to craft a three-phase plan involving a variety of factors including technologies to stimulate regional economic development and build new regional agriculture centers.*

**Keywords**: IoT, Agribusiness, Goals of Agribusiness, Current Status

## I. Introduction

The agricultural sector must rise to meet demand despite a rising population that is projected to reach 0.6 billion by 2050, regardless of environmental problems such as adverse weather and climate change. The agriculture industry needs new innovations to obtain a much-needed edge to meet the needs of this rising population. Increase operating efficiencies, lower expenses, minimize waste and boost the quality of their yields, new agricultural applications in intelligent farming and precision agriculture through IoT [1].

The Internet of Things (IoT) is a global knowledge society system that enables advanced services by interconnecting (physical and virtual) things using current and emerging interoperable information and communication technologies [2]. Because of the convergence of multiple technologies, such as real-time analytics, machine learning, commodity sensors, and embedded systems, things have changed [3].

Traditional fields such as embedded systems, wireless sensor networks, control systems, automation (including home and building automation), and others all contribute to the Internet of Things' implementation. In the consumer market, IoT technology is most closely associated with products related to the concept of the "smart home," such as devices and appliances (such as lighting fixtures, thermostats, and home security systems).

Hence, the Internet of Things (IoT) aims to make "dumb" things "smart" by connecting them to one another and to the internet. It enables the remote sensing and control of physical objects, allowing for more direct integration of the physical world and computer-based systems [4].

Moreover, Precision agriculture base on internet of Things (IoT) enables growers and farmers to reduce waste and increase productivity in areas ranging from the amount of fertilizer used to the number of journeys made by farm vehicles, as well as the efficient use of resources such as water, electricity, and so on.

Lastly, farmers can monitor field conditions from any location. They can also choose between manual and automated options for taking action based on this data. For example, if the soil moisture level drops, the farmer can use sensors to trigger irrigation. When compared to the traditional approach, smart farming is far more efficient [5].

## II. Significance of Agribusiness

Agriculture exports accounted for an average of 17 percent of total merchandise exports across 94 countries in 2018, according to World Trade Organization data [6]. The transition from agriculture to agribusiness has resulted in numerous advantages. These include less drudgery for laborers, the release of workers for non-agricultural endeavours, higher food and fiber quality, a wider range of products, improved nutrition, and increased mobility of people [7].

Agricultural practices also lead to a better food protection environment and sustainable food supply, as well as jobs for the majority of the poor in developed countries. However, the practices raise greenhouse gas emissions and lead to global warming, which is why the industry relies on creativity to fix those issues [8].

Agribusiness views the various facets of agricultural commodity production as a whole. Farmers use advanced harvesting techniques, such as GPS to guide activities, to collect livestock and harvest fruits and vegetables. Manufacturers are creating highly powerful self-driving vehicles. The best way to clean and package livestock for shipment is determined by processing plants. Although each business subset is unlikely to engage directly with the customer, they are both concentrated on working effectively in order to keep costs fair [9].

## III. Common Goals of Agribusiness

### 3.1 Source of Livelihood

The ways and means by which people make a living in the country. The definition revolves around resources such as land/property, seeds, food, expertise, finances, social relationships, and their interconnected relationship with an individual community's political, economic, and socio cultural characteristics [10].

### 3.2 Contribution to National Income

A wider economic indicator at the national level than personal revenue. National revenue covers payments to people (wages and salaries, as well as other benefits), payments to the government (taxes), and residual income by the private sector (depreciation and undistributed profits), fewer changes (subsidies, government and consumer interest, and statistical discrepancy) [11].

### 3.3 Food Security

This is the sense that all people at all times have access to enough, safe, and nutritious food that satisfies their food needs and nutritional requirements for an active and stable life, physically, socially and economically [12].

### 3.4 Significance to the International Trade

International trade helps countries to expand their markets and access commodities and services that otherwise may not have been available locally. As a result of foreign trade, the economy became more dynamic. This finally leads in more competitive pricing and delivers a cheaper product home to the customer [13].

### 3.5 Marketable Surplus

This represents the excess crop that will, after a farmer has sold his crop, be sold for profit to offset the costs of sustaining and running his farm. The farmer has fixed costs for equipment, labor costs, fertilizer and mortgage on their property [14].

### 3.6 Origin of Raw Material

Denotes unprocessed or least processed materials, e.g. raw latex, petroleum, cotton, coal, raw biomass, iron ore, air, logs, water or "any commodity in its natural form of agriculture, land, fisheries, or minerals which underwent a processing process needed to prepare for significant foreign marketing." [15].

## IV. Agribusiness Approaches Using IoT

The Internet of Things (IoT) has an effect upon the lives of everyone, rendering all wise, current and potential. It is a network of various machines that create a network that configures itself. Smart Farming's latest advances of IoT usage will by day transform the face of traditional farming practices into optimal, cost-efficient farmers as well as reducing crop waste. The aim is to provide a technique that can communicate with farmers on various platforms [16]. The influence of the Internet of Things (IoT) and mobile devices in today's world is undeniable. It has now spread nearly everywhere, from the home to the health market, smart cities, fitness, and the manufacturing sector. It can be used in almost any industry, and agriculture is no exception. Indeed, IoT and smart devices have the potential to have a huge effect on agricultural activities, freeing farmers from the need to rely on horses and plows[17].

## V. Common Approaches In Agribusiness Using IoT

### 5.1 Data Collected by Smart Agriculture Sensors

Sensors, monitoring system, robots, standalone engines, automatic hardware, variable rate systems, motor detectors, camera buttons and wearable gadgets constitute a core component of farm management approach. This information will be used to track the status of the company as well as the quality of its employees and facilities. The ability to predict production results makes for a smoother delivery of the commodity [18].

### 5.2 Agricultural Drones

Drones are and increasingly in the agriculture industry as part of an effective approach to sustainable agriculture management that enables agricultural producers, farmers, and farmers to assist in streamlining their activities by rigorous data analysis to obtain effective insights into their crops. The use of drone data to schedule and render ongoing changes, such as use of dikes and emerging fertilizer applications, is facilitated for example by crop tracking. Instead of conventional and work-intensive data collection, products can be reliably tracked from farm to fork using GPS coordinates for each travel point [19].

### 5.3 Livestock Tracking and Geofencing

Producers can use GPS technology to create landmarks and geofences around specific geographic locations. This aids in livestock rotation by grazing areas, crop preparation, planting, and harvesting in order to increase yield and maintain livestock in specified areas. Via temperature control, GPS-enabled animal monitoring and tracking collars and tags are used to keep track of livestock position, grazing patterns, and general health. By immediately alerting the producer when livestock leave their assigned area, this technology can also help with livestock safety and stock theft prevention [20].

### 5.4 Smart Greenhouses

Machine learning is used in smart greenhouses to process and remember information about your crops and their ideal climate. Based on their results, these systems can then make recommendations, or growers can use their mobile app to change key factors to achieve higher yield rates. In any case, the ability to monitor your microclimate through a mobile device gives you a lot more control over your operations and what you do with your time [21].

### 5.5 Predictive Analytics for Smart Farming

Predictive analytics involve the success of good data and incomplete or incorrect data can give insights which are not analyzed in full. Data from in-field sensors, input data collection at each stage, and economic functions of decisions will continue to be crucial for predictive analytics performance. As IoT grows in popularity and data collection becomes more important to operations around the world, the ability to make impactful, constructive, and efficient decisions that can maximize opportunities and efficiencies on the farm remains of interest [22].

## VI. Conceptual Framework of IoT In Agribusiness

The layers of the IOT system for agribusiness are depicted in Figure 1. It's also worth noting that various layers are taken into account. There are three (3) parts of it. 1. Computer and contact planes make up the lower layer. 2. Data and data analytics make up the intermediate layer. 3. Device and end-user planes make up the higher layer. A wide variety of software components for individual data collection, modelling, interpretation or visualization operations are present on each layer. [23].

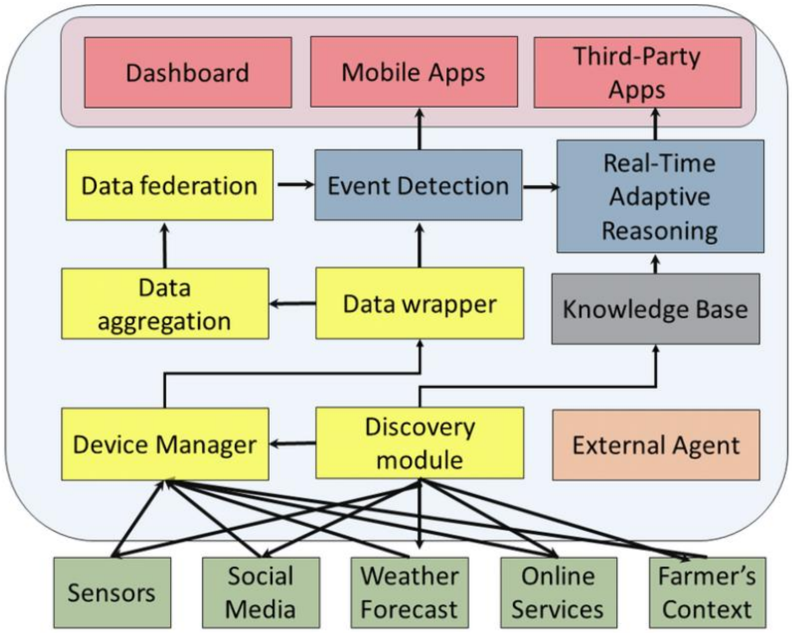


**Figure 1:** The IOT Framework for Agribusiness [23]

## VII. BENEFITS OF IOT IN AGRIBUSINESS

The Internet of Things (IoT) is a fascinating collection of technology that is already influencing humanity's future. IoT is focused on the idea of gathering data from uniquely recognizable interconnected devices (such as sensors, computers, and mechanical devices), storing it in the cloud, and processing it with intelligent algorithms to achieve common goals [24].

In agriculture, as in other sectors, the Internet of Things offers previously unattainable productivity, resource and cost savings, automation, and data-driven processes. However, in agriculture, these advantages aren't improvements; they're fixes for an entire sector grappling with a slew of dangerous issues [25].

### 7.1 Excelled Productivity

Today's agriculture is a competition. Farmers must produce more product in the face of deteriorating soil, decreasing land availability, and rising weather variability. Farmers can track their commodity and conditions in real time with IoT-enabled agriculture. They gain insights quickly, can anticipate problems before they occur, and make educated decisions about how to prevent them. Furthermore, IoT solutions in agriculture allow automation, such as demand-based irrigation, fertilizing, and robot harvesting [26].

### 7.2 Increase

The world's population will hit 9.1 billion by 2050, a 34% increase from today. Almost all of this population growth will take place in developed countries. Urbanization will proceed at a rapid pace, with approximately 70% of the world's population living in cities by 2050. (compared to 49 percent today). Income levels would be several times higher than they are now. Food production (net of food used for biofuels) must increase by 70% to feed this larger, more populated, and wealthier population [27]. Food can be grown in supermarkets, on the walls and rooftops of skyscrapers, in shipping containers, and, of course, in the comfort of everyone's home, thanks to smart closed-cycle agricultural systems.

### 7.3 Condensed Capital

The Internet of Things (IoT) is a promising technology that is providing numerous novel ideas to improve agriculture. IoT-based solutions and products are being developed by research institutes and scientific groups to address various aspects of agriculture [28].

### 7.4 Cleaner Method

Farmers will be able to cut waste and increase output by using IoT technologies in smart farming. This could be due to the amount of fertilizer applied or the number of trips the farm trucks have taken. As a result, smart farming is essentially a high-tech system for producing clean, long-lasting food for the public. It is the introduction of modern ICT (Information and Communication Technologies) into agriculture as well as its application [29].

### 7.5 Speed and Development

Real-time data analysis can help predict and monitor weather, humidity, crop health, and other variables, improving overall process efficiency. With farmable land becoming scarcer, IoT devices can assist urban greenhouses and other similar systems in simulating optimal farming conditions and facilitating production [30].

### 7.6 Better-Quality of Product

The rise of OIT and farming is a way for increasing food output while lowering input costs by substantially integrating digital technology [31]. The impact of Big Data applications in Smart Farming extends beyond primary agriculture to the entire food supply chain. Furthermore, smart sensors and devices generate massive amounts of data, enabling unprecedented decision-making capabilities [32].

## VIII. Agribusiness Limitation Using IoT

IoT has few limitations in the agribusiness sector. The internet connections in farms are usually poor since most farms are located in rural areas and may not have strong enough internet access to enable rapid transmission speeds. In addition, communication cables, plants, canopies and other physical impediments may be blocked. High Cost of Hardware is another limitation. Currently, farmers are relying on a thinly dispersed sensor network to collect data on farm conditions. Furthermore, cloud connectivity is disrupted. Farmers now collect data on farm conditions on a sparsely distributed sensor network [33].

## IX. Current Status of Agribusiness in The Philippines

Turning agricultural agriculture into a thriving agricultural sector involves developing agriculture technologies, providing training in more advanced agriculture techniques, creating stable supply chains, developing transport and agricultural infrastructures, investment and R&D, and securing a sound system for rights of property.

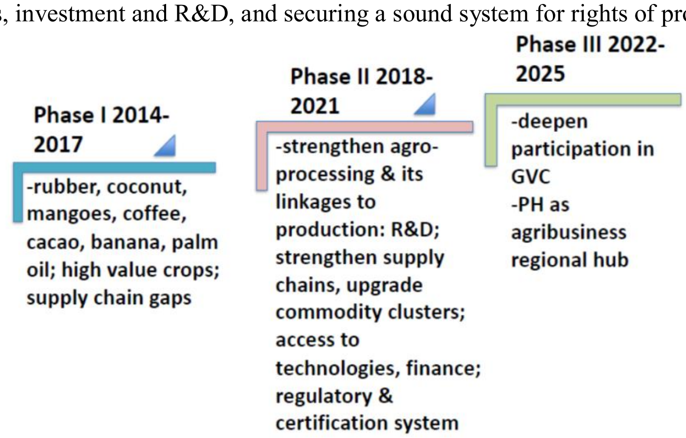


**Figure 2:** Catalyst to Drive Regional Economic Transformation

These activities can not only help diversify and enhance the value of agricultural company products, but can also contribute to the Philippine government's inclusive growth and rural development objectives. As a result, the agricultural sector is positioned to make a major contribution to the Philippine economy's industrial development [34].

Fig.2. depicts the three (3) stages of agribusiness transformation in the Philippines, from traditional farming to a globally competitive agribusiness sector. The transformation of economic thrust from 2014 to 2025 is also emphasized.

## X. Conclusion

The potential of the agricultural IoT industry by installing intelligent technology to improve competitiveness and sustainability in their output must be understandable for large landowners or small farms. Demand can be met with a rapid population growth if crops and small farmers are successfully implementing agribusiness IoT technologies.

Moreover, temporary impediments arise, such as the frequent integration / compliance between sensors from different platforms, the internet connectivity or local network configuration, the volume of Big Data generated and the uncertainties that still persist in farmers' minds. The impact of IoT on agribusiness will become more visible after these minor hiccups are overcome.

