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Modern Technology Techniques for Adoption of Agriculture; An Implementation Review for Developed and Developing Countries Using the CCE Model Approach

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Abstract

The main focus of this paper is to give an introduction review of the modern technology techniques, their value, usage and contribution to better agriculture. In the recent past, the basic agricultural technologies such as machines has changed; as much as the modern technologies, harvesters and planters perform better or are slightly altered from their predecessors. The current US$250,000 combine harvester still cuts, threshes and separates grains as always was being done in the past. However, modern technology is transforming the ways humans operate the machines, GPS Systems Locators, as computer monitoring systems and self-driven software allow advanced tractors and other equipment to be more accurate and economical in the use of fuel, seeds or fertilizer. This study aimed at establishing the value and contribution of using modem technology techniques in the adoption of Agriculture. Content analysis was done on selected developing and developed countries using purposive sampling on the content covered. The data extracted from the content analysis was analyzed quantitatively. It was established that countries that have embraced modern technology in their Agricultural practices have more output in Agricultural production and are more food-stable as opposed to those countries that have not fully embraced the use of modern technology techniques in Agriculture. Therefore, the study concluded that as technology becomes more advanced and complex, in future, there is likely to be a mass production of driverless tractors and other agricultural machinery which will likely be required to make use electronic sensors and GPS maps, requiring less human intervention with greater agricultural output.

Key words: **C**ritique, **C**onfigure, **E**xtend, Modern Technology, Pesticides, Crop Sensors, Gross Domestic Product, Biotechnology and Inorganic Fertilizers

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Introduction

In the recent few years, development measures in agricultural sector and policies have been set in successfully while emphasizing on external inputs so as to increase production of food (Niels & Jules, 2023). Thus, leading to growth in consumption of pesticides, inorganic fertilizer, animal feeds, tractors and other machinery. These and other inputs have been replaced with natural resources with new processes, rendering them less powerful. Pesticides have replaced with cultural and biological methods mainly for control of pests, weeds and diseases. Inorganic fertilizers have best been substituted with manure in composts and nitrogen fixing crops. The main challenge of sustainable agricultural practice is to ensure better use of these internal resources. This will ensure the overall minimizing of inputs used externally, by regenerating internal resources more effectively. It is clearly evident that technologies and practices which are developmental and resources conserving can bring both environmental and economic benefits to farmers, communities and nations (Eva & Matin, 2018).

The modern technologies used in agricultural sector can substantially increase the agricultural production and sustainability. For example, best management practices for advancement of agriculture are extensively used nowadays, (Abdul *et al.,* 2017). New disease resistant hybrids, reduced pesticide use, biological pest control, cultural practices which can reduce the incidence of pests and diseases. Insect-specific chemicals and biological insect controls are now being applied, instead of broad-spectrum pesticides, which actually reduce the number of sprays needed and therefore its capitals. GIS, Crop models and remote sensing can provides information to farmers for attaining precision agriculture, which is done by matching inputs as per all actual yields of different portions on the field. These tools play an important role and also allow the industry to manage land for both agriculture and wildlife. (Rajendra & Sunsanee, 2016)

For increasing food production the evidence comes from some countries of Africa, Latin America, and Asia where farming has been largely untouched by the modern technology (Niels & Jules, 2023). There are three common elements in which these have success. They are using resource conserving technologies like as integrated pest management, soil and water conservation, nutrient recycling, water harvesting and

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waste recycling. Some groups and communities are helping farmers in becoming experts at managing farms as ecosystems; they also have supportive and enabling external government and non-government institutions, which have realigned their activities to focus on local capabilities and needs. Most policies still actively encourage farming that is dependent on external technologies and inputs. (World Bank, 2023).

