



## A Comparative Study of Traditional Farming and AI-Based Farming A Statistical Analysis

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**DOI - 10.5281/zenodo.18898920**

### **Abstract:**

*Both food security and economic growth depend heavily on agriculture. Artificial intelligence has become a revolutionary instrument in contemporary farming methods due to the quick development of technology. A descriptive and statistical comparison of AI-based farming systems and conventional farming is presented in this work. Crop yield, fertilizer and water use, labour productivity, economic performance, and environmental sustainability are the main topics of the examination. When compared to conventional approaches, AI-based farming dramatically increases production, resource efficiency, and profitability, according to data gathered from farms operating under comparable climatic conditions across two agricultural seasons. The results highlight how crucial it is to implement data-driven farming methods in order to guarantee future food supply that is sustainable.*

### **Introduction:**

One of the world's oldest and most significant economic sectors, agriculture employs between 27 and 30 percent of the world's workforce and plays a major role in rural livelihoods and food security. Agriculture is the foundation of many emerging nations' economies, accounting for 15 to 25 percent of GDP. Traditional agricultural techniques, which rely on human expertise, natural rains, manual work, and simple instruments, have been used for generations. Climate change, water shortages, soil degradation, rising input costs, and increased food demand are all posing challenges to traditional farming, which has supported people for generations. Global agricultural projections indicate that in order to fulfil the demands of the expanding population, food production must rise by around 60–70% by 2050. However, low productivity and wasteful resource consumption are common outcomes of conventional farming practices. According to studies, cereal crop yields

on conventional farms usually range from 3,000 to 3,800 kg per hectare, depending on the climate and farmer skill. Furthermore, the average amount of water used in typical irrigation methods is about 6,500–7,500 liters per hectare, much of which is lost to evaporation and over-irrigation. Additionally, fertilizer is applied uniformly in traditional farming, which wastes nutrients and pollutes the environment.

Artificial Intelligence (AI)-based farming has been a ground-breaking solution to these problems in recent years. Soil sensors, drones, satellite imaging, machine learning models, and automated machinery are some of the technologies used in AI-based farming to gather and process data in real time. This makes it possible for farmers to make accurate choices about harvesting, insect management, fertilizer, and irrigation. Data-driven agricultural systems have been shown to increase yields by 30–40% while cutting fertilizer and water use by 20–25% and 35–45%, respectively. For instance, AI-

assisted precision irrigation systems greatly increase water-use efficiency by only applying water when soil moisture levels drop below ideal thresholds.

**Objectives:**

1. This study's main goal is to compare traditional farming with AI-based farming in a thorough descriptive and statistical manner.
2. The study's objectives are to examine variations in agricultural output, labour needs, resource use, cost effectiveness, and environmental impact.
3. The study also aims to assess if AI-based farming has long-term ecological and economic advantages despite its greater initial cost.

**Hypotheses:**

1. Hypothesis 1: Because AI-based farming employs data-driven and precision agriculture methods, it yields substantially more crops than traditional farming.
2. Hypothesis 2: Compared to conventional farming practices, AI-based farming makes better use of water and fertilizer.

**Research Methodology:**

The study uses a data-driven, comparative methodology. Ten farms in comparable agro climatic regions provided the data, five of which used traditional farming methods and five of which used AI-based farming methods. To guarantee dependability, the study included two whole farming seasons. Due of their extensive cultivation, crops like wheat and maize were chosen. Agricultural research articles provided secondary data, whereas farm records, sensor readings, and field observations provided primary data. The data was analysed using statistical

methods like mean, standard deviation, percentage change, and t-tests.

**Analysis & Discussion:**

Crop yield study shows that the two agricultural strategies differ significantly. AI-based farming produced an average yield of almost 4,800 kilograms per hectare, compared to an average of roughly 3,500 kilograms per hectare in traditional farming. AI-enabled precision agricultural methods like ideal sowing timings, real-time nutrient monitoring, and early disease identification are responsible for this roughly 37% rises. Additionally, yield variability was lower in AI-based farms, suggesting higher stability and decreased risk for farmers. Patterns of water use reveal a stark difference between the two methods. Due to set irrigation schedules and a lack of soil moisture evaluation, traditional farming used an average of 7,000 liters of water per acre. By using sensor-based irrigation systems that only provide water when needed, AI-based farming, in contrast, used about 4,200 liters per hectare. This indicates a roughly 40% reduction in water use, demonstrating the efficiency of AI in preserving vital natural resources. AI-based farming was also proven to use fertilizer more effectively. Fertilizers were administered consistently throughout fields on traditional farms, which resulted in overuse and nutrient runoff. AI-based farming only needed 190 kilograms of fertilizer per acre, compared to an average of 250 kilos for traditional farming. AI-based farms produced higher yields despite using less fertilizer, indicating better soil health management and increased nutrient-use efficiency.