Lastly, The Philippines is on pace to enhance agriculture using the internet. Regularities in many industries adopt initiatives to develop the benefits of this technology. By the end of 2025 the Philippines will deepen its participation in IoT and established the agribusiness regional hub.

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# On-Campus Solar Energy: A Review Towards Green Technology

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**Abstract:** *This review paper discusses renewable energy, specifically solar photovoltaic (PV) energy, which provides benefits in selecting the proper technology for campuses. This study aims to direct scholarly attention to the processes that underpin strategic renewable energy investment decisions, as well as how these decisions are influenced by national energy policy. It discusses three (3) common PV technologies that could be adopted by universities and colleges in support of the renewable energy in the Philippines. Different benefits and drawbacks in using solar energy were also discussed. The proposed approach framework was presented. Finally, the status of solar energy in the Philippines and the innovative initiatives of higher education institutions in the Philippines were highlighted.*

**Keywords**: Renewable Energy, Solar Photovoltaic, Thin film Solar Cells Technology, Mono Silicon Solar Cells Technology, Polysilicon Solar Cells Technology.

## I. Introduction

Solar energy is solar radiation that can produce heat, cause chemical processes, or generate electricity. The overall amount of solar energy incident on Earth exceeds the world's current and projected energy needs by a large margin. This highly distributed source has the ability to meet all future energy needs if properly exploited. Solar energy, in contrast to the finite fossil fuels coal, petroleum, and natural gas, is predicted to become increasingly popular as a renewable energy source in the twenty-first century due to its limitless supply and nonpolluting nature [1]. New renewable energy has gotten a lot of attention as a potential future energy source that might play a big role in developing a long-term energy supply system [2].

In the Philippines, Republic Act (RA) No. 9513 also known as Renewable Energy Act of 2008, has been crafted to accelerate the exploitation and development of renewable energy resources such as, but not limited to, biomas, solar, wind, hydro, geothermal and ocean energy through the adoption of sustainable energy development strategies to reduce the country's exposure to price fluctuations in the international markets, the effects of which spiral down to almost all sectors of the economy, to increase the utilization of renewable energy by institutionalizing the development of national and local capabilities in the use of renewable energy systems, and promoting its efficient and cost-effective commercial application by providing and nonfiscal incentives, to establish the necessary infrastructure and mechanism to carry out with the protection of health and the environment; and to establish the necessary infrastructure and mechanism to carry out the mandates specified in this Act and other existing laws [3].

Universities and Colleges in the Philippines continue to expound the development of renewable energy by installing solar panels in their respective campuses. Strategic adoption and implementation of solar energy in higher education institution is a big challenge not only on financial budget.

Renewable energy technology investments are becoming increasingly popular as a way to boost growth and speed up the recovery from the recent financial crisis. Despite their popularity and the numerous policies enacted to encourage these technologies, the adoption of RE projects has lagged behind predictions. This low adoption is attributable to a lack of adequate funding as well as a reluctance to invest in these technologies [4].

Renewable energy sources (RES) have a large potential to contribute to the sustainable development (SD) of specific territories by providing them with a wide variety of socioeconomic and environmental benefits. However, the existing literature has put much emphasis on the environmental benefits (including the reduction of global and local pollutants), while socioeconomic impacts have not received a comparable attention. These include diversification of energy supply, enhanced regional and rural development opportunities, creation of a domestic industry and employment opportunities. With the exception of the diversification and security of energy supply, these benefits have usually been mentioned, but their analysis has been too general (i.e., mostly at the national level) and a focus on the regional and, even more so, the local level, has been lacking. At most, studies provide scattered evidence of some of those regional and local benefits, but without an integrated conceptual framework to analyze them [5].

The management and exploitation of renewable energy sources is now recognized as central to sustainable development. Environmental concerns, recurring oil crises and market weaknesses, combined with the availability of power from natural resources and resulting possibilities for job creation and energy independence, have all pushed developed and developing countries towards new energy [6].

Electric energy security is essential, yet the high cost and limited sources of fossil fuels, in addition to the need to reduce greenhouse gasses emission, have made renewable resources attractive in world energy-based economies. The potential for renewable energy resources is enormous because they can, in principle, exponentially exceed the world’s energy demand; therefore, these types of resources will have a significant share in the future global energy portfolio, much of which is now concentrating on advancing their pool of renewable energy resources. Accordingly, this paper presents how renewable energy resources are currently being used, scientific developments to improve their use, their future prospects, and their deployment. Additionally, their paper represents the impact of power electronics and smart grid technologies that can enable the proportionate share of renewable energy resources [7].

Electricity market is undergoing a tremendous transformation throughout the world. A drastic reduction of carbon emission cannot be realized if renewable energy resources are not increased in share of generation mix. Currently, most of the traditional mechanisms, including regulatory policies, fiscal incentives and public financing, are initiated from and heavily relied on policymakers and governments. However, not only these schemes do not necessarily align with business interests of investors, but also the motivations for renewable energy developments are always initiated by governments. In order to realize the full potential of renewable energy investment, an innovative approach is necessary to motivate investors and lessen government expenditures [8].

Major developments, as well as remaining challenges and the associated research opportunities, are evaluated for three technologically distinct approaches to solar energy utilization: solar electricity, solar thermal, and solar fuels technologies. Much progress has been made, but research opportunities are still present for all approaches. Both evolutionary and revolutionary technology development, involving foundational research, applied research, learning by doing, demonstration projects, and deployment at scale will be needed to continue this technology-innovation ecosystem. Most of the approaches still offer the potential to provide much higher efficiencies, much lower costs, improved scalability, and new functionality, relative to the embodiments of solar energy-conversion systems that have been developed to date [9].

## II. Photovoltaic Solar System

Solar photovoltaic (PV) systems are semiconductor devices that convert sunlight into DC power by the transfer of electrons. They are a mature technology with a life expectancy of 20–30 years. The energy conversion process is divided into two stages: the generation of an electron-hole pair through light absorption in semiconductor material, and the subsequent separation of the electron to the negative terminal and the hole to the positive terminal by the device's structure to supply electricity [10].

Figure 1 illustrates how the electrical energy generated by such a solar system can be supplied into the electrical network while maintaining pre-defined quality and reliability criteria and without causing disruption to the network's normal operation. An inverter connects the PV array to the network by converting the DC output of the array PV panels to an AC output waveform that matches the voltage and frequency of the local network. It's worth noting that the system depicted in Figure 1 lacks any energy storage capability; this is the typical architecture of many contemporary grid-connected photovoltaic systems [11].

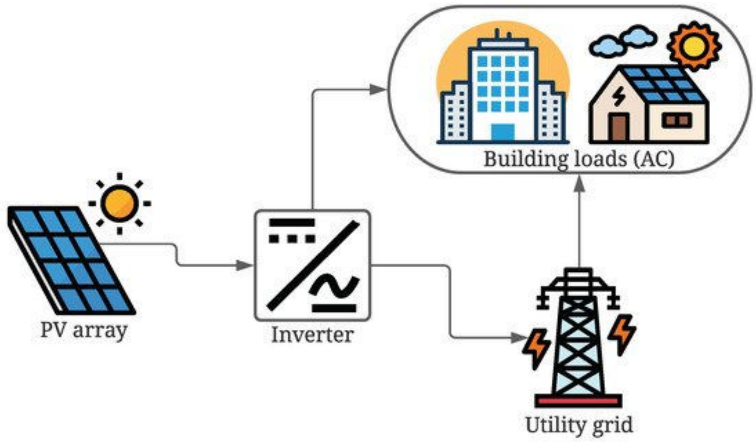


**Figure 1:** Layout of the grid-connected photovoltaic system [11]

## III. Common Types of Solar Panels

### 3.1 Thin Film Solar Cells Technology

Cells Thin film solar cells are made up of micron-thick photon-absorbing material layers placed on a flexible substrate to convert light energy into electrical energy (via the photovoltaic effect). Thin-film solar cells were first developed in the United States in the 1970s by researchers at the University of Delaware's Institute of Energy Conversion. As technology advanced, the worldwide thin-film photovoltaic market grew at an unprecedented rate in the early twenty-first century, and was expected to continue to rise. Several types of thin-film solar cells are widely used because of their relatively low cost and their efficiency in producing electricity [12].

There are three main types of thin-film solar cells, depending on the type of semiconductor used: amorphous silicon (a-Si), cadmium telluride (CdTe) and copper indium gallium diselenide (CIGS). Amorphous silicon is basically a trimmed-down version of the traditional silicon-wafer cell. As such, a-Si is well understood and is commonly used in solar-powered electronics [13].

Thin-film solar cells made of amorphous silicon are the most developed. The duality is commonly p-i-n (or n-i-p), with the p-layer and n-layer mostly employed for producing an internal electric field (i-layer) made of amorphous silicon. The i-layer is typically 0.2–0.5 m thick due to the high absorption capacity of amorphous silicon. It has an absorption frequency of 1.1 to 1.7 eV [14].

A thin-film cell efficiency of 16.5 percent in cadmium telluride (CdTe) has been obtained, whereas the current record module efficiency is 10.6 percent. In 2002, CdTe accounted for 0.7 percent of global cell manufacturing, the majority of which was for indoor usage in consumer products. The efficiency of commercial modules is often less than 7%. A glass superstrate and a layer of transparent conducting oxide (TCO) as front contact, a near-transparent n-type cadmium sulphide (CdS) window layer, p-type CdTe, and a metallic rear contact make up the fundamental structure. The module is divided into cells by scribing the contact films, which are then connected in series to provide the needed voltage [15]. Cu (In1-x Gax) Se2 nanocrystalline bulk semiconductor is used as the absorber material in copper-indium-gallium-diselenide (CIGS) thin-film solar cells, which are multilayer thin-film devices. In compared to silicon wafer-based solar cells, CIGS thin film solar cells have a low-cost substrate and monolithic interconnection of individual cells in a module. CIGS have a good energy band gap, which is another advantage of this compound semiconductor. The band gap of the absorber should theoretically be between 1.0 and 1.8 eV, with 1.5 eV being the ideal value [16].

### 3.2 Mono Silicon Solar Cells Technology

Monocrystalline silicon solar cells, which are produced from pure silicon on thin silicon wafers, are the most common and oldest technology. Monocrystalline silicon is formed up of organized crystal formations in which each atom is perfectly aligned [17].

These cells are comprised of monocrystalline silicon in its purest form. Silicon has a single continuous crystal lattice structure in these cells, with nearly no flaws or impurities. Monocrystalline cells' main advantage is their high efficiency, which is typically around 15%. The disadvantage of these cells is that monocrystalline silicon requires a sophisticated production process, resulting in slightly higher costs than alternative technologies [18].

### 3.3 Polysilicon Solar Cells Technology

Polycrystalline silicon (polysilicon) is a substance made up of tiny silicon crystals that convert sunlight into electricity and is used to make crystalline silicon PV modules. Because the cells are formed in a huge block of numerous crystals rather than individually, polycrystalline panels are slightly less expensive and less efficient than monocrystalline panels. Polycrystalline has a mosaic or shattered-glass appearance due to the crystals. To construct the individual cells that make up the solar panel, the block of silicon is split into wafers, just as monocrystalline cells [19].

## IV. Common Benefits of Solar Energy

### 4.1 Solar Power Is Good for the Environment

Solar energy has numerous environmental advantages. Switching to solar energy will help conserve important resources, reduce air pollution, and safeguard our environment from global warming's destructive consequences. Solar panels and systems allow us to utilize the sun's clean, renewable energy while also protecting the environment [20].

Furthermore, solar energy is particularly environmentally friendly because it may decrease 40 million tons of $CO_2$ emissions per year with the establishment of solar grids that only meet 1% of global electric energy demand [21].

### 4.2 Solar can Drastically Reduce or Eliminate Your Electric Bills

Solar power systems could reduce, if not eliminate, office building's electric. This money saving can have an enormous effect on large and small enterprises. Installing a solar power system means that you pay a prepayment of nearly 40 years of energy, but only a fraction of the electricity you currently pay for. Your current energy bills are probably significantly more expensive per unit than what you would spend on solar electricity [22].

These incentives reduce the effective cost of a rooftop solar panel installation for the average homeowner. A targeted discount scheme in one U.S. county resulted in 47 people installing rooftop solar panels, saving each home an estimated average of $1250 per year on their power bills and resulting in a total effective reduction of 206 metric tons of carbon dioxide emissions [23].

### 4.3Versatile installation

Solar energy is inexhaustible, more reliable, requires less maintenance, is silent and is more versatile as it can be installed in cities as well as in rural areas [24]. This feature, combined with the system's simplicity and adaptability, makes it easier to construct small-scale solar projects, with the added benefit of being able to scale up depending on the demands at any given time [25].

## V. Common Drawbacks of Solar Energy

### 5.1 Location and Sunlight Availability

The season has an impact on solar efficacy. During summer or dry season, more electricity is generated than what people really need because the earth is oriented such that the sun is closer to the Earth [26]. It is also noted that during cloudy days solar panels normally generate 30 % – 50 % of their optimum generation and during heavy rain solar panels generate 10 % – 20 % of their optimum generation [27].

### 5.2 High Initial Cost

The high initial cost of installation is one of the major hurdles in the development of renewable energy [28]. Solar panels would provide significant long-term benefits, but the initial expenses can be prohibitive. It could cost an arm and a leg to buy solar panels, depending on the business you choose. It is even more difficult to estimate the total cost of installation without the assistance of manufacturers. It could take anything from 10 to 15 years to break even on your initial investment [29].

## VI. Approach Framework

The proposed approach is a three-step framework. By applying the approach, renewable energy global market leaders and trends will be identified and analyzed based on: (1) economics and renewable energy policy, (2) specific renewable energy sectors that presents the most attractive investment opportunity, (3) and finally the most promising renewable energy investment vehicles for investors. Other stakeholders can also use the developed framework, such as consumers and policymakers, to make socio-economic decisions and assess renewable energy investments [8].

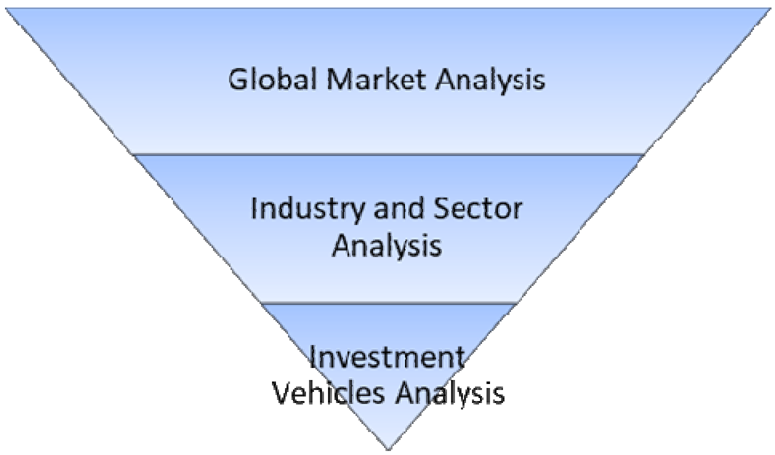


**Figure 2:** The proposed approach is a three-step framework [8]

## VII. Status of Solar Energy in the Philippines

According to a study by Ateneo de Manila University, renewables already account for 30% of national power generation capacity, with hydropower accounting for 16% of the total and geothermal energy accounting for 8%. However, in 2018, they accounted for 23.4 percent of total generation. Renewable Portfolio Standard guidelines, enacted in 2017, require energy companies to source or create at least 35% of their electricity needs from renewable sources by 2030, in order to meet the Renewable Energy Act's requirement that renewables account for 35% of capacity [30].