Objectives of the study

The study will be guided by the following objective:

1. To establish the contribution of modern technology techniques towards the improvements of Agriculture.

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Materials and Methods

Content analysis on selected developing and developed countries was performed to assess the food and agricultural production levels. This was done in respect to the use of Modern technology techniques for adoption of Agriculture. This helps to quantify and analyze the presence of relationships, patterns and concepts (Kathryn Reis, 2023). Purposive sampling was applied in the selection and drawing boundaries for what will be included in the analysis followed by the procedures for extracting a sample of content from the population. This follows an overview of these procedures used in a systematic quantitative analysis (Pavelko *et al.*, 2017)

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Results and Discussions

Modern Agricultural Technology and Machinery Usage

Modern technology and machinery usage in agriculture as employed today is as below with details.

Autopilot Tractors

New GPS tractors and sprayers machines can accurately drive themselves through the field with no drivers. Using Configured onboard computer system, a user draws width of a path a given piece of equipment will cover as he drives a short distance setting A and B points to make a line (Vibhav Mittal, 2018). The GPS system will have a track to follow and it extrapolates that line into parallel lines set apart by the width of the tool in use. The tracking system is tied to the tractor's steering, automatically keeping it on track freeing the operator from driving. This allows the operator to keep a closer eye on other things. Guidance is great for tillage since it eliminates human error from overlapping, saving equipment hours and fuel (Matthew Digman, 2021).

Crop Sensors

Programmed crop sensors will help the use of fertilizer in a very effective manner, maximizing uptake (André & Rob 2018). Sensing how your crop is feeling and reducing potential leaching and runoff into ground water. This is taking variable rate technology to the next level. Instead of making a prescription fertilizer map for a field before you go out to apply it, crop sensors tell application equipment how much to apply in real time. Optical sensors are able to identify how much fertilizer a plant needs based on the amount of light reflected back to the sensor (André & Rob 2018).

Fig 1: Cover Crops, Sensors, and Food Security (*source: Mogoi, OB*)

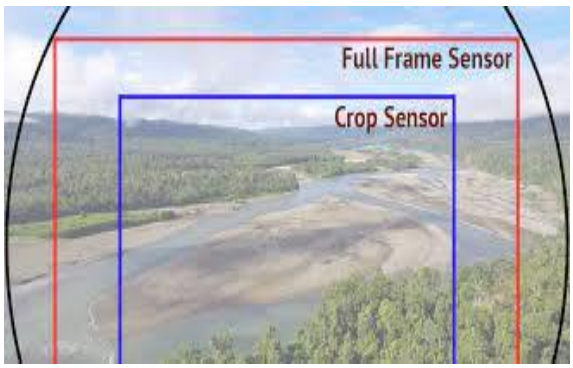

Fig 2: Crop Sensors (*source: Forward-Thinking Ideas for the USDA's Agriculture Innovation Agenda*)

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VRT and Swath Control Technology

Through Variable Rate Technology (VRT) and swath control technology, guidance begins to show returns on investment. Swath control is just what it sounds like. The farmer is controlling the size of the swath a given piece of equipment takes through the field (Vibhav Mittal, 2018). The savings come from using fewer inputs like seed, fertilizer, herbicides, etc. Since the size and shapes of fields are irregular, you are bound to overlap to some extent in every application. The GPS mapping the equipment in the field already knows where it has been and swath control shuts off sections of the applicator as it enters the overlap area. VRT works in a similar fashion. Based on production history and soil tests a farmer can build a prescription GPS map for an input (Vibhav Mittal, 2018).

