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Research Article

Smart and Efficient Value Chain in Agriculture by Digital Transformation A digitally enabled and tech driven transformation of the Agriculture value chain

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ABSTRACT

The digitalization of farming is expected to greatly help in addressing major sustainability challenges. A framework for the agricultural value chain has been developed, incorporating 512,678 datasets of various crops. The temperature and humidity data of 345,336 crops are being analyzed. The main goal of this paper is to improve the agricultural supply chain, particularly focusing on cotton farming. It will also provide a detailed analysis of the entire process of food production and distribution from farms. In simpler terms, the paper aims to understand how cotton is grown and distributed, and what challenges are faced along the way. Data from 201 different regions in India collected using sensors measuring moisture and temperature. This shows that cotton irrigation needs a moisture content of 62.9% and a temperature of 27.75°C. Data from 345336 datasets on Kharif and Rabi crops from different districts in India indicate that Kharif crops thrive with a humidity of 50-70% and a temperature of 25-35°C. Any deviation from this temperature range can affect crop growth.

Keywords: *Supply Chain Management (SCM), Internet Of Things (IOT), Radio Frequency Identification (RFId), Wireless Sensor Networks (WSN)*

I. INTRODUCTION

In India, many people work in farming, which is very important for economy. However, even though a lot of people are involved in farming, it doesn't make up a large part of the country's total income [1]. India is the second-largest producer of food from farming, which is impressive. But when it comes to exporting food to other countries, India only contributes 0.2% of the world's total food trade. This is very low compared to other developing countries like Vietnam and Brazil, which have much bigger parts in global food trade[2][3]. Improving the whole process of producing and delivering food products is very difficult without enough information [4]. Many important people and companies, like farmers, processors, and transportation workers [5], are involved in this process [6] [7]. This research can be split into different parts: a basic explanation of how the food supply chain works and the rules that affect each part of it. A literature review is a summary of all the research studies on a specific digital transformation. The suggested methods of this paper are using both quantitative (numbers) and qualitative (descriptions) to get a complete understanding of the digital transformation [8] [9] [10]. The IoT is seen as very important for improving supply chains [11] [12]. In this paper, it has been discussed that how IoT can affect supply chains. Supply chain management and how companies can use their resources to perform better than their competitors. This plan is called the resource-based view theory [13] [14]. The use of the Internet of Things (IoT) to enhance supply chains is the primary focus of this paper. There are five sections in this paper. The introduction is discussed in the first section. The background and related work are discussed in the second section. The methodology is discussed in the third section. The result and discussion are discussed in the fourth section. The section that deals with the conclusion is the last.

II. RELATED WORK

A lot of research (162 studies) have occurred to understand the Digital Transformation. This research found five important abilities that supply chains need: working together, being innovative, connecting different parts, having good quality, and being able to see what's happening. Five big challenges for supply chains: dealing with a global market, facing competition, quickly adapting to market changes, ensuring supply meets demand, and meeting demanding customers' needs. Using the resource-based view theory in our study helped strengthen the supply chain. Identified four major advantages for supply chains: being reliable, being flexible, being able to see what's happening, and being fast. To make sure our plan was good; other experts reviewed it and agreed with our findings from the research by Ben Daya et al [11]. Using IT (Information Technology) in the supply chain can help a company make the most of its IT resources [15][16] that how companies can use IoT to handle the problems they face. Not enough research has been done on understanding and dealing with supply chain challenges and abilities. So, the main goal of this paper is to introduce, explain, and discuss these important ideas in supply chain management. This research is about supply chain management in general, not about a specific company. The Internet of Things (IoT) can make better and more efficient, giving the supply chain a better chance to compete with other companies. Using the resource-based view theory, we believe that the supply chain becomes stronger with the help of IoT and its supporting technologies [17] [18] [19]. This paper aims to address challenges in supply chain management, such as competition, rapidly changing markets, globalization, matching supply with demand, and dealing with demanding customers [20][21][22][22][23]. SCM (Supply Chain Management) capabilities help create advantages in supply chain management, such as making sure everything works smoothly and is dependable [24]. Resilience means the ability to recover quickly from difficulties or tough situations, like being strong and flexible enough to handle tough times and come back even stronger [25]. Traceability means being able to track something, knowing where it came from or where it's going, like having a clear map that shows the whole journey of something from start to finish [26][27]