Industry appears to be moving in the same direction as these goals. AC Energy, the energy division of Philippine conglomerate Ayala Corporation, said in April 2020 that it would phase out coal investments entirely by 2030, delivering a strong message to the rest of the industrial sector about the necessity of sustainable energy. Meralco announced four months later that it would increase its energy capacity by 3000 MW over the next five to seven years, with renewables accounting for one-third of that capacity. MG D Renewable Energy is working on a 50-MW solar farm in Bulacan that is expected to be completed in early 2021 [30].

## VIII. Solar Energy Initiatives of Philippine Higher Education Institutions

There are a few initiatives of Philippine higher education institutions in terms of solar energy implementation that could be identified. The Philippine government has also been supportive of this cause in order to advocate for access to modern energy services and renewable energy.

The La Consolacion College Manila (LCCM) has initiated its Solar Photovoltaic (PV) Net Metering Facility in 2014. The LCCM Solar Facility is the Department of Energy's first solar project for academic institutions. The installed capacity of Phase I is 42.84kW, while Phase II of the project would add 90.27kW, bringing the total capacity to 133.11kW [31]. The project aims to underscore the country's goal of energy sustainability.

Other universities and colleges have also followed the lead of LCCM. Manuel Luis Quezon University (MLQU), St. Scholastica's College – Manila, St. Scholastica's Academy – Marikina, University of Perpetual Help, and Miriam College are among the other academic institutions that have indicated interest in a Solar PV net-metering facility on their campuses [31].

The Urdaneta City Campus, Sta. Maria Campus, Binmaley Campus, and Infanta Campus of Pangasinan State University (PSU) use more than 590,000-kilowatt hours (kWh) of electricity each year. The PSU is looking for ways to reduce the cost of their activities as well as their environmental impact. Solar energy is one viable option for generating electricity on the four (4) campuses. Both financial and non-financial benefits from the university's usage of solar were assessed through discussions and meetings. A solar photovoltaic rooftop system has been demonstrated to be the cheapest option, with a payback period of nine and a half (9.5) years and a cost of ten PHP (Philippine Peso) per kWh. From the 3,360 square meters of rooftop space that is now accessible, up to 336,000 kWh, or 57 percent of the four (4) campuses' power demand, might be produced with solar energy in 2018 [32].

Moreover, the Mariano Marcos State University has a project entitled "Renewable Energy Park Model for Education, Research and Extension Towards Agro-Industrialization and Inclusive Development", this is to establish a feasible and viable RnE Park through R&D integration of biomass, hydro, solar and wind energy innovative technologies for a sustained, cleaner and greener agricultural productivity, strengthen MMSU faculty and staff to pursue 6P's (product, publications, people and services, partners, process and policy) metrics deliverables on R&D under the Republic Act No. 10055-The Technology Transfer Act of 2009, To create an interactive life-long learning RETs live laboratory for students, faculty, researchers, farmers, industries, collaborators and other stakeholders; and To showcase the socio-cultural and techno-economic viabilities of RETs optimum designs, low-cost, efficient and life-cycle and impact assessment (LCIA)-based smart RETs model structures that sustain the promotion and development of institutional knowledge exchange, capacitation and development of sustainable partnerships [33].

Meanwhile, solar energy devices that use nanostructures are being pursued through collaborative approach by research groups from the University of the Philippines, Ateneo de Manila University, and De La Salle University. It focuses on solid state-based and dye sensitized-based solar cells [34].

Lastly, the Tarlac Agricultural university uses solar street lights and solar pumps for irrigation. This helps the university observe austerity measures in consuming electricity power. The establishment of solar farm in the university through public-private partnership is also in review.

## IX. Conclusion

The sources of energy play vital roles and are required to support quality of life in practically every practical system. The speed of production of energy is a driving factor for industry and progress and a major indicator in society's improvement. It is very important to note that different types of solar panel must be identified to know the capability of each technology.

The three-step framework identified in the study is an acceptable approach in the implementation of solar energy projects and programs. However, the need to adhere to all the steps is emphasized for its effective and efficient application.

Finally, the support of government and the proactive involvement of its agencies such as the Department of Energy and the Department of Science and Technology are critical in the successful implementation and adoption of solar energy in the campuses of various Philippine higher education institutions.

## Acknowledgment

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## BIOGRAPHY

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# Biochar from Corn Waste as Biofilter in a Recirculating Aquaculture System

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***Abstract: The use of biofilter with the application of biochar technology for the improvement of water in a recirculating aquaculture system (RAS) provides a lot of advantages in aquaculture production. The research aimed to devise a biofilter system for the enhancement of TAN and un-ionized ammonia levels in a RAS using biochar from corn cobs for Nile tilapia Oreochromis niloticus production. It has five main parts: fish tank, biochar filtration tank, sediment filter, sludge filter and pump. The fish tank used is a 1 $m^3$ plastic cubical tank. The biochar filtration tank with a height of 85 cm and a diameter of 30 cm. The sludge filter has a height of 52 cm with a diameter of 13 cm. An electric water pump was used to recirculate the water. The system was fabricated and were able to effectively enhance the level of total ammonia nitrogen (TAN) at a rate of 0.56 ppm per hour for every 1kg biochar and 0.72 ppm per hour for the reduction of un-ionized ammonia. The devised biofilter proved to reduce the level of TAN by 9.45 ppm and un-ionized ammonia levels by 2.18 ppm in 6 hours and 30 minutes using corn cob biochar.***
***Keywords: Biochar, Biofilter, Recirculating Aquaculture Systems (RAS), Total Ammonia Nitrogen (TAN), Un-ionized ammonia***

## I. INTRODUCTION

Research and studies about biochar technology are vastly growing over the years because of its multidisciplinary approach and different applications. Biochar is a carbon- rich solid material produced by thermal decomposition of organic material or biomass in the absence or under limited supply of oxygen (Lehman and Joseph, 2009).

Ammonia and nitrite are toxic to fish. Ammonia in water occurs in two forms: ionized ammonium ($NH_4^+$) and un-ionized ammonia ($NH_3$). The latter, $NH_3$, is highly toxic to fish in small concentrations and should be kept at levels below 0.05 mg/l. The total amount of $NH_3$ and $NH_4^+$ remains in proportion to one another for a given temperature and pH, and a decrease in one form will be compensated by conversion of the other. The amount of un-ionized ammonia in the water is directly proportional to the temperature and pH. As the temperature and pH increase, the amount of $NH_3$ relative to $NH_4^+$ also increases. The ammonia poisoning of fish is as imminent danger in a RAS (Helfrich and Libey, 2019). With this, a biofiltration system plays a vital role in maintaining a good aquaculture water quality.

Recirculating Aquaculture Systems (RAS) has been in existence, in one form or another, since the mid-1950s. However, only in the past few years has its potential to grow fish on a commercial scale been realized. New water quality technology, testing and monitoring instrumentation, and computer enhanced system design programs, much of it developed for the wastewater treatment industry, have been incorporated and have revolutionized our ability to grow fish in tank culture. Nevertheless, despite its apparent potential, RAS should be considered a high-risk, experimental form of agriculture at this time. It can be used to culture high densities of fish annually, but its ability to do so economically remains to be demonstrated, conclusively and repeatedly (Helfrich and Libey, 2019).

With these characteristics, a potential to develop biochar from corn cobs for improving TAN and un-ionized ammonia levels in a RAS shows a potential researchable area since corn cobs are abundant in supply, low-cost, and readily available in the area. With the expansion of tilapia culture, together with the shortage of freshwater and competition of the water use into different applications, and with the growing number of human populations through the years, tilapia farming has been shifted from traditional semi-intensive systems to more intensive production systems such as the production in fish tanks and fish cages with the use of a RAS.

RAS is characterized by its ability to support extremely high stocking densities and high net production with a limited volume of water requirements. However, high stocking density will result in high fish wastes which are toxic ammonia compounds in the form of TAN and un-ionized ammonia excreted into the water and uneaten feed particles that need to be removed.

Biochar has the potential role in improving aquaculture water quality in fish culture by lowering the level of TAN and un-ionized ammonia in a RAS.

Also corn cobs has a potential media in improving aquaculture water. The use of charcoal for water purification to remove unwanted dissolved organic pollutants is well established. However, there has been limited research on the potential of biochar to improve the quality of aquaculture water in RAS for fish production. Therefore, the project will contribute to the aquaculture sector by establishing the potential of biochar filtration in improving the quality of aquaculture water specifically in reducing the TAN concentration.

## II. MATERIALS AND METHODS

### *A. Preparation and Carbonization of Corn Cobs*

Corn cobs samples were collected. Impurities and other foreign materials were removed to attain the uniformity of the samples. A pyrolytic converter was used to carbonize the corn cobs. For each batch of the biomass samples, ten kilograms (10 kg) of samples were loaded inside the kiln. Rice hulls were fed around the fuel feeder every 20 min and when the fire reached the top feeder until the samples were fully carbonized.

The biomass samples were subjected to heat with minimum presence of oxygen at an average of five hours. Carbonized samples were left inside the kiln overnight to release the heat inside the kiln and to make sure that it would not become ash when in contact with air. After carbonization, samples were crushed to achieve uniformity then sieved manually within wire mesh sizes of 1 and 5 mm to attain a 1-5 mm biochar sample size. Figure 1 shows biochar production and utilization method.

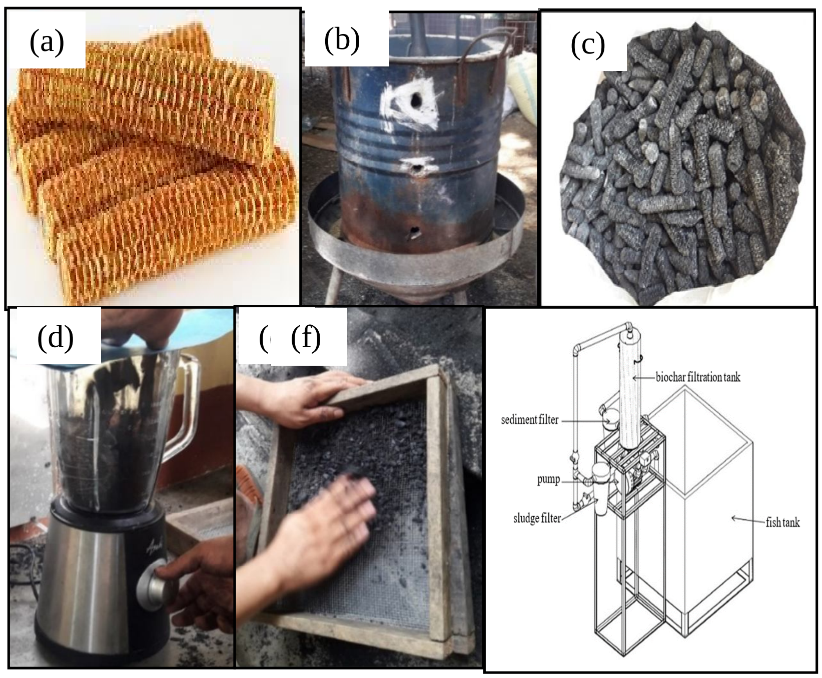


*Fig 1*. Biochar production and utilization (a) corn cobs (b) pyrolytic converter (c) carbonized biochar from corn cobs (d) crushing of samples (e) sieving (f) biochar filtration system

### *B. Devising a Biochar Filtration System in RAS*

A biochar filtration system for the reduction of TAN and un-ionized ammonia, removal of the feed residues, and aeration in grow out tank was devised. The system was devised from the principle of operation of a commercial water filtration system (Figure 2). The first stage of the system aimed to remove the feed residues by suctioning the bottom layer of the tank using a water pump. After the residues were filtered, the water was then transported to the biochar container wherein the TAN was adsorbed and reduced. To avoid the black coloring of the water in the biochar container, another filter system was installed. Lastly, the filtered water was released back to the fish tanks.

The flow of water into the tank was then used as aeration in the fish tanks during the biochar filtration process. With this, there was no need for an aerator to provide for the desired dissolved oxygen level during the operation of the biochar filtration system.

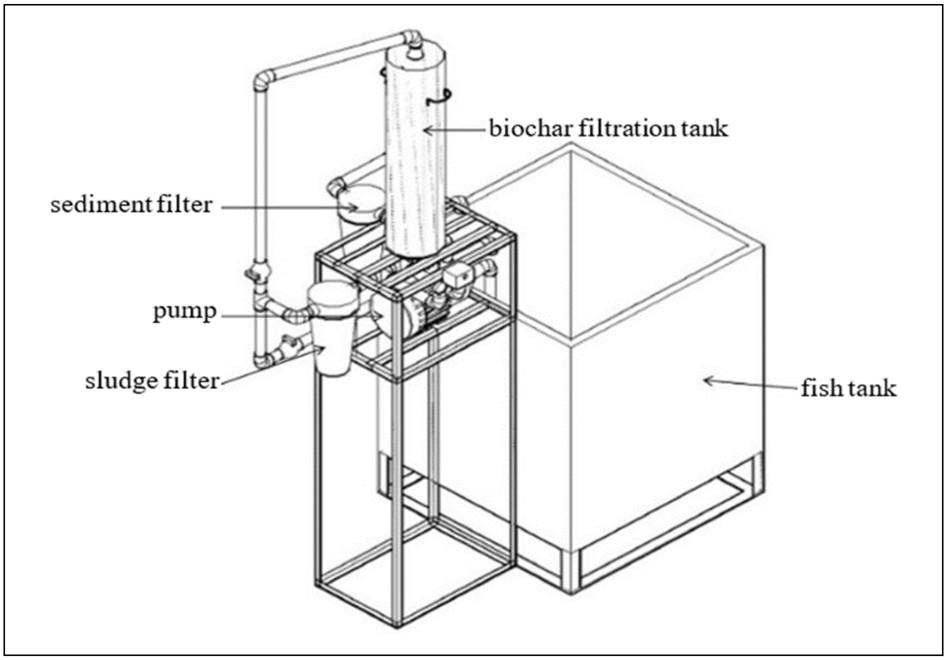


Fig 2. The biochar filtration system

*C. Un-ionized Ammonia Adsorption Capacity of Biochar*

Un-ionized ammonia ($NH_3$) which was more toxic to fish than ionized ammonia ($NH_4^+$) was calculated from total ammonia readings (Emerson *et al.*, 1975). Total ammonia is the sum of ammonia ($NH_3$) and ammonium ($NH_4^+$) concentrations. A multi-parameter tester was used to determine the adsorption capacity of biochar in terms of the total ammonia.