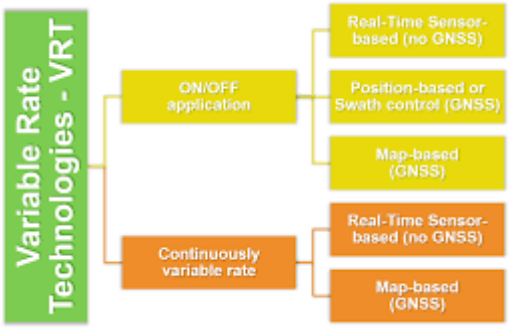

Fig 3: Site-specific management using Variable Rate Technologies (*source: Mogoi, OB*)

Fig 4: Variable Rate Technology (*source: Mogoi, OB*)

Fig 5: SWATH Control *Carnahan & Sons, Inc.*)

Fig 6: Spinner spreaders swath control (*source:*

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Monitoring and Controlling Crop Irrigation Systems via Smartphone

Mobile technology is playing a vital role in monitoring and controlling crop irrigation systems. With this modern technology, a farmer can control his irrigation systems from a phone or computer instead of driving to each field. Moisture sensors in the ground are able to communicate information about the level of moisture present at certain depths in the soil (Leo B., 2023). This increased flexibility allows for more precise control of water and other inputs like fertilizer that are applied by irrigation pivots. Farmers can also combine this with other technologies like VRT to control the rate of water applied (Vibhav Mittal, 2018). Critically. it's all about more effective and efficient use of resources.

Fig 7: Smart Irrigation Technology and System (*source: www.renke.com*)

Fig 8: Smart Irrigation (*source: Mogoi, OB*)

Biotechnology

Biotechnology or Genetic Engineering (GE) is not a new technology, but it is a principal technology with much more potential yet to be unleashed (Hossam S., 2023). The practice of Genetic Engineering that most people have probably heard of is herbicide resistance. Crops can be made to yield toxins which control particular pests. Many employ toxins that are similar to those found in some organic pesticides. It means farmers will not need to make a pass through their fields to apply pesticide (Margarida S., 2023). This not only saves on pesticide, but fuel, wear on equipment and labor too. Another ways to look at it would be that farmers who irrigate their crops can cut back on water use and not see yields suffer. Nitrogen use efficiency is similar to this except you are doing it with fertilizer instead of water (Prabhu G. *et al.,* 2023).

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Fig 9: Plant Biotechnology (*source: www.plantlet.org*)

Fig 10: Applications of Plant Biotechnology (*source: Mogoi, OB*)

Documentation of Fields via GPS

Due to programmed on-board monitors and configured GPS, the power of document yields and application rates are becoming easier and more precise every year. In fact farmers are getting to the point where they have so much good data on hand and able figure out what to do with all of it. The favorite form of documentation of every farmer is the yielding map and it sums up a year's worth of planning and hard work on a piece of colorful paper. These equipment of harvesting roll through the field and they calculate yield and moisture as they go tying in with GPS coordinates (James A. Taylor, 2023). The field is printed when finished with a map of yield. These maps are usually called heat maps. Now the farmers can see the varieties that had the best, worst, or most consistent yield over varying conditions. Maps like these can tell a farmer how well a field's drainage system is working (Kateryna Sergieieva, 2022).

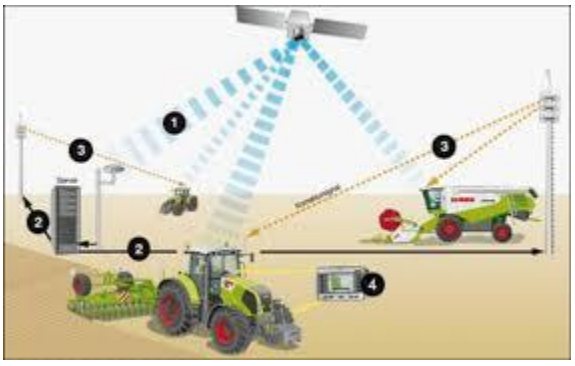

Fig. 11: GPS in agriculture (*source: Mogoi, OB*)

Fig. 12: GPS-controlled Optical plant growth (*source: Mogoi, OB*)

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Ultrasounds for Livestock

Ultrasound is not only for checking on baby animals in the womb, also can be used to discover what quality of meat might be found in an animal prior to going to the market (Jamie Lynn Stewart, 2022). Testing of DNA helps producers to identify animals with good pedigrees and other desirable attributes. For improving the quality of the herd, these information can be used to help the farmer to improve quality (Alexandre G. *et al.,* 2021).