III. METHODOLOGY

To fully understand a market system, it's important to use a value chain approach. This means looking at all the businesses involved in the industry, from those providing materials to those selling the final products. It also includes the markets that offer specialized services to the industry and the overall business environment. The market system and its environment can have barriers that affect competitiveness, so it's necessary to analyze the industry broadly. If these obstacles are not recognized and addressed, any efforts to improve the situation may have limited or negative effects. The goal is to achieve sustainable economic growth and reduce poverty. To do this, interventions in the value chain should be based on this end goal. For example, focusing on specific parts of the value chain or certain groups of recipients (like small-scale producers) requires careful planning within the overall value chain and a clear focus on benefits for those involved. The value chain and the supply chain are similar ideas, but they focus on different things. The supply chain is about getting materials and selling products for individual companies, usually led by big companies. It's mostly a business management tool. In contrast, a value chain is a special kind of supply chain where the companies involved know each other well and have long-term relationships. They work together to be more efficient and competitive, helping each other to meet customer needs and increase profits.

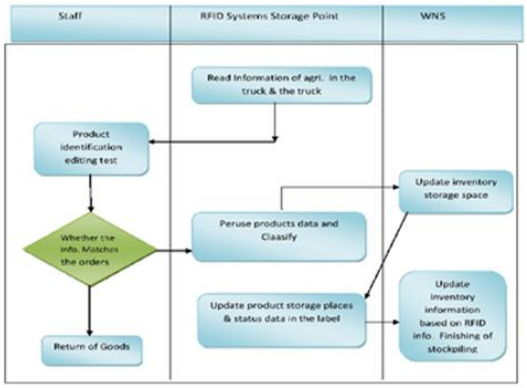

Fig 1: Framework for value chain in agriculture

Figure 1 shows a system of sensors used to monitor and track different things on the Internet of Things (IoT). These sensors have many uses, like measuring temperature, flow, level, taking images, detecting noise, air pollution,

proximity, infrared, moisture, humidity, and speed. In Wireless Networks Sensor (WNS), these sensors work as nodes connected through wireless networks to send the measured data. RFID is a technology that lets machines and computers identify objects using radio waves to record information about them. When RFID readers are connected to the Internet, they can automatically identify, track, and monitor tagged objects worldwide in real-time. RFID is important for the IoT because it allows connecting objects to the web cheaply. Inventory management involves controlling the inflow and outflow of stock, as well as maintaining and managing that inventory. Return of goods refers to a transaction where the buyer sends items back to the seller.

A. Cost analysis methodology to test the Analytical model

In the market, people have faced both challenges and opportunities due to the global economy growing and changes in different industries. To succeed and make the most of these situations, it's important to improve and stay ahead of the competition. Companies can do this by creating and using a good plan to be better than others. The concept of "competitive advantage" comes from traditional strategies developed by Watchman [28]. To be successful, companies need to compete in different areas, like offering low prices, unique products, and focusing on customer needs. To do this, they need a good system that provides accurate information about costs. This helps management make smart decisions about using technology and improving the business to gain an advantage over other companies [29].