*D. Amount of TAN Adsorbed and Removal Efficiency using Biochar*

The amount of TAN adsorbed and removal efficiency of using biochar was computed using Equation 1.

$$q_e = V/W \times ( C_f - C_i ) \qquad \text{(Equation 1)}$$

where: $q_e$ - the amount of TAN and un-ionized ammonia removed ($mg \cdot g^{-1}$)
$C_f$ - final TAN concentration, ($mg \cdot L^{-1}$)
$C_i$ - initial TAN concentration, ($mg \cdot L^{-1}$)
V - volume of the aquaculture water in tank, L
W - weight of the biochar, g

Two basic approaches were used in interpreting the experimental results for adsorptive capacity. Nameni et al (2008) computed the percent of MB adsorbed (adsorption efficiency, %) using the formula in Equation 2.

$$\%\ \text{TAN adsorbed} = [(C_i - C_f) / C_i] \times 100 \qquad \text{(Equation 2)}$$

where: $C_i$ - initial concentration,
$C_f$ - final concentration

*E. Statistical Analysis*

Paired t-test was performed for the validation of the results in an actual RAS using the devised biochar filtration systems. Comparison among treatment means was analyzed using Duncan Multiple Range Test (DMRT) at 5% level of significance.

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## III. RESULTS AND DISCUSSION

### A. Corn Cob Properties

Corn cobs properties were determined by performing proximate analysis. Properties such as percent moisture, volatile combustible matter, ash and carbon content were determined to assess its quality. The higher the fixed carbon from biomass, the higher the biochar yield.

Proximate analysis revealed that the percent moisture of the corn cobs samples was 4.43 percent. Results revealed that the amount of water in biochar is within the acceptable value and much lower than the accepted moisture content of 10%. The moisture content has no effect on the adsorptive property of the biochar. Hence, if the moisture content is high, the more susceptible is the carbon to fungi growth, thus, the shelf life is reduced.

The carbon, oxygen and hydrogen component of corn cobs also known as the volatile combustible matter revealed a 14%. The result of the volatile matter is considered excellent which means that the carbonization is prolonged and at a high temperature. This also signifies that the corn cobs used is of good quality. The ash content of the biochar samples revealed that corn cob has only 6.65% which was within the acceptable values. The desirable value of ash content of activated carbon ranges from 1-20 % as mentioned by Abdul (2007). Ash content dictates the quality of an activated carbon since it reduces its mechanical strength. Corn cob has fixed carbon content of 80.3%.

The amount of TAN adsorbed and removal efficiency using biochar was attributed to thermolysis of cellulose. This cellulose or lignin is considered as the main component of biochar which formed carboxyl groups. This functional groups were the basis for the effective adsorption of ammonia (Asada, *et.al.* 2002).

### B. Biochar Filtration in a Recirculating Aquaculture Systems

The devised biochar filtration system in RAS (Figure 3) aimed to enhance the TAN and un-ionized ammonia level in RAS. It also served as a device to take in the sludge and sediment particles from grow out tank; filter the accumulated sludge, solid particles, and sediments; and for additional aeration inside the tank during the biochar filtration process.

The biochar filtration system was composed of five main parts, namely: fish tank, pump, biochar filtration tank, sediment filter, sludge filter and pump. The fish tank used for Nile tilapia production was a 1 $m^3$ plastic cubical tank. The biochar filtration tank with a height of 85 cm and a diameter of 30 cm was filled with 5-9 mm gravel at the bottom, 1 kg of 5-10 mm corn cob above the gravel, and then followed by 1-5 mm of sand on top of the corn cob (Figure 4).


Fig 3. The devised biochar filtration system

 

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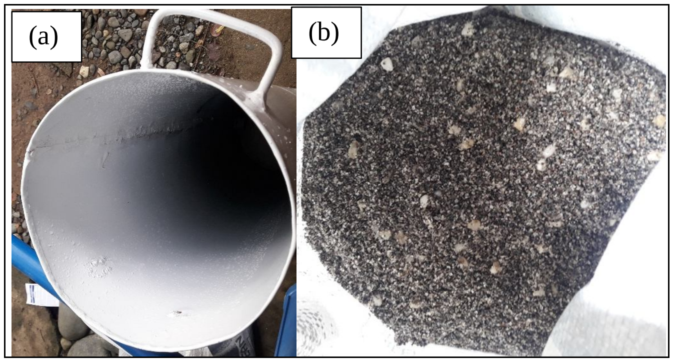

Fig 4. The biochar container (a) the biochar container (c) fine sand

The sediment filter aims to filter the sediments as well as the black coloring of the water when mixed with biochar (Figure 5). The sludge filter was used to filter the accumulated sludge and other solid particles inside the tank such as unconsumed feeds and fish excreta that settled at the bottom part of the tank (Figure 6). A sweeper/ suction pipe was connected to the filter to suck the sludge particles below the experimental tank. Also, this served as a first stage filtration so that the sludge particles were not transported to the biochar container. The sludge filter has a height of 52 cm with an inside diameter of 12 cm and an outside diameter of 13 cm.
An electric water pump was used to circulate the aquaculture water from the experimental tank, passing it through the sludge/solid filter, to the biochar filtration tank, to the sediment filter tank and lastly, to transport back the water to the experimental tank;

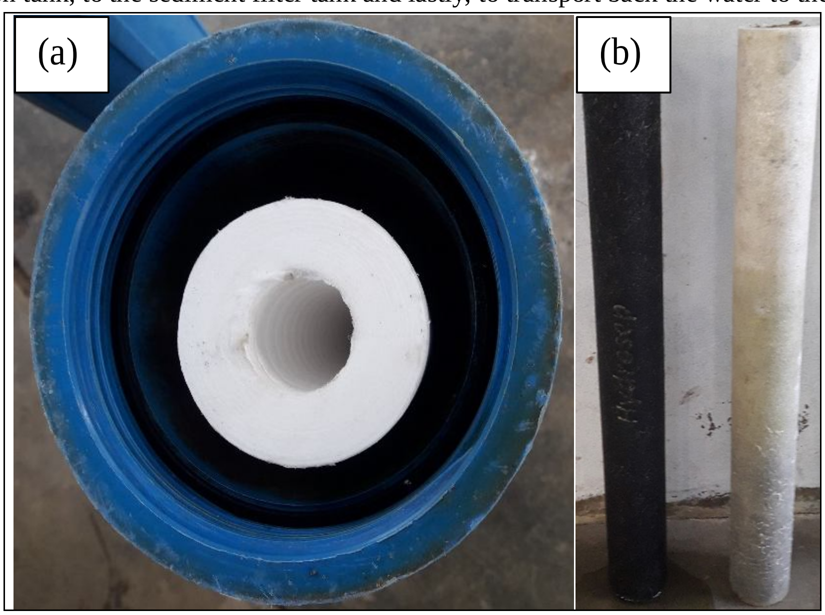

Fig. 5. The sediment filter (A) top view (B) filter media

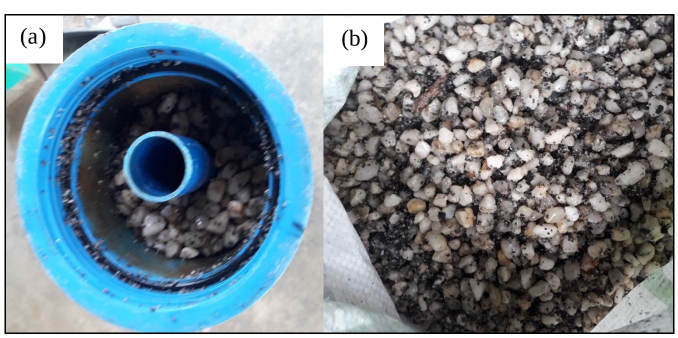

Fig. 6. The sludge filter (a) top view (b) gravel particles

### *C. Operation of a Biochar Filtration System*

The biochar filtration system was operated by pumping the water from the RAS tank passing to the sludge filter then filled up to the biochar container wherein biochar filtration takes place. The aquaculture water was then pass through to the sediment filter then flows back to the RAS tank (Figure 7).

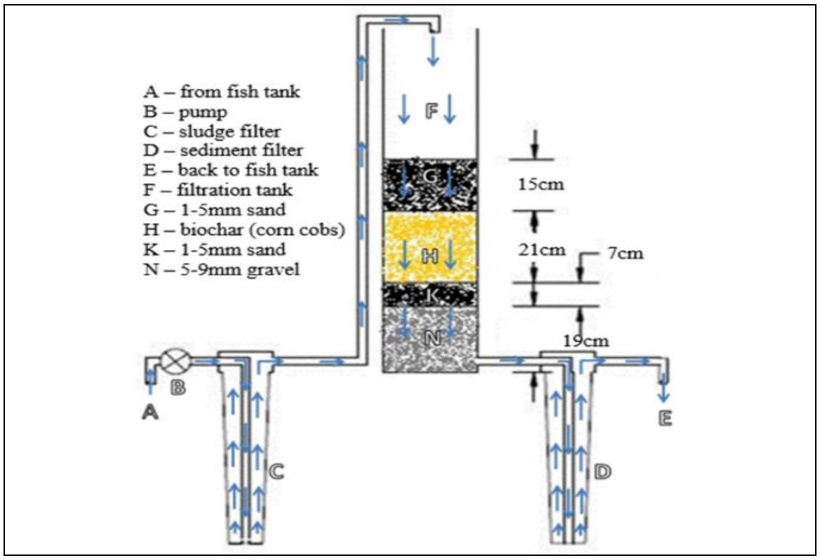


Fig. 7. Flow diagram of the biochar filtration system

### *D. Performance of the Devised Biochar Filtration System in a RAS*

The performance of the devised biochar filtration system was evaluated through actual validation of the TAN and un-ionized ammonia reduction in an actual fish production environment (fish tank) in a RAS and was compared to the fish tank without biochar filtration.

### *E. TAN Reduction using the Biochar Filtration System*

Results of the TAN reduction using the biochar filtration system revealed that for eight hours of operating the biochar filtration system, there is an evident enhancement of TAN in the grow-out tank. First run showed a decrease of 4.48 ppm from 6.12 ppm to 1.64 ppm. Another run showed a 4.47 ppm decrease from 5.8 to 1.33 ppm and lastly, a decrease of 3.35 ppm from the initial reading of 4.97 to 1.43 ppm (Figure 8).

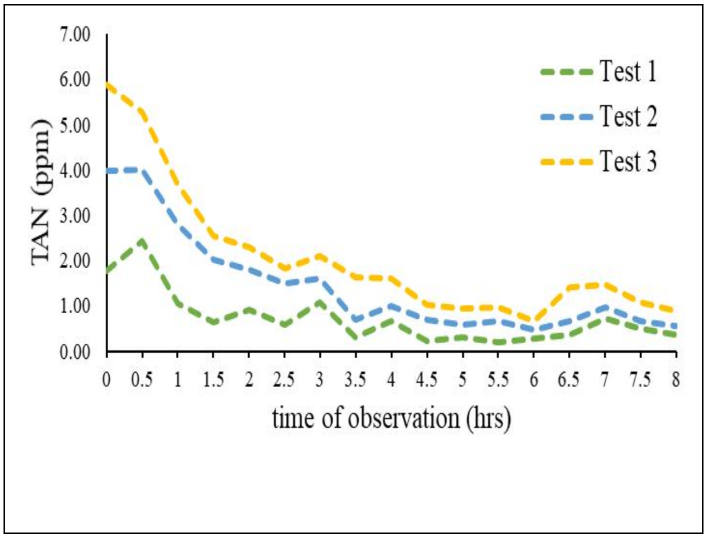


Fig.8. TAN reduction using biochar filtration system

### *F. Un-ionized Ammonia Reduction using Biochar Filtration System*

Un-ionized ammonia reduction using biochar filtration system was calculated from total ammonia readings (Emerson, et al., 1975). Data showed that the average un-ionized ammonia levels were above the desirable level (Figure 11). The ideal un-ionized ammonia level for fish production was 0.01 ppm.

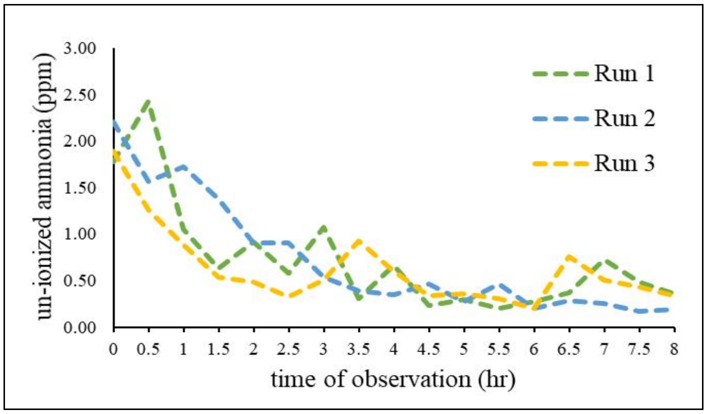


Fig. 9. Un-ionized ammonia reduction using the biochar filtration system

### *G. TAN Reduction at Different Stages of Biochar Filtration*

The amount of TAN reduced at different filter stages was measured and evaluated. Results revealed that RAS tank had the lowest TAN reduction of 3.45 ppm after seven-hours of observation at a rate of 0.49 ppm per hour.

| Time of observation (hr) | RAS Tank (ppm) | Filter 1 (Sludge Filter) (ppm) | Filter 2 (Biochar Filter) (ppm) | Filter 3 (Sediment Filter) (ppm) |
|---|---|---|---|---|
| 0.0 | 4.97 | 5.20 | 5.35 | 5.17 |
| 0.5 | 5.03 | 4.80 | 3.09 | 3.72 |
| 1.0 | 4.73 | 4.56 | 3.94 | 3.93 |
| 1.5 | 4.26 | 4.19 | 3.77 | 3.78 |
| 2.0 | 4.01 | 3.97 | 2.80 | 3.01 |
| 2.5 | 3.55 | 3.22 | 2.08 | 2.23 |
| 3.0 | 2.87 | 2.66 | 1.90 | 1.86 |
| 3.5 | 2.43 | 2.33 | 1.71 | 1.65 |
| 4.0 | 2.09 | 1.98 | 1.53 | 1.57 |
| 4.5 | 2.01 | 1.92 | 1.23 | 1.42 |
| 5.0 | 1.86 | 1.70 | 1.15 | 1.11 |
| 5.5 | 1.67 | 1.75 | 1.09 | 1.03 |
| 6.0 | 1.73 | 1.64 | 1.26 | 1.15 |
| 6.5 | 1.55 | 1.71 | 1.05 | 1.08 |
| 7.0 | 1.52 | 1.43 | 1.12 | 1.10 |

Table 1. TAN reduction at different stages of biochar filtration

Biochar filtration (biochar filter) tank had the highest TAN reduction of 4.23 ppm with a rate of 0.60 ppm per hour, followed by the sediment filter of 4.07 ppm at a rate of 0.58 ppm per hour. Next was the sludge filter with 3.77 ppm at a rate 0.54 ppm per hour (Table 2). Results revealed that at the first filter (sludge), there was no significant difference on the reduction of TAN after passing through it while there was a significant difference on the second filter (biochar filter) before and after the biochar filtration. On the last filter, (sediment filter) results showed that there was no significant difference before and after passing.