Fig. 13: Animal Biotechnology (source: www.whichcollege.ie)

Fig. 14: Veterinary Ultrasound Scanner Kit (source: WOERD)

Usage of Mobile Technology and Cameras

Mobile technology and cameras are playing a big role for farmers and ranchers are using all the social media sites for all types of reasons. Some are using apps like foursquare to keep tabs on employees. Putting up cameras around the farm is a new trend catching on. Livestock managers are securing their barns, feedlots and pastures with cameras that send images back to a central location like an office or home computer in real-time. They can keep a closer eye on animals when they are away or home during the night.

Fig. 15: IoT in agriculture (*source: Mogoi, OB*)

Fig. 16: Real-time farm monitoring (*source: Mogoi, OB*)

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Table 1 below shows Ten Countries African using Modern Agricultural Technology with Agricultural Outputs in 2021 with GDP in million USD.

Table1: Africa's Top 10 most food-secure countries (*source: IOA*)

#	Country	ACBR Food security score
1	Tunisia	68.20
2	Mauritius	67.33
3	Morocco	64.38
4	Algeria	63.86
5	Egypt	60.03
6	Gabon	58.81
7	South Africa	57.88
8	Ghana	53.57
9	Senegal	52.16
10	Namibia	51.42

Table2: Top 5 Agricultural Producing Countries in the World (*source: Our World in Data*)

Country	Exports (in billions)
United States	$118.30
Netherlands	$79
Germany	$70.80
France	$68
Brazil	$55.40

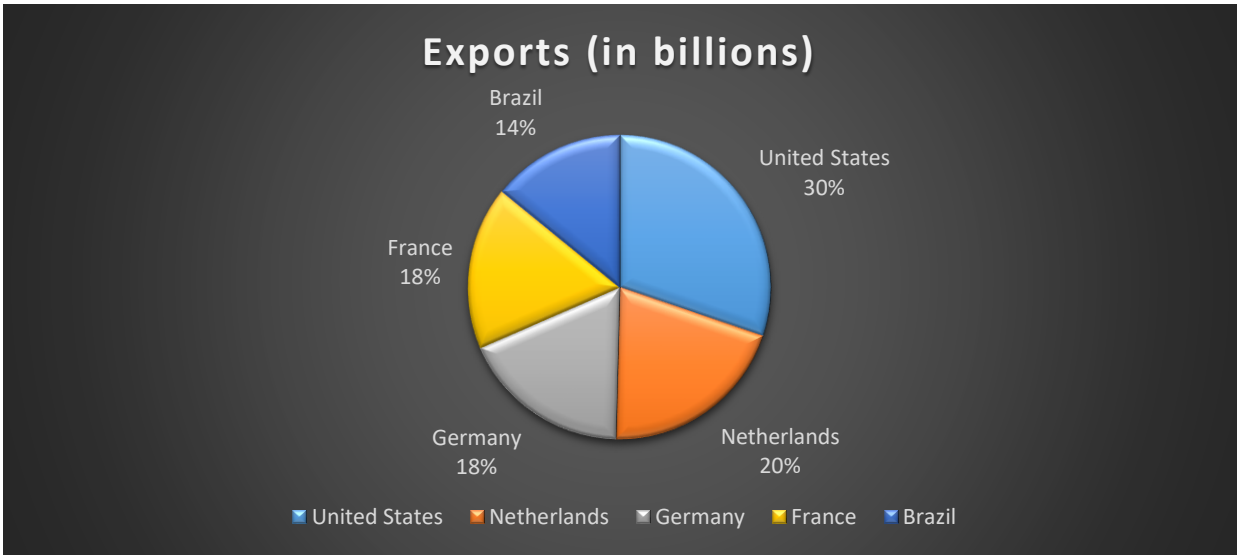

Fig 15: Top 5 Agricultural Producing Countries in the World (*source: EarthDaily Agro*)