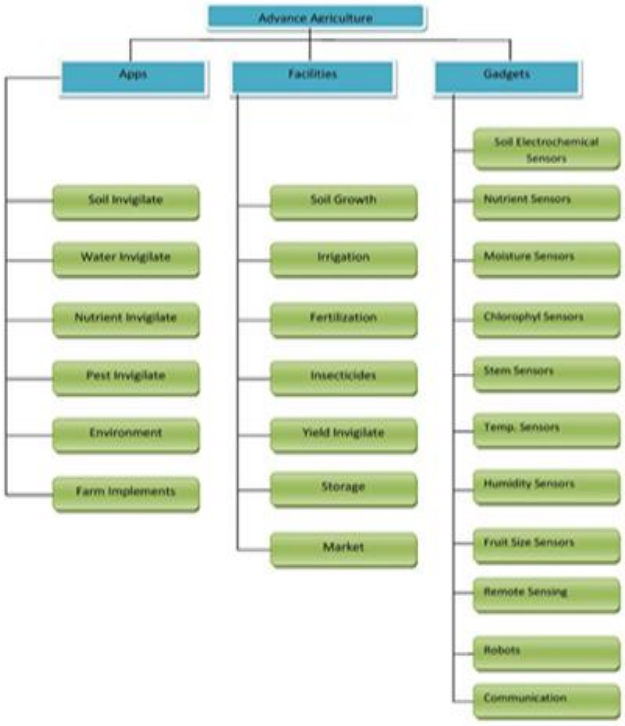

Fig 2: Flowchart of Advance Agriculture System

Figure 2 discusses the Advanced Agriculture System using Internet of Things (IoT), which allows devices to connect remotely to achieve smart farming. The IoT is now impacting many industries, such as healthcare, business, communications, energy, and agriculture. Its goal is to improve efficiency and performance in all areas of business. For plants to stay healthy, several factors come into play, like soil moisture, nutrients, light, humidity, rainfall, and even the color of their leaves. To ensure plants are doing well, we carefully monitor the amount of light and temperature they receive. We also provide them with water and energy through a small irrigation system. This is where various sensors come in. These sensors can detect different conditions and changes. The value chain works in three stages: upstream, activity, and downstream. It helps create extra value for the industry. When we do a value chain analysis, we can identify different steps in the process where the business can improve things for customers and reduce costs. This helps the business become more competitive and successful.

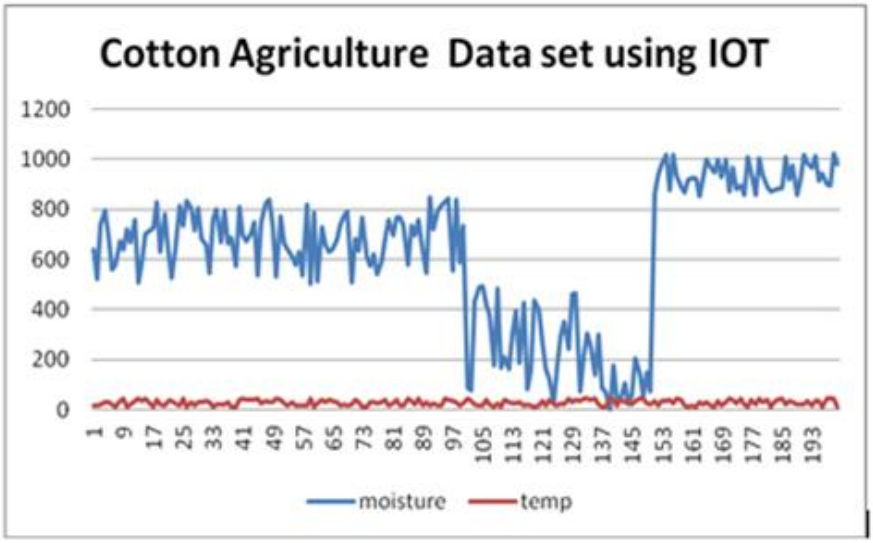

Fig 3: Need of moisture and temperature in cotton crop

Figure 3 shows the importance of moisture and temperature in cotton farming in Advanced Agriculture System using Internet of Things (IoT). The main goal of this system is to provide automatic watering. The idea is to keep farmers happy by automatically supplying water based on their crops' needs. Devices are Arduino board, a soil moisture sensor, a DHT11 sensor, and NodeMCU. machine learning algorithms is used to find out how dry the soil is and to predict the water needs for the next watering cycle, as well as to predict when to turn the pump on and off for easy access[30][31][32][33]. For subjective indicators, we can use a method to grade them into five levels: A (excellent), B (good), C (average), D (fair), and E (poor). Then, we assign scores to each grade: A gets 100, B gets 80, C gets 60, D gets 40, and E gets 20. Experts use the Delphi method to calculate scores for each level using scores given by all the experts. The formula for calculation is: 100fa+80fb+60fc+40fd+20fe, where f equals the number of experts who gave a grade divided by the total number of experts.

X	X=X/8	Y	Y/X^2	$1/X^2$	$1/X^4$
8	1	12	12	1	1
11	1.4	8	4.08	.5102	.2603
13	1.6	7.3	2.85	.3906	.1526
19	2.4	6	1.04	.1736	.0301
21	2.6	6.2	0.93	.1479	.0219
27	3.4	5.8	.50	.0865	.0075
29	3.6	5.2	.40	.0772	.0060
Total:	-	50.6	21.80	2.3860	1.4784

Table 1. Calculation of cotton cost and productions

We need to calculate $\sum y$, $\sum y/x^2$, $\sum 1/x^2$, and $\sum 1/x^4$. We use Table 1 for these calculations. The equations that describe the relationship between output and cost are determined. It is found that as the output increases, the cost stabilize around the value is 4.9. If the experiment results show that as X increases, the dependent variable Y decreases quickly, it is useful to use a third-order hyperbola equation to smooth the data series. The dataset has detailed information about crop production in India, organized by state and region. It includes data for four main crop seasons: kharif, rabi, summer, and autumn, from 1997 to 2023. The data shows how much crop is produced and how much yield is obtained each year in different areas. This information is useful for experts, policymakers, and farmers who want to understand crop production patterns across India. By studying the data, experts can figure out what affects crop yields and production, which helps them make better decisions to boost farming productivity in the country.