## IV. CONCLUSIONS

Results indicated that biofilter using corn cobs has a potential for the enhancement of TAN and un-ionized ammonia levels in RAS. It can be concluded that the percent moisture of the corn cobs samples was 4.43 percent, volatile combustible matter of 14%, ash content of 6.65% and fixed carbon content of 80.3%. The biochar filtration system successfully reduced the level of TAN at a rate of 0.56 ppm per hour for every 1kg biochar and 0.72 ppm per hour for the reduction of un-ionized ammonia in a 1 cubic meter fish tank under RAS. These results indicated that unutilized corn cobs in a biofilter can be used to mitigate the negative effect of un-ionized ammonia in a RAS.

## V. ACKNOWLEDGMENT

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Bennidict, ZheyAnne and Zhia Kate, who served as inspiration in finishing this project; and, above all, to our Almighty God for all His endless blessings.

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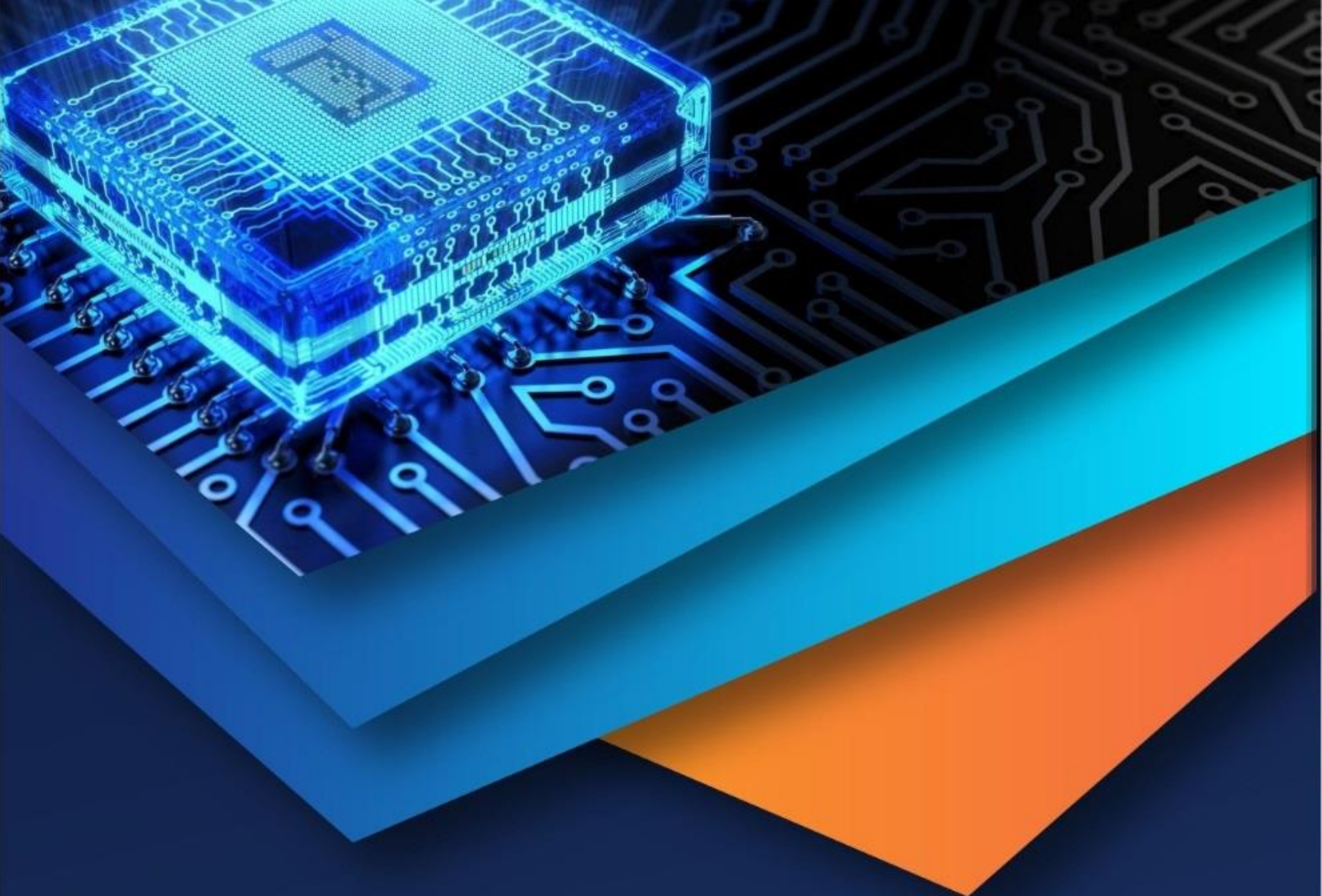

# Nitrogen Deficiency Mobile Application for Rice Plant through Image Processing Techniques

**Geraldin B. Dela Cruz**

***Abstract:*** ***Driven by the opportunity that digital devices and robust information are readily available, the development and application of new techniques and tools in agriculture are challenging and rewarding processes. This includes techniques learned that is based on traditional methods, practices, experiences, environmental patterns and human capability. The most sought technique comes from human intelligence that is dynamic, adaptive and robust. Nitrogen deficiency in rice plants can be determined via the color of the leaves. It is dependent on the depth of the green pigment in the color spectrum present in the leaves. Based on these characteristics, the application of computational artificial intelligence and machine vision can be adopted to create assistive technologies for agriculture. In this paper, a mobile application is developed and implemented that can be used to assist rice farmers determine nitrogen deficiency, through the leaf color in rice plants. The application can be used alternatively or together with the traditional protocol of nitrogen fertilizer management. It is mobile, simple and it also addresses some drawbacks of the human eye to distinguish color depths brought about by other factors, like sunlight, shading, humidity, temperature, etc. It utilizes image processing techniques to digitally captured images represented in numerically transformed Red, Green, and Blue color formats. The digital images are then normalized to remove the effects of illumination and then compared using the image/pixel subtraction technique with the base color images converted and extracted from the leaf color chart standard. Eventually, the application determines nitrogen deficiency and suggests the concentration and volume of fertilizer to be applied to the rice plants. Accuracy of the technique is determined by computing the Z statistic score.***

***Keywords*****:** ***Algorithms, image processing, fertilizer management, mobile application.***

## I. INTRODUCTION

Fertilizer management is governed by processes triggered by specific events and attributes from the environment and most especially from the crop. The method is based on a standard protocol developed by researchers together with the farmers with years of tests and trials. This fertilization protocol is a tedious activity especially for the rice (*Oryza Sativa L.*) plant, it is not as easy as just throwing nutrients into the soil and everything will just be fine. There are some issues to be considered, such as applying too much fertilizer and the plant becomes succulent and susceptible to insect and disease. Too little and the plant grows poorly and unproductive. In the Philippines, majority of the farmers cultivate their farms the traditional way. These farmers apply fertilizers not only based on plant condition but also take into consideration predetermined dates after seeding or transplanting. Not following holistically the protocols established for fertilizer management, farmers suffer the consequences of bad fertilizer management, thus lesser harvest yield. Fertilizers must be applied only when necessary and based on the crops' nutritional status. However, most farmers rely on the age (days after transplanting) of the rice plant and not on its condition. Consequently, this causes a deficiency in the required nutrient of a plant from the fertilizer in terms of growth, development, and yield. Moreover, there are some unaware farmers, that applying fertilizer too soon, will result to undesirable effects on growth and yield of rice and thus have a significant addition to the production cost which is not ideal [1].

## II. RELATED WORKS

There have been many developed methods of the proper application of fertilizer [2]. One of the most effective means to determine the volume and when to apply fertilizer is to use the developed Leaf Color Chart (LCC). The LCC is used to assess the plant Nitrogen (N) status. It is an inexpensive tool consisting of four (4) color shades from yellowish green to dark green. The color strips are fabricated with veins resembling those of rice leaves. The assessment will depend on the greenness of the leaf matched to the LCC window. Each window defines a level of N status. This method however, limits the capability of the human eye to distinguish from the colors given in the chart from the colors of the rice plant leaf as evidenced in the findings of the on-farm evaluation. The color matching is relative to the person's color perception so it is recommended that the same person should do the matching. The use of the LCC is also limited to a period of a day due to the effect of sunlight to the colors, both of the leaf and the chart [3], [4].

In the Philippines, the on-farm evaluation of the LCC technique has demonstrated its usefulness for real-time nitrogen management in rice. The increase in N-use efficiency was due to slightly less, same or higher yields grain, with lower levels of N application in the LCC-monitored fields. Savings in N fertilizer of -14 to +53 kg per hectare were realized in farmers' fields of other collaborating countries [5].The work of P. Sanyal and U. Bhattacharya explained that rice deficiencies in the balance of mineral levels can be identified by detecting the change in the appearance of rice leaves [6]. This work is also supported by P. Murakami et al, that changes in foliar color are a valuable indicator of plant nutrition and health.

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The leaf color is measured with visual scales and inexpensive plant color guides that are easy to use, but not quantitatively rigorous, or by employing sophisticated instrumentation including chlorophyll meters, reflectometers, and spectrophotometers that are costly and may require special training [7].

The International Rice Research Institute (IRRI), and the Department of Agriculture (DA) in the Philippines, initiated the NM Rice Mobile application. It applies the concept of Site Specific Nutrient Management (SSNM), a set of scientific principles for optimally supplying rice with essential nutrients. The LCC is covered by SSNM. Farmers dial a toll-free number and a voice response will follow which will direct them to a set of 12 to 15 questions related to the status of the rice plant. Eventually, a text message will be sent to the farmer's phone containing recommendations on fertilizer application duly customized for his field. The mobile application is available in Tagalog, Cebuano, and Ilocano dialects [8].

The paper of S. Pongnumkol, P. Chaovalit and N. Surasvadi, presented a review of the capability of smart phones to becoming a very useful tool in agriculture, mainly to their mobility that matches the nature of farming, the cost efficiency and accessibility of computing power. It systematically reviewed smart phone applications that utilize built-in sensors to agricultural solutions [9].

Similarly, the work of V. Patodkar et al, presents a developed android software application for sustainable development for farmers. The application assists the farmer in decision making regarding selection of fertilizer, pesticide and time to do particular farming actions. It combines internet and mobile communications with Global Positioning System (GPS) [10].

The system developed by Sanjana, Sivasamy, Jayanth [11] consisted of a mobile application which enables farmers to take digital images of plants using their mobile phones and send it to a central server where the central system analyzes the pictures based on visual symptoms using image processing algorithms to measure the disease type. An expert group will be available to check the status of the image analysis data and provide suggestions based on the report and their knowledge, which is then sent to the farmer as a notification in the application.

Based on the insights from these pieces of literatures, this project aims to apply digital processing techniques in a mobile application that can be used as a tool to assist rice farmers in fertilizer management of the rice plant based on the LCC framework and its guidelines.

The project intends to implement the image normalization technique as a preprocessing method and the digital image pixel subtraction technique as the processing algorithm into a mobile phone application [12]-[14].

The application is to be used in the rice paddy field as an assistive technology for rice plant farmers. It aims also to archive data sampled from the rice field to be used as baseline comparative statistics by other researchers. The framework of the study was inclined on the use of smart mobile phone technology, image processing and rice farming technologies.

## III. SYSTEM ARCHITECTURE

### A. Application architecture

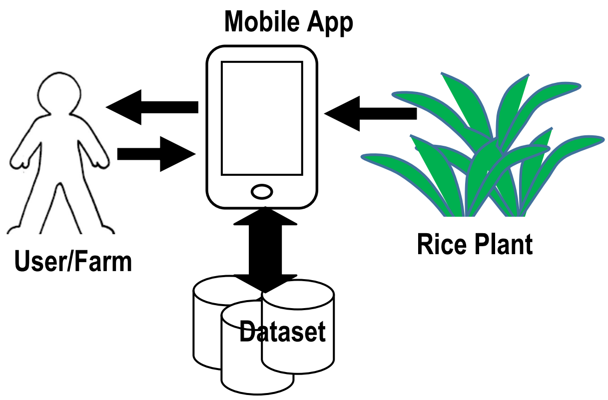


**Fig. 1.**A system view of the application.

Shown in Fig. 1, is the conceptual framework of the system: the mobile phone application processes sample images of leaves taken from rice plants in the field through its built-in camera device, these images are processed and eventually references the average image against the digitized LCC dataset. This process determines the nitrogen deficiency of the rice plant. The number of samples is dependent on the size of the rice field. Ideally, more samples from a large area, the better the outcome of the mobile application. However, the LCC standard suggests that five (5) leaf samples per hectare taken randomly from the field are sufficient to represent the whole area.

The intelligence of the application relies on the digitized LCC dataset that is used as the basis in determining the nitrogen content of the captured rice plant leaf color. The whole process is integrated into the mobile application: the user launches the application and through the camera of the phone, to take samples of the rice plant leaf. The application converts the images one at a time, calculates the average of the samples and performs image comparison. The method uses the color depths of the captured image from the base image and compares it from the digitized LCC database. Subsequently, the application displays the result, suggesting the amount of fertilizer to be applied. The results are archived in the database for future reference and further study.

### B. Computational processing of the application

Fig. 2 presents the computational algorithm of the mobile application. The system takes sample images of rice leaves in the rice field. These images are then processed by converting it to its equivalent Red, Green, Blue (RGB) formats. By subtracting the average value of the sample images from the value of the baseline LCC images present in the application, consequently, a resulting near accurate color value is returned. If the sample images are out the range, then the user is alerted that the image is not a rice leaf. The same procedure is done until the captured image is valid. While the application captures the images, it also records the ten greenness values of the rice leaves.

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The average greenness values of the ten images are also stored. The average greenness value of the sample images is then subtracted from the baseline values per window of the digitized LCC. After this process, the indicative result based on the interpretation of the greenness value is displayed. Included in the indicative result is the fertilizer recommendation accordingly to the specified window.

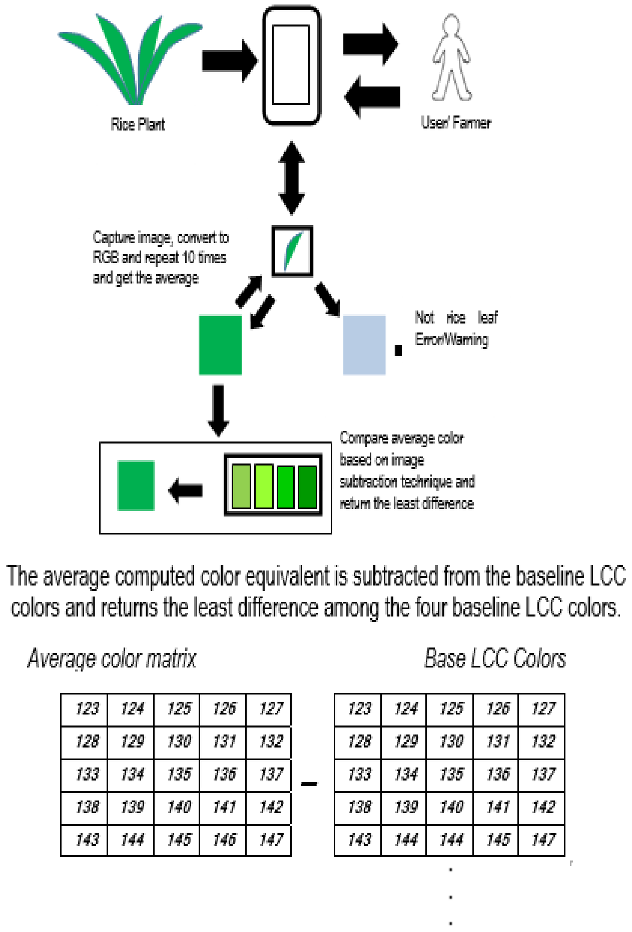


**Fig. 2.**Processing mechanism of the mobile application.

The RGB color space of the captured bitmap image is used as the numerical representation of the image. The RGB data value of each pixel's color sample has three numerical values to represent the colors Red, Green, and Blue. These three RGB components are three 8-bit numbers for each pixel. Each 8-bit RGB component can have 256 possible values, ranging from 0 to 255.