From an economic standpoint, the initial costs of AI-based farming were greater because of the investment in software, hardware, and technology. Compared to USD 950 for conventional farming, the total cost per hectare

for AI-based farming was almost USD 1,300. However, AI-based farms made much more money thanks to improved market quality and higher yields. A net profit of USD 250 was produced by traditional farming, which brought in an average of USD 1,200 per hectare. On the other hand, AI-based farming produced a net profit of USD 600, or around USD 1,900 per hectare. This shows an almost 140 percent increase in profit, demonstrating the long-term financial sustainability of AI-based farming. The supremacy of AI-based farming is further

supported by environmental sustainability measures. Due to overuse of pesticides and fertilizers, traditional farming had higher levels of chemical runoff and soil deterioration. In contrast, AI-based farms reduced the use of chemicals by using predictive analytics to identify insect infestations early. In addition to having higher soil organic matter content and biodiversity indicators, AI-based farms also had far lower carbon emissions because of better machinery usage and less input waste.

### Crop Yield Analysis:

**Table No. 1 Crop Yield Analysis (kg/ha)**

Sr. No.	Statistic	Traditional Farming	AI-Based Farming
1	Mean	3,500	4,800
2	Median	3,450	4,850
3	Minimum	3,100	4,400
4	Maximum	3,900	5,200
5	Standard Deviation	280	310
6	Coefficient of Variation (%)	8.00%	6.50%

**(Researcher compilation and statistical analysis)**

AI-based farming performs better overall because its mean value is higher than that of traditional farming. Additionally, the median indicates that the majority of farmers that use AI get better results. AI-based farming has a far higher minimum value, indicating lower risk and improved security. Due to uncertainty and inefficiency, traditional farming has lower minimum performance. AI-based farming's highest value suggests a higher potential for profitable outcomes. The upper performance

range of traditional farming is constrained. The standard deviation of AI-based farming indicates somewhat higher absolute variability. However, the coefficient of variation shows that AI-based farming has less relative variability. This suggests that even while AI-based farming produces more, it is more reliable and consistent. In terms of productivity, dependability, and sustainability, AI-based farming generally performs better than conventional farming.

**Water Usage Efficiency Analysis:****Table No. 2 Water Consumption (Liters per Hectare)**

Sr. No.	Statistic	Traditional Farming	AI-Based Farming
1	Mean	7,000	4,200
2	Median	6,900	4,150
3	Minimum	6,300	3,800
4	Maximum	7,600	4,600
5	Standard Deviation	420	290
6	Water Saving (%)	—	<b>40%</b>

**(Researcher compilation and statistical analysis)**

Traditional farming uses more water on average than AI-based farming, as indicated by the higher mean value. Additionally, the median demonstrates that conventional farming continuously uses more water than AI-based farming. According to the minimum value, AI-based farming uses less water than traditional farming, even with the lowest water use. Precision irrigation methods enable AI-based farming to achieve lower minimum water use. Excessive water use during peak times is reflected

in the maximum value of traditional farming. AI-based farming, on the other hand, efficiently regulates water application, restricting maximum usage. AI-based farming has reduced variability, which is indicative of improved monitoring and regulation. AI-based farming's 40% water savings demonstrates how effective it is at conserving resources. All things considered, AI-based farming greatly increases water-use efficiency and advances sustainable agriculture.

**Fertilizer and Input Optimization (Fertilizer Usage (kg/ha)):****Table No. 3 Fertilizer and Input Optimization (Fertilizer Usage (kg/ha))**

Sr. No.	Parameter	TF	AIF
1	Average Fertilizer Used	250	190
2	Reduction (%)	—	<b>24%</b>
3	Yield per kg Fertilizer	14 kg	25 kg

**(Researcher compilation and statistical analysis)**

AI-based farming uses less fertilizer on average than traditional farming. By applying fertilizer precisely and according to need, AI-based farming reduces fertilizer use by 24%. Farmers can lower their output costs by using less fertilizer in AI-based farming. In conventional farming, overuse of fertilizer frequently results in nutritional imbalance and soil deterioration. AI-based farming uses data and real-time monitoring to optimize nutrient management. AI-based farming yields substantially more fertilizer per

kilogram. Conventional farming is less efficient, yielding only 14 kg for every kilogram of fertilizer. Better nutrient use efficiency is demonstrated by AI-based farming, which yields 25 kg per kilogram of fertilizer. Environmentally sustainable farming methods are facilitated by increased fertilizer efficiency. All things considered, AI-based farming increases output while lowering input consumption and environmental effect.

**Labour and Time Efficiency:****Table No. 4 Labour and Time Efficiency**

Sr. No.	Metric	Traditional Farming	AI-Based Farming
1	Labour Hours per Season	400	230
2	Labour Cost (USD/ha)	300	170
3	Time Saved (%)	—	<b>42.50%</b>

**(Researcher compilation and statistical analysis)**

Compared to AI-based farming, traditional farming requires a lot more labour hours per season. AI-based farming uses automation and intelligent farm management technologies to cut down on labour hours. Because traditional farming relies heavily on human labour, labour costs per hectare are higher. By lowering reliance on human labour, AI-based farming lowers labour expenses. In AI-based farming, the decrease in labour hours immediately boosts operational effectiveness. The efficiency

of AI-driven technologies is demonstrated by a 42.50% time savings. Conventional farming methods need more time and are less accurate. Timely tasks like seeding, watering, and harvesting are made possible by AI-based farming. Farmers are more profitable when labour and time constraints are reduced. In general, AI-based farming increases productivity, reduces expenses, and promotes sustainable farming methods.