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Table3: Top 6 Staples Export in the World (*source: Visual Capitalist*)

Commodity	Leading country	% of Global Exports
Corn	United States	26% ($7.6 billion)
Fish	China	9.2% ($6.6 billion)
Palm Oil	Indonesia	51% ($10.4 billion)
Rice	Thailand	34.5% ($6 billion)
Soybeans	United States	50.5% ($16.5 billion)
Wheat	United States	18% ($5.4 billion)

Conclusion

Modern agricultural technology has been developed with keeping two important things in mind: first thing is to obtain the highest yields possible and second thing is to get the highest economic profit possible. To achieve these goals, six basic and important practices have come to form the backbone of production in agriculture: application of inorganic fertilizer, irrigation, intensive tillage, monoculture, chemical pest control and enatic manipulation of crop plants. Autopilot tractors, crop sensors, VRT and swath control technology, monitoring and controlling crop irrigation systems via smartphone, documentation of fields via GPS, biotechnology and ultrasounds in livestock as the backbone in production and its use for its individual contribution to productivity. All these combined are promising much less-human-intervened Agriculture with maximum agricultural output. The CCE Adoption Model principles in the use of Technology include Critique, Configure and Extend. Using the three CCE Model key principles in the use and implementation of Technology in any field, the diagram below summarizes how technology can be applied in Agriculture for maximum production.

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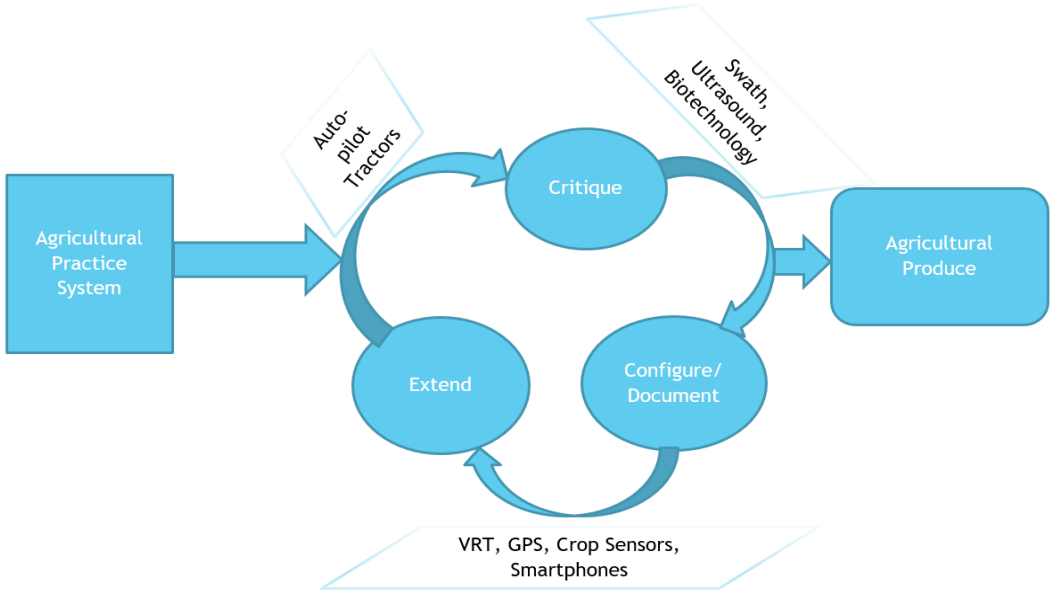
- The Agricultural Production Practice Model (CCE)



Recommendations

It is recommended that as technology is becoming more advanced and complex, countries, governments, both private and public corporations should modernize their practice in agriculture and use of modern technology to improve on agricultural outputs. For food stability to be achieved, use of modern technological techniques is inevitable. This study also recommends further research on the use technology in farming and agriculture, impact and their relevance.

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