To get the area of concern from the image, the height and width of the bitmap is first calculated, which is denoted by:

$$Z = (0...x, 0...y) \tag{1}$$

Where:

Z = bitmap image
x = x coordinate plane
y = y coordinate plane

The color value of each pixel is represented in (2) denoted by:

$$P_{(x,\,y)} = (R, G, B) \tag{2}$$

Where:

$P_{(x,\,y)}$ = pixel in the x and y coordinate plane
(R,G,B) = (0...255, 0...255, 0...255)

Color normalization is also applied to the pixels to reduce the effects of light. Normalization of the color space of the image removes highlighted regions and shadows this makes it easier to detect the color of the leaf. Based on equation (2), the normalization method is presented below:

$$Total = (R + G + B) \tag{3}$$

$$R' = round((R / Total) * 255) \tag{4}$$

$$G' = round((G / Total) * 255) \tag{5}$$

$$B' = round((B / Total) * 255) \tag{6}$$

Thus, the normalized images are denoted by the equation in (7):

$$P1|2_{(x.y)} = (R', G', B') \tag{7}$$

The pixel subtraction technique is as simple as taking two images as input parameters, this mechanism produces a third image whose pixel values are simply the difference of the corresponding pixel values from the two images. It is also often possible to just use a single image as input and subtract a constant value from all the pixels. Some versions of this technique produce the absolute difference between pixel values, rather than the straightforward signed output.

The subtraction of two images can be performed straightforwardly in a single pass using the formula in equation (8).

$$[Q_{(i,\,j)} = P1_{(i,\,j)} - P2_{(i,\,j)}] \tag{8}$$

Where :

Q = the output value
P1 = the first image value
P2 = second image value

Or the absolute differences between the two input images can be computed from equation (9).

$$[Q_{(i,\,j)} = | P1_{(i,\,j)} - P2_{(i,\,j)} |] \tag{9}$$

Or simply subtract a constant value C from a single image if desired using the formula in equation (10):

$$[Q_{(i,\,j)} = P1_{(i,\,j)} - C] \tag{10}$$

Where:

P1 = first image value
C = baseline image value

The green (G) color component value in a pixel is simply extracted separately to produce the nearest output value.

## IV. RESULTS

### A. Detection Testing

Tests were conducted on the premise that the algorithm may result and interpret colors from other leaves other than of the rice leaf. Thus, a mechanism was integrated to accurately identify whether the captured image is that of a rice leaf.

Shown in Fig. 3, is the result after capturing thru the mobile phone camera the rice leaf. The image presents the confirmation of the object being a rice leaf which does not display warning or notification of an error. The application converts the image and saves it in RGB format

**Fig. 3.**Correct rice leaf image.

Fig. 4 and Fig. 5 shows the status screen of the mobile application when a different leaf or an object with the same color of a rice leaf is captured. It is capable of determining that the image taken is not a rice leaf, resulting in the notification display of an error-warning to the user. Not only the difference in color but also the difference between the two objects can be detected, even though the object captured has a similar color with a rice leaf. Fig. 6 shows the indicative results when the application correctly determines the captured image that is of a rice leaf. Consequently, the result of the detection process is displayed. In this case, the leaf is in category 4 of the LCC, which means the plant requires a certain amount of fertilizer. The application will also display the required volume of the fertilizer that should be applied in the rice field.

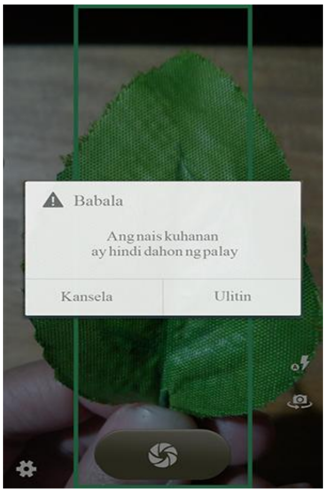


**Fig. 4.Error detection warning for a different leaf with similar color.**

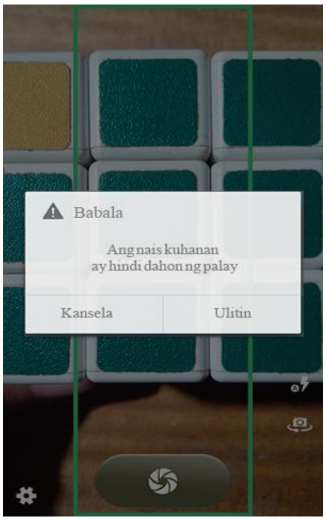


**Fig. 5.Error detection warning for a different object with a green color.**


**Fig. 6.The indicative result when fertilizer deficiency is detected from the rice leaf.**


**Fig. 7.The indicative result when rice the plant is not fertilizer deficient.**

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Fig. 7 shows the result when the processed data from the captured image is within category 5 of the LCC, which means, not fertilizer deficient. The application will display a notification to the user that there is no need for fertilizer to be applied to the rice field.

## B. Actual Field Test Results

The test data were gathered from the five (5) week actual field testing. The process was synchronized with the growth stages of the rice plant, to get the real colors of the rice plant throughout its different growth stages. The Z-test statistic was used to verify and validate the hypothesis that the developed mobile application using the image subtraction technique does not have a significant difference with the traditional LCC.

The field test consisted of a rice field of approximately three hectares. The area was divided equally into three zones (Area 1, Area 2 and Area 3) due to the geographical contours and for an equal number of samples per area sampled. Thirty (30) leaf sample pictures were taken from each area randomly, these thirty samples were also divided into three (3), so that ten (10) leaf samples for each strip one area, for a total of ninety (90) leaf samples each week.

The field test was done from the vegetation and milking stages of the rice plant, giving a total of 450 leaf samples, with an average of 45 samples. During the field tests, the researchers also synchronized the use of the traditional LCC. This was done so that readings are consistent with the LCC due to the leaf's condition for a short time. This is to lessen the effect of other factors like sunlight, moisture, wind, temperature, shading, etc.

Table- 1: The success rates of the system in the field test

| Week | Area 1 | | | Area 2 | | | Area 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***a*** | ***b*** | ***c*** | ***a*** | ***b*** | ***C*** | ***a*** | ***b*** | ***c*** |
| 1 | 6 | 6 | 6 | 8 | 8 | 8 | 6 | 6 | 6 |
| 2 | 6 | 6 | 6 | 8 | 8 | 8 | 6 | 6 | 6 |
| 3 | 6 | 6 | 6 | 8 | 8 | 8 | 6 | 6 | 6 |
| 4 | 7 | 7 | 7 | 7 | 7 | 8 | 9 | 7 | 9 |
| 5 | 7 | 7 | 7 | 8 | 8 | 8 | 9 | 7 | 10 |

a. *$n$ = 45 $\bar{x}$ = 7.08 $\sigma$ = 0.03*

Table 1, shows the success rates readings of the mobile application in comparison to the LCC. The study assumed that the null hypothesis is equal to, Ho = 5, which is the mean success rate of the mobile application and the alternate hypothesis is greater than H1 > 5. To test the hypotheses if the application has no significant difference between the traditional LCC, the z-test statistics is employed.

To compute for the z-test statistic the formula in equation (11) is used. The alpha level considered by defaults is 5% (0.05). The rejection region area in the z-table is 0.05, which is equal to a z-score of 1.645.

$$Z = \frac{\bar{X} - \mu_0}{\sigma / \sqrt{n}} \quad (11)$$

Where:

Z = the test statistic, $\bar{x}$ = mean score, $\sigma$ = standard deviation, $n$ = population, sample, and $\mu_0$ = null hypothesis

Continuing with the computation, the equation is used straightforward. The Z statistic value is then derived in (12):

$$Z = \frac{7.08 - 5.0}{0.03 / \sqrt{45}} = 1.033 \quad (12)$$

Comparing the computed Z-statistic test result score of 1.033 with the z score of 1.645, it shows that the computed Z statistic test score is less than the Z score prescribed in the Z table. This suggests that the null hypothesis is not rejected. Further, the results imply that using the mobile application can be an effective assistive technology for rice farmers and as efficient as the LCC. The accurateness of the system is assured as it has been proven thru statistical analysis that the mobile application does provide significant and similar results compare to the traditional LCC.

# V. CONCLUSION

A mobile application was developed and the proposed method was successfully implemented. The results of the field experiment demonstrated that machine vision can be a tool to assist farmers in detecting the level of nitrogen deficiency of rice plant, by implementing image processing techniques as the mechanism. Specifically, the intelligence of the developed system is the application of the image or pixel subtraction algorithm. By using digitally captured bitmap images with their corresponding RGB numerical formats. This technique was proven to be easily executed as a function in the application, using an android based smart phone.

Field test results suggested that the developed mobile application is comparable to the traditional LCC standard. Meaning, they are complementary with each other or can be used individually without a significant difference in their outputs. Similarly, the statistical test result also implies that machine vision can be used as an assistive technology to rice farmers, specific to the detection of nitrogen deficiency of rice plants presented in this study. The implemented detection algorithm for nitrogen deficiency is accurate and efficient. Future endeavors to include other variables like temperature, time of the day, and age of the plant may be considered for the improvement of the application. To cover a larger area and for faster acquisition of images, an unmanned aerial vehicle is also being considered.

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# Improving SQL Query Response Time thru Client Side Processing in Client-Server Environment

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**Abstract.** Queries executed by a client in the database server were profiled, managed and reused to respond to future subdued queries to be executed in the client. This technique not only reduced the number of queries to be processed by the database and the server but also contributes in decreasing the utilization of network, database and server resources because future subdued queries to be executed that are subdued from the previous executed query were responded locally. Conditions in the query were removed before sending to the database for evaluation in order to increase its effectiveness for its intended purpose. Profiled queries that are subdued by incoming query were purged including its corresponding result set while the incoming query was profiled in the repository. This was implemented as a technique to avoid storing redundant data in the repository as well as to avoid query capability duplication. Tests showed that utilization of a local repository of previous executed queries to respond to a subdued requested query decreased the latency incurred in fetching data both in small, medium and large number of records as compared to a requested query responded by a database and server where the data still travelled thru the network.

**Keywords:** SQL Query, Database, Reusing Result set, Condition Elimination, Query logs, serial scanning.

## 1. Introduction

Query processing in a client-server database system raises the question of where to execute queries to minimize the communication costs and response time of a query, and to load-balance the system [1]. The latency incurred in the processing of a query depend on the server-side and on client-side query processing capabilities [2]. SQL query statement sent by the client to be responded by the server performs some steps before a user may be able to view the requested information. 1. The user formulates query using the application software. 2. The application software connects to the database and submits the query. 3. The database retrieves data and returns these to the user. 4. The application software receives the incoming data, and presents them to the user. These four steps will be repeated from time to time for every query that will be requested. This method constantly utilizes the resources of the database, server and the network. To this end in a recent paper of [3], to reduce the number of queries to be sent by the client to the server, previous queries requested by the client should profiled and reused to respond to a future subdued queries to be requested. Management of the query includes removing the conditions (if there is any) attached to the query before sending to the database for evaluation so as not to affect the number of records to be returned and to enhanced its usefulness to respond to a future subdued queries to be requested. Profiling a query includes the storing of the text of the query and its result set [4]. Every future queries executed by the client subdued to previously executed query will be responded using the repository to speed up the execution time [5] because the request was served locally as compared to sourcing out the data to the original source and travels thru the network [6]. This processed shifted the workload of the database in the server-side to the client-side. Queries that are unable be responded by the latter were fetched its data to the database server which will then be subjected to profiling in the repository.

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## 2. Objectives

The objective of the study is to design an algorithm that will reuse previously executed query to answer future subdued query to be requested. Specifically it aims to;

1. Enhance the ability of the query that are subjected to be profiled.
2. Utilization of the profiled query to answer future subdued query to be requested.
3. Evaluate the performance of the algorithm in responding to a requested subdued query.

## 3. Related Literature

### 3.1. Session-Based browsing for more effective query reuse

Session Based Browsing allows users to access past queries stored in query logs which are the starting point of the users in formulating or writing a query. SQB provides keyword search over a query log. Instead of simply listing all matching queries, it presents the results as a set of query sessions. It allows users to view the result of the query in order to visualize and understand how the query works which eventually serve as the users' guide in formulating a new query [7].

### 3.2. Super rack: reusing the results of queries in MapReduce systems

One of the options to speed up the execution of workflows in MapReduce system is to save the results of the query and reuse them in future if needed. Each workflow can store query result in Super Rack, so incoming query can simply reused them rather than obtaining the data in the original source and employ parsing the query to produced results [8].

### 3.3. Pass-Thru architecture via Hash techniques to remove duplicate query results

First hash index was computed for the first query result from the data source and it passed on to the user. For the second query results, a second hash index will be computed and compared to the first hash index. It will be checked if there is a collision between the first and second index, if the first and second indexes match, then the first data Source is queried for data corresponding to the Second query result. And if the first data Source contains the data, then the Second query result is considered a duplicate and is discarded [9].

### 3.4. Method for presenting database query result sets using polymorpic output format

Database queries are submitted with an indication of a selected output format. To process the query, data records are retrieved and formatted according to the selected output format, as well as formatted for additional output formats supported by a given a query application. Once returned, query results may be presented in the selected format. A user may switch the presentation of the query result from the selected format to others, without having to re-execute the database query [10].

### 3.5. Efficient Server Side Data Retrieval for Execution of Client Side Applications

A system, method and article of manufacture are provided for efficiently retrieving data. A total amount of data required for an application executed by a client is determined. In a single call, the total amount of data from a server is requested over a network. All of the data is bundled into a data structure by the server in response to the single call. The bundled data structure is sent to the client over the network and the data of the data structure is cached on the client. The cache data of the data structure is used as needed during execution of the application on the client [11].

### 3.6. Prefetching Query Results and its Impact on Search Engines

The study proposes offline and online strategies to select and prioritize queries that will potentially benefit from prefetching. The offline strategy relies on the observation that the queries tend to repeat on a daily basis and applies query log mining to identify queries whose results are to be prefetched. The online strategy relies on a machine learning model that predicts the next occurrence time of issued queries. Prefetching operations are then prioritized based on these expected times [12].

## 4. Methodology

### 4.1 Query Condition Elimination

Before a query sent to the database for evaluation, it must have to undergo evaluation to determine the presence of a condition. This condition limits the number of result set to be produced because every record to be returned must passed to the criteria set. Serious drawback for this is, if the result set of the query will be utilized to respond to future subdued queries to be requested because it is capable only respond to subdued queries joined with similar condition. The presence of a where keyword in the query signifies that it contains condition. Performing serial scanning on the text of the query to be profiled was implemented [13]. Serial scanning works by directly searching the presence of a "where" keyword in the query to be profiled followed by elimination including its attributes before sending to the database for evaluation.