B. *Establish evaluation index set*

The green supply chain performance evaluation system has three levels: high, medium, and low. We set the top-level indicators as P, which include P1, P2, P3, P4, and P5. Each top-level indicator (P1, P2, P3, P4, P5) has its own set of medium-level indicators: P1 = {P11, P12, P13}, P2 = {P21, P22, P23, P24, P25, P26, P27}, P3 = {P31, P32, P33, P34, P35}, P4 = {P41, P42}, and P5 = {P51, P52, P53}. The low-level indicators can also be detailed further, such as P11 = {P111, P112}. P12={P121,

P122, P123}

C. *Establish the weight coefficient matrix*

If X has a weight of W and I equals 1, 2, 3, 4, and 5, then the first-order weight set is as follows: W is equal to (R1, R2, R3, R4, R5). Let the weight coefficient of the second-level index Xij be Wij = (Rij|i= 1, 2, 3, 4, and 5; j=1, 2, ..., Gi). It is as follows:

R1= {R11, R12, R13}

R2= {R21, R22, R23, R24, R25, R26, R27} R3= {R31, R32, R33, R34, R35}

R4= {R41, R42}

R5= {R51, R52, R53}

Similarly, the third-level index set can be obtained as follows: R11= {R111, R112}

R12= {R121, R122, R123} .....(1)

R54= {R541}

The weight factor judgment strategy is a technique used to decide how important different factors are. It measures people's opinions about the importance of each factor. This method is simpler and easier to use compared to other methods like AHP. First, a group of 20 experts, including supply chain researchers and management professionals, is chosen. They fill out a judgment table to record their opinions about the factors. Then, experts are asked to evaluate and fill in a form to give their opinions about the importance of each factor. They use a 5-point scale, where the most important factor gets 5 points, the next most important gets 4 points, and so on. Finally, the experts' scores are analyzed to understand the overall importance of each factor.

Equation 2 and 3 shows that cotton irrigation needs a moisture content of 62.9% and a temperature of 27.75°C. Data from 345336 datasets on Kharif and Rabi crops from different districts in India indicate that Kharif crops thrive with a humidity of 50-70% and a temperature of 25-35°C. Any deviation from this temperature range can affect crop growth.

(2) Find the average score of the evaluation indicators:

$Vi = \sum_{n=1}^{N} H\text{in}/N$ ---------- (2)

Where N is the total number of experts.

(3) Calculate the weight value of the evaluation index:

$Wi = V\text{i}/\sum_{1=1}^{Gi} V\text{i}$ ---------- (3)

IV. RESULT AND DISCUSSION

Many factors can greatly affect the value chain ecosystem. Different measurements are important for understanding where the value chain can be improved and how well it works overall. For the value chain ecosystem to be successful, all must work together and integrate effectively. Better coordination, faster decision-making, and shared goals, made possible by efficient information flow and communication, are all direct results of increased efficiency. Efficiency in the value chain ecosystem can only be increased through widespread use of automation and technology. We looked at the assurance coefficient (R2) and the method coefficient, along with their p-values. The R2 values for the three factors we studied (supply chain flexibility, performance, and willingness to adopt AI) show that our model provides good information (ranging from 0.236 to 0.404). The hypotheses we proposed are mostly supported by the results.

In particular, the findings show a significant positive connection between the use of artificial intelligence and the benefits of AI technology, supply chain collaboration, and environmental resilience. With p-values below 0.01, these relationships were statistically significant. Therefore, the results strongly support our hypotheses (Hypotheses 1-3). With statistically significant coefficients and p-values less than 0.01 or 0.001.