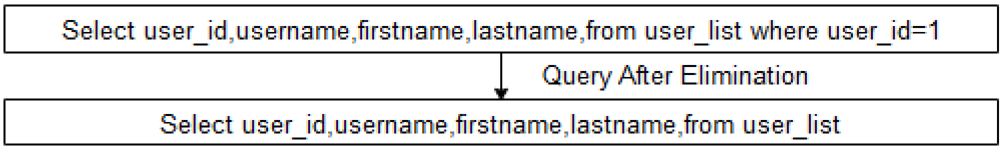


Fig. 1: Shows the state of the query after undergone condition elimination process

### 4.2. Query Profiling

Query Profiling was applied after the query undergone elimination process. A folder that serves as the repository of unique requested query was created to store the text of the query and its result set. A file was created and it will contain the text of requested queries which referred to as the query logs [14]. The result set of the query was exported as text file [15] [16] and it was stored in a row and column patterned on the format replied by the database over the requested query. The uniqueness of the query is determined by comparing the text of incoming query to the text of queries stored in the query logs in terms of their source and the included field. Before the text of the query was registered in the query logs, it was attached with QUERY INDENTIFICATION NUMBER, which is an auto number generated by the algorithm [17]. The generation of QIN number will start to one (1) and progresses sequentially. The same QIN number was used as a filename of the exported result set of the query. The QIN number is used to: 1. Identify the text of the query in the query logs; 2. Identify the result set of the query; 3. Established relationship between the text of the query and its result set and 4. Key to pinpoint who among the profiled queries are capable to respond to the requested query. The query logs was used purposely to respond to queries that are subdued from the past queries. Requested Queries that are unable to be responded by profiled queries was directed to source-out its data to the database and it was deposited in the repository which will become one of the queries to be used as referenced to respond to future queries that will be requested.

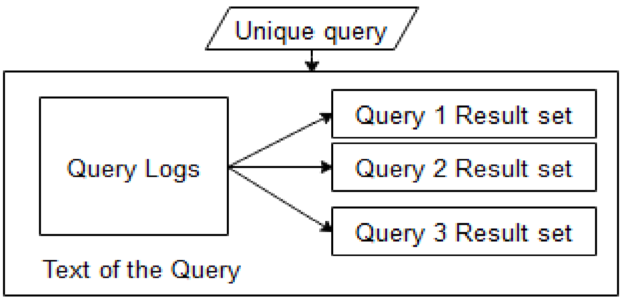


Fig. 2: The text of the select statement of the unique query was stored in the query logs while its result set was exported in the same repository which the QIN establishes relationship between the Query logs and the result set of the query.

### 4.3. Query Purging

Queries that are profiled were subjected to purging if it is subdued by an incoming query. Profiled queries were considered as subdued by an incoming query if they have the same table source and the fields of profiled query are existed in the incoming query. In this scenario the profiled query considered as duplication of the incoming query, so the profiled query/ies were purged while the incoming query was profiled [18]. Purging is a process of deleting the text of profiled query in the query logs including its exported corresponding result set. This technique was implemented in order to avoid query capability duplication because the incoming query contains or has the capability to respond to future queries that can also be served by queries that are already profiled. This way it avoids the redundant storing of query text and its corresponding result set in the repository. So, retained query in the query logs are considered unique and with different capabilities.

## 4.4. Identifying the qualified profiled query

The text of the requested query was compared to the text of profiled queries in the query logs in order to determine who among the profiled queries are responsive to the requirement of the requested query. The responsiveness of profiled query in the query logs is determined by having a similar source to that of the requested query and the field/s in the text of the requested query are existed in the text of the profiled query [19].

## 4.5. Establishing a local and temporary database.

MySQL database were installed in the client side for the purpose of creating table with memory type which were populated with the result set of the profiled query and eventually became the local source of the subdued requested query.

## 4.6. Creating table

After identifying the qualified profiled query to respond to the subdued requested query, a create table statement with memory type was created using the text of the profiled query as bases**.** Then a table name in the create table statement was statically assigned, in the study we named the table as "***qtbl***". The number of fields to be created in the create table statement were depend on the number of fields existed in the identified profiled query and these were renamed as "f1, f2, f3…" which the "f1" signifies as the first field, "f2" as the second field, "f3" as the third field and progresses sequentially are as long as there is/are fields in the text of the profiled query. The fields in the text of the profiled query are found between the "SELECT and FROM statement". Memory type of table was utilized for this purpose to ensure a high degree of performance. After executing the create table statement it results to the creation of a memory type of table in the database then followed by loading the corresponding result set of the profiled query using the attached QIN to the profiled query that identifies the result set of the profiled query [20] [21].

*Assume that the profiled query below was identified and used to respond to subdued requested* query

**select user_id,username,first_name,middle_name,password status from users**

*The create table statement would be;*

**create table qtbl (f1 varchar(30), f2 varchar(30), f3 varchar(30), f4 varchar(30), f5 varchar(30), f6 varchar(30));**

## 4.7. Executing the subdued incoming query

Before a requested query was executed, its field/s and table source were restructured using the text of the identified profiled query as bases. Restructuring is the process of replacing the field/s and table source of the incoming query in order to become identical to the created table. The replacement of its fields was by means of comparing and finding the position or index of the fields of the incoming query in the fields of the profiled query. The newly field/s of the incoming query becomes "f1,f2,f3…" while the table source was the name of the created table in the create table statement.

*Assume that the profiled query below was identified and used to respond to subdued requested query.*

***select user_id,username,first_name,middle_name,password status from users***

*Assume that the query below was requested and subdued to profiled query*

***select user_id, first_name,middle_name from users***

*The restructured query which would be;*

***Select f1,f3,f4 from qtbl***

The field "user_id" in the requested query becomes "***f1***" because it is the first field in the profiled query, the field "first_name" in the requested query becomes "***f3***" because is the third field in the profile query and the field "middle_name" in the requested query as "***f4***" because it is the fourth field in the profiled query.

The same method of replacement were applied for the succeeding fields (if there is any) in the requested query. The keyword after the “from” which is “users” were also replaced by “qtbl” because it is the name of the table used in the create table statement. After restructuring or reconstructing the subdued requested query, execution follows and by this time, the subdued query were directed to source out its data locally. The created table were deleted after the result set of the query has been displayed. This was done in order to prevent and free the memory of the client from storing large amount of information.

# 5. Results and Discussion

## 5.1. Testing query

Seven (7) different queries were formulated and executed in a client-server environment. Three types of sample data consisting of 10,000, 100,000 and 500,000 rows categorized as small, medium and large number record respectively were used in the testing [22][23]. The sample data was downloaded at https://www.sample-videos.com/download-sample-sql.php. The server was installed with MySql and uploaded the downloaded sample data utilizing the interface of phymyadmin. In the client side, each of the queries below were executed eleven times in each category of data using the designed algorithm and the standard way of fetching data in the database server. In the eleven times of execution, the response time of the first execution was excluded because it took longer time to render output due to caching works. The computed averaged response time of the next ten executions (2-11) were taken and served as the response time of each of the query [24] both in the designed algorithm and the standard way of fetching data in the database.

1. Select user_id from user_details
2. Select user_id,username from user_details
3. Select user_id,username,firt_name from user_details
4. Select user_id,username,first_name,last_name from user_details
5. Select user_id,username,first_name,last_name,gender from user_details
6. Select user_id,username,first_name,last_name,gender,password from user_details
7. Select user_id,username,first_name,last_name,gender,password,status from user_details

## 5.2. Order of query execution

Two scenarios were used in the execution of the formulated queries, these are the ascending and descending order of execution. In ascending order of execution, each of the queries were profiled and accepted in the repository because the algorithm treated each of them as different from each other but when the next query comes-in, the previous query was purge while the incoming query was profiled. This is because the profiled query is subdued by incoming query which means the queries that can be responded by the profiled query can also be responded by the incoming query. In this case, only the seventh query which is the “Select user_id, username, first_name, last_name, gender,password,status from user details” retained in the repository. In descending order of execution, the seventh query was executed first, then the next six queries were not accepted in the repository because they are all subdued to the previous query.

Table 1: Average response time (in milliseconds) of execution in ascending order

| **Queries** | **Standard fetching** | | | **Fetching using the Model** | | |
|---|---|---|---|---|---|---|
| | **Small** | **Medium** | **Large** | **Small** | **Medium** | **Large** |
| **1** | 0.103 | 5.403 | 12.521 | 0.085 | 0.783 | 8.0576 |
| **2** | 0.091 | 5.771 | 17.701 | 0.090 | 1.257 | 12.0593 |
| **3** | 0.081 | 6.023 | 13.615 | 0.078 | 1.467 | 13.8807 |
| **4** | 0.095 | 6.307 | 24.287 | 0.069 | 1.734 | 16.5249 |
| **5** | 0.078 | 3.778 | 22.711 | 0.070 | 1.738 | 13.7572 |
| **6** | 0.076 | 7.670 | 43.877 | 0.069 | 4.491 | 31.0488 |
| **7** | 0.081 | 4.468 | 40.402 | 0.054 | 3.941 | 30.1295 |

Table 1 shows the average response time of ten executions using the standard fetching and fetching using the algorithm in ascending order of execution of the queries. In general it is noted that the fetching using the algorithm performs faster compared to standard fetching in all of the categories of data. The average response time incurred by fetching using the algorithm in executing the queries for small number of records is lower by .09 milliseconds as compared to standard fetching which translates to an equivalent of four ten percent (14%) improvement. Furthermore, in medium and large number of records, fetching using the model recorded an average difference of twenty four (24) milliseconds and fifty (50) milliseconds respectively as compared to the standard fetching. This translates an equivalent improvement of sixty percent (60%) for medium number of records and twenty eight percent (28%) for large number of records.

Table 2: Average response time of execution in descending order

| **Queries** | **Standard fetching** | | | **Fetching using the Model** | | |
|---|---|---|---|---|---|---|
| | **Small** | **Medium** | **Large** | **Small** | **Medium** | **Large** |
| **1** | 0.0767 | 8.5508 | 34.2958 | 0.0630 | 4.0252 | 30.4180 |
| **2** | 0.0747 | 7.2726 | 33.0053 | 0.0572 | 4.0436 | 31.0439 |
| **3** | 0.0760 | 1.9033 | 14.4684 | 0.0678 | 1.7616 | 12.2233 |
| **4** | 0.0830 | 1.7654 | 15.2745 | 0.0678 | 1.7665 | 15.2570 |
| **5** | 0.0850 | 1.6573 | 12.3372 | 0.0710 | 1.5170 | 11.2573 |
| **6** | 0.0939 | 1.2940 | 10.3029 | 0.0943 | 1.0974 | 9.9910 |
| **7** | 0.1072 | 0.9288 | 7.60139 | 0.0875 | 0.4311 | 7.22380 |

Table 2 shows the average response time of ten executions using the standard fetching and fetching using the algorithm in descending order of execution of the queries. In general it is noted that the fetching using the algorithm performs faster compared to standard fetching in all of the categories of data. The average response time incurred by fetching using algorithm in executing the queries for small number of records is lower by .09 milliseconds as compared to standard fetching which translates to an equivalent of four ten percent (14%) improvement. In medium and large number of records, fetching using the model recorded an average difference of nine point eleven (9.11) milliseconds and nine point eighty seven (9.87) milliseconds respectively as compared to the standard fetching. This translates an equivalent improvement of thirty nine percent (39%) for medium number of records and eight percent (8%) for large number of records. Furthermore, it is noted that the standard fetching demonstrated a better performance in terms of its response time for the medium and large number of records as compared in the ascending order of execution, however, still did not exceeded the performance of the algorithm.

### 5.3. Failure transparency test

After executing all of the seven queries, the database in the server side were turned off to signify that the database and the server encountered problems which causes the database and database server of being unable to respond to a request. In the client side, all of the seven queries specified in the testing query were executed. As expected, the standard fetching encountered error due to unavailability of the source while the algorithm were still able to respond to the entire request. This is because all of the queries executed are subdued to a previously executed query that is already profiled in the client side, so there is no need to transfer the request to the database via the network, instead it was served locally. This is one of the reasons why the performance of the model outperformed the standard fetching data in all of the categories of data.

## 6. Conclusions

Based on the result of performance testing, it is concluded that the utilization of previously executed query to answer a subdued requested query decreased the response time and cost of processing on the database, database server and network because the data was serve locally as compared to the data that still requesting from server and travels thru the network The dependency of the client to the database server in terms of responding to queries was decreased as the number of query in the query logs increases. The shifting of some of the workloads of the database server to the client prevents the constant utilization of infrastructure such as the database server and network resources by properly utilizing the previously requested information..

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# Hydroponics Reservoir Temperature Monitoring and Controlling System under Greenhouse Condition

**Amy Lizbeth J. Rico**

***Abstract:*** ***An automated reservoir temperature monitoring and controlling system for hydroponic system was developed, calibrated and validated in this study. The automated monitoring and controlling system was developed to monitor and control the reservoir temperature of nutrient solution in hydroponic system. The greenhouse available at the Center for Hydroponics and Aquaponics Technology (CHAT) and locally available materials and hardware for the hydroponics and automation were used in the development of the system. These devices were designed and assembled based on the conceptual framework of the study. The reservoir temperature sensor sends signal to the microcontroller which triggers the turning on/off of water chiller and the mixer. The instruments used were calibrated prior to the performance evaluation and obtained calibration equation for the water temperature sensor is y = x + 0.37. Validation of the automated reservoir temperature monitoring and controlling system was done and the recorded maximum temperature is 31 °C and the minimum temperature is 24 °C. The lettuce planted during the validation has an average height of 14.61 cm and the average leaf count of 12 for the lettuce crops during the 4th week after planting. A total of 4.78 kg of lettuce crop was harvested with an average of 20.6 grams per lettuce crop was obtained. Based on the performance evaluation and validation done on the automated reservoir temperature monitoring and controlling system, it was found to be reliable. This system becomes useful in reducing labor cost, and allows for real-time monitoring of reservoir temperature, therefore increasing farmers' crop productivity and income.***

***Index Terms: automation, greenhouse, hydroponics, reservoir temperature, sensor***

## I. INTRODUCTION

In the present scenario, almost everything can be controlled and operated automatically, but there are still a few important sectors in our country where automation has not been adopted or not been put to a full-fledged use, perhaps because of several reasons such as cost. Agriculture has been one of the primary occupations of man since early civilizations and even today manual interventions in farming are inevitable. Without automation in hydroponics, many growers spend approximately 15-30 minutes a day testing and correcting the system levels. This means that beginning growers will often spend more time on testing parameters until the farmers familiarize themselves with the nutrient levels needed. Also, farmers tend to over-correct one or two of the variables. The automated reservoir temperature monitoring and controlling system keeps the system levels stable and provides the optimal environment for the plants which results to bigger and healthier plants.