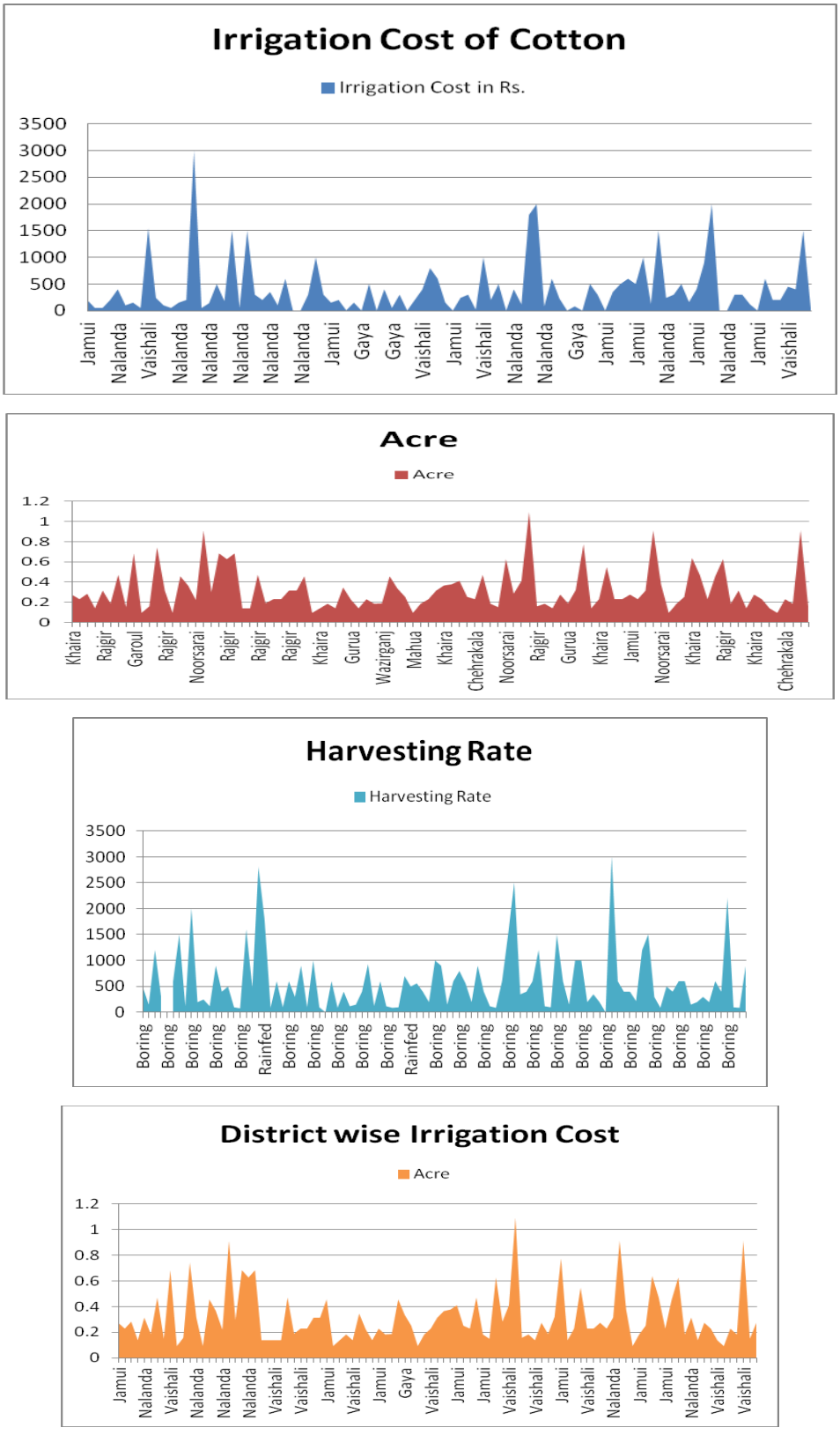

Fig 3: Cotton Irrigation Cost after and before Digital Transformation

V. CONCLUSION

This paper takes a close look at research on the agricultural supply chain, particularly focusing on cotton farming. In simple terms, it will examine past studies related to principles and methods concerning cotton cultivation. A thorough examination of the agricultural supply chain and various issues related to different aspects of agricultural production will be conducted. Data from 201 cotton fields in various Indian regions were collected using sensors that measure moisture and temperature. For cotton irrigation, it's important to have a temperature of 27.75 degrees Fahrenheit and a moisture content of 62.9 percent. By analyzing 345,336 datasets of crops grown during the kharif and rabi seasons from different districts of India, we found that kharif crops thrive in temperatures between 25 and 35 degrees Celsius and have optimal humidity ranging from 50.1 to 70.2 percent. Temperature plays a significant role in crop growth.

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