Hence, this study is conceptualized to develop an automated system by monitoring the reservoir temperature of the nutrient solution in a hydroponic system for optimum plant growth as this factor can greatly affect the growth of lettuce. Specifically, the study aimed to; (1) install an automated reservoir temperature monitoring and controlling mechanism for the nutrient solution, (2) evaluate the performance of the automated monitoring and controlling device, and (3) determine the response of lettuce on the automated monitoring and controlling device

## II. MATERIAL AND METHODS

### A. Conceptualization of the Study

The conceptual paradigm of the study is presented in Figure 1. The study aimed to monitor and control the reservoir temperature of the nutrient solution using hydroponic system under greenhouse condition. Through this process, time and labor can be saved as well as real time monitoring of the parameters can be achieved.

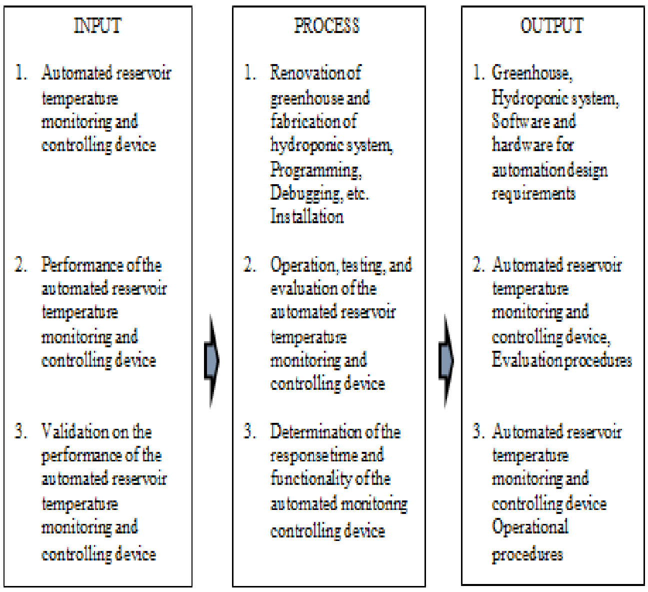


**Figure 1. Conceptual framework of the study.**

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### B. The Production System

The automated hydroponic system used in the study is composed of the structural system, the hydroponic system, and the automation system.The automated reservoir temperature monitoring and controlling was tested in one of the greenhouse facilities located at the Center for Hydroponics and Aquaponics Technology (CHAT) measuring 3.0 meters in width, 4.0 meters in length, and 3.5 in meters height. The frames of the greenhouse are made from 2.54 cm galvanized iron pipes bended and welded together to form a Quonset-type structure. The structure is provided with three roof covers: the insect-proof net in the inner side, the ultraviolet- resistant plastic film in the middle and the gravy woven net shade on the outer side that offers strength and improve aerodynamics to withstand strong wind gust and heavy rains. The available water supply and power supply was used in the operation of the hydroponics system.

The recirculating tube culture system was used in hydroponic system. The hydroponic system was enclosed in the structural system. The grow pipes used was 300.0 cm in length and 0.075 cm diameter. A slope of 1 cm/100 cm of the pipe length was employed for the water to flow through the pipe with ease. The PVC pipes were drilled with 5.08 cm diameter holes and were spaced at 16.5 cm between holes (center to center) and made in 2-layer and 4-column pipe layout. A 150 L reservoir served as the source of water in the hydroponics system where the water was pumped to each growing tubes. The water flow in the hydroponic system was run by a 65-watt submersible pump, 1-2 liters/min flow for each growing tube that lifts the water to the upper layer of the growing tubes. A mixer inside the reservoir was installed to equally dispense the nutrient solution to the reservoir water.

Figure 2 shows the set-up of the automated pH monitoring and controlling device. The automation system served as the main component of the study and was composed of the controls, sensors, and hardware.

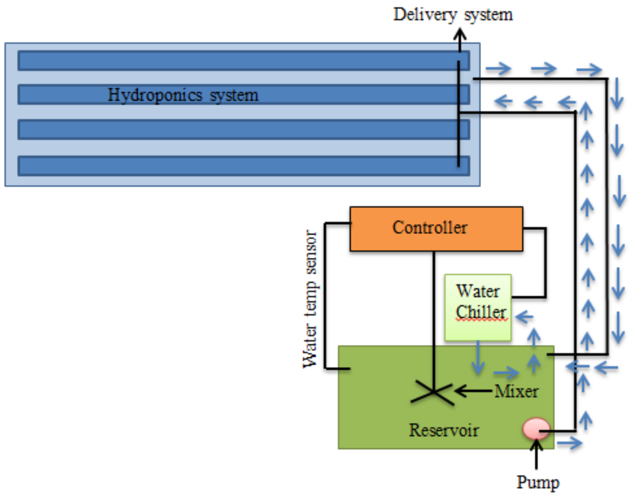


**Figure 2. Set-up of the automated reservoir temperature monitoring and controlling device**

### C. Automation of the Reservoir Temperature Monitoring and Controlling Device

The automated reservoir temperature monitoring and controlling device basically monitor and control the temperature of the nutrient solution in a hydroponic system under greenhouse condition. Sensors were used to determine the reservoir temperature in the reservoir. The block diagram shown in Figure 3 is the layout of the hardware design that was used for the automated monitoring and controlling device. A microcontroller using the Arduino platform was used in programming the automation of the reservoir temperature monitoring and controlling device. Using this data, the microcontroller adjusts the temperature of the water in the system by turning on the mixer and the water chiller

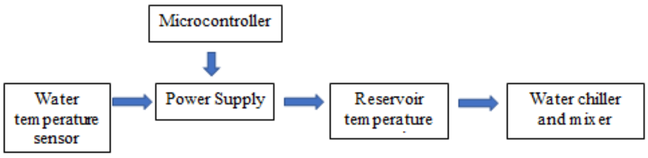


**Figure 3. Block diagram of the automated reservoir temperature monitoring and controlling system**

Shown in Figure 4 is the flow diagram of the automation used in the study. The LCD is initialized when the automation system is turned on. The reservoir temperature range of 24ºC - 30ºC for the nutrient solution was entered in the system. These ranges determine when the chiller and the mixer will be turned on. and determined using the water temperature sensor submersed into the reservoir. If the reservoir temperature reading is above 30ºC , the sensor sends signal to the microcontroller to trigger the chiller and the mixer to turn on. When the entered reservoir temperature range is attained, the sensors send signal the microcontroller to turn off the chiller and the mixer.

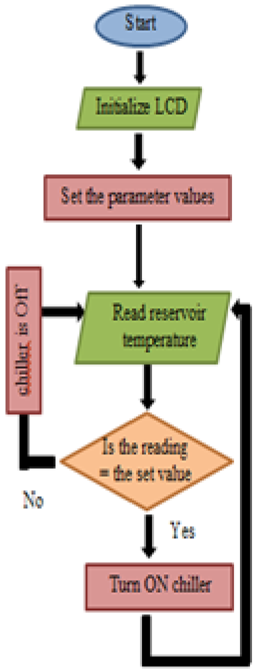


**Figure 4. Flow diagram of the automated system**

### D. Calibration of the Water Temperature Sensor

The water temperature sensor was calibrated in order to achieve precision and accuracy.

The hourly reading for 24-hour period in the sensor was compared with the reading from the calibrated instruments. The difference in reading from the sensor and the calibrated instrument were recorded and graphed. Linear regression of the sensor reading and the calibrated instruments was obtained. The equation from the linear regression was inputted into the program for the water temperature sensor.

### E. Final Testing

The reservoir temperature was monitored every day based on their response to the whole system. Automatic turning on of the device when the parameters are beyond the threshold range, response time of the device to be able to attain the threshold range, and automatic turning off of the devices when threshold range is attained were among the data gathered and recorded.

### F. Lettuce Production

The leafy variety of lettuce (*Lollo rossa*) was used as planting material in the automated hydroponics system as this is commonly used as planting material in hydroponics system. Media composed of carbonized rice hull, sand and rice hull was used as planting media in the automated hydroponics system since these contain most nutrients needed by the plants. The planting cups containing 2-3 lettuce seeds were placed in cups. The cups were placed on individual cut-outs of the growing tubes. The net cups should touch the flowing water in the growing tubes to avoid the plants to be dehydrated. The pump continuously lifts the water and nutrient solution allowing the roots to avail of the nutrients. The reservoir temperature level of the nutrient solution was maintained at a range of 24ºC - 30ºC level which is the recommended reservoir temperature level for lettuce production under hydroponics system. At this reservoir temperature level, the needed nutrients were made available to the lettuce plants. These parameters were maintained throughout the growing stage until harvesting stage of the lettuce. The lettuce was harvested 27 days after planting.

### G. Validation

Validation refers to the process of checking that a system meets the specifications and that it fulfils its intended purpose. In the automated hydroponics system, the data gathered from the final testing was analysed and graphed. The automation system was modified to optimize the production system based on the data gathered. Another growing cycle of the lettuce was planted in the automated hydroponics system. Response of the system was monitored from planting to harvesting of the lettuce. The gathered data during validation was compared from the gathered data from the final testing. The differences from the two growing cycle and their relationship was obtained.

## III. RESULTS AND DISCUSSION

The microcontroller used in the automated hydroponics system is Arduino Mega 2560 which served as the brain of the system and served as the trigger. It also processes the sensor data. Most of the parts were connected to the Arduino using simple jumper wires and the wires were soldered to ensure that they would not get loose. All of the electronic parts were then placed into plastic enclosure to protect delicate electronic parts from dust and moisture.

### A. Installation of the Automated Reservoir Temperature Monitoring and Controlling System for Nutrient Solution

The microcontroller used in the automated hydroponics system is Arduino Mega 2560 which served as the brain of the system and served as the trigger. It also processes the sensor data. Most of the parts were connected to the Arduino using simple jumper wires and the wires were soldered to ensure that they would not get loose. All of the electronic parts were then placed into plastic enclosure (Figure 5) to protect delicate electronic parts from dust and moisture.

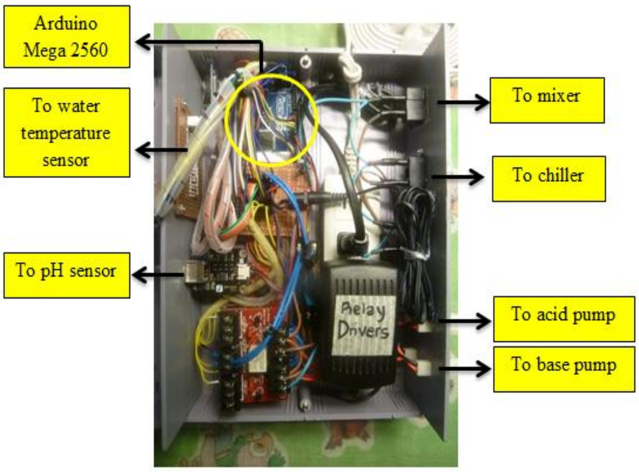


**Figure 5. Electronic parts used in the automated hydroponic system**

### B. Water Temperature Sensor

The DS18B20 water temperature sensor shown in Figure 6 was used to determine the temperature of the reservoir in the hydroponics systems. The water temperature sensor was submerged to the reservoir and sends trigger signals to the microcontroller to activate the chiller thermostat and the mixer in the reservoir.

**Figure 6. The water temperature sensor used in the study**

### C. Calibration of the pH Monitoring and Controlling System

Calibration of the reservoir temperature sensor used was done at the Center for Hydroponics and Aquaponics Technology in a 24-hour period before the data gathering. The reading from the sensor and calibrated instrument was obtained, recorded and graphed.

The graph of the calibration for the reservoir temperature sensor is shown in Figure 7. The graphs show linear relationship between the sensor reading and the instrument reading which also obtained an $r^2$ of 0.84. Based on the data gathered, the calibration equation for the reservoir temperature is $y = x + 0.37$. This equation was inputted in the program for the automation of the hydroponics system.

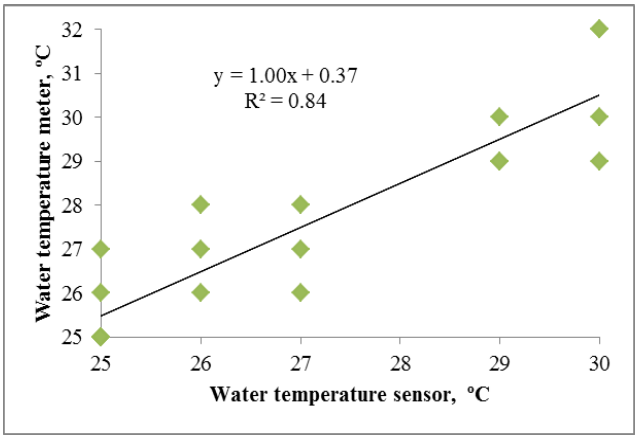


**Figure 7. Calibration curve for water temperature sensor**

### D. Performance Evaluation

Based on the results, the obtained maximum reservoir temperature is 31ºC and minimum is 22ºC. The ability of the system to respond to the set threshold level, the response time of the system to the parameters, and the difference from the calibrated instrument were observed to be able to determine the reliability of the automated hydroponics system. Results showed that turning on of the chiller and mixer when the reading is beyond the threshold range is attained immediately after the reading is beyond the set value in the hydroponics system.

### E. Validation of the Automated Reservoir Temperature Monitoring and Controlling System

During the validation period, the system was observed based on the criteria set for the reservoir temperature of the nutrient solution. Based on the results, the reservoir temperature reading and responses were accepted during the validation. Similar performance of the system during the validation and during the performance evaluation was observed. During the validation of the automated temperature monitoring and controlling system, the growth and number of leaves of the lettuce (test crop) were gathered and recorded weekly and the yield of the lettuce was obtained during harvesting. The lettuce crops obtained a total yield of 4.78 kg and an average of 20.6 grams per crop.

## IV. CONCLUSIONS

Based on the objectives, the following conclusions were drawn:

1. the installed automated reservoir temperature controller was able to maintain the desired condition for the hydroponic system;
2. based on the observed successes and failures in monitoring the reservoir temperature, the performance of the developed automated reservoir temperature controller was found to be reliable, and;
3. the automated reservoir temperature controlling and monitoring device was able to grow lettuce with yield and responses similar to normal growing conditions.

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## AUTHORS PROFILE

The author was born on March 30, 1984 in Camiling, Tarlac. She is the second among the five children of Mr. Carlos O. Rico and the late Mrs. Estela J. Rico. She finished her elementary education at the Camiling West Central Elementary School in 1996 and took secondary level of education at the Tarlac College of Agriculture-Laboratory School, Camiling, Tarlac in 2000. She earned her Bachelor of Science in Agricultural Engineering degree from the University of the Philippines-Los Baños major in Land and Water Resources Engineering and Technology in 2005 and passed the Licensure Examination for Agricultural Engineer the same year. Months after, she was able to work as an Instructor at the then Tarlac College of Agriculture (now Tarlac Agricultural University). In 2009, she decided to pursue a higher degree and enrolled at the Central Luzon State University under the Master of Science in Agricultural Engineering, blessed to be accepted as one of the scholars in the Engineering Research, Development and Technology of the Department of Science and Technology (DOST-ERDT). Through hard work and dedication, she was able to finish her MS degree in 2014. With her goal to further enhance her skills and competencies, she pursued a PhD degree program in Agricultural Engineering at CLSU, again, through the Engineering Research and Development for Technology Scholarship Program of the Department of Science and Technology.