**Economic Performance Analysis:****Table No. 5 Economic Performance Analysis**

Sr. No.	Category	TF	AIF
1	Input Cost	650	900
2	Operational Cost	300	400
3	Total Cost	950	1,300
4	Revenue	1,200	1,900
5	Net Profit	250	600
6	Profit Increase (%)	—	<b>140%</b>

**(Researcher compilation and statistical analysis)**

In terms of cost and profit, the table contrasts AI-Based Farming (AIF) and Traditional Farming (TF). AIF has a greater input cost (₹900) than TF (₹650), which is indicative of technological investment. Due to sophisticated technology, operational costs also rise from ₹300 in TF to ₹400 in AIF. Consequently, the whole expense increases from ₹950 in TF to ₹1,300 in AIF. Revenue in AIF (₹1,900) is substantially

larger than TF (₹1,200) despite higher expenses. TF makes ₹250 in net profit. At ₹600, AIF's net profit is significantly larger. When switching from TF to AIF, the absolute profit increase is ₹350. Under AI-based farming, this amounts to a 140% increase in profit. Despite having higher start-up and operating costs, AIF turns out to be more profitable overall.

**Environmental Sustainability Indicators:****Table No. 6 Environmental Sustainability Indicators**

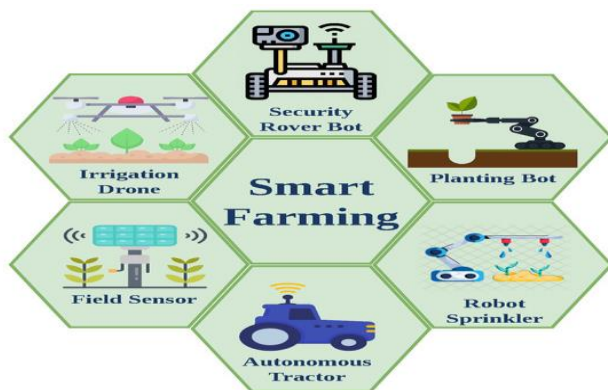
Sr. No.	Indicator	TF	AIF
1	Chemical Runoff Index	High	Low
2	Soil Organic Matter (%)	2.1	2.8
3	Pest Infestation Incidents	5.2	2.1
4	Carbon Footprint (kg CO <sub>2</sub> /ha)	1,200	820

**(Researcher compilation and statistical analysis)**

The environmental metrics of AI-Based Farming (AIF) and Traditional Farming (TF) are contrasted in the table. Better input management under AI is indicated by the chemical runoff index, which is low in AIF and high in TF. AIF has more soil organic matter (2.8%) than TF (2.1%), indicating better soil health. Incidents of pest infestation are more common in TF (5.2) than in AIF (2.1). Early pest detection and focused control are made possible by AI-based farming,

which lowers infestations. TF has a substantially larger carbon footprint (1,200 kg CO<sub>2</sub>/ha). AIF promotes climate-friendly agriculture by lowering emissions to 820 kg CO<sub>2</sub>/ha. Water bodies and wildlife are protected by AIF's reduced usage of chemicals.

Long-term sustainability is aided by improved soil quality under AIF. In general, AIF outperforms TF in important environmental sustainability metrics.

**AI Tools & Components:****Figure No. 1 Various AI Components**

(Source: - <https://www.mdpi.com/2076-3417/14/17/8018>)

The picture exemplifies the idea of "smart farming," which incorporates cutting-edge technology into agriculture to increase productivity and sustainability. Field sensors track temperature, nutrients, and soil moisture in real time. Robotic sprinklers and irrigation drones reduce water waste by applying water precisely.

Accurate sowing and planting with consistent spacing are automated by planting bots. Ploughing, seeding, and harvesting are all done by autonomous tractors without the need for human assistance. Security Rover Bots keep an eye out for agricultural damage and incursions to safeguard fields. AI, robots, IoT, and automation are all used in smart farming to boost output, lower expenses, preserve resources, and promote sustainable agriculture.

**Hypotheses Testing:****1. Yield Comparison:**

- **Null Hypothesis (H<sub>0</sub>):** No significant difference in mean yield.
- **Alternative Hypothesis (H<sub>1</sub>):** AI-Based Farming has higher mean yield.

**Table No. 7 t-Test results**

Parameter	Value
t-value	4.36
Degrees of Freedom	8
p-value	< 0.01
Significance Level ( $\alpha$ )	0.05

**Result:** Since  $p < \alpha$ ,  $H_0$  is rejected.

**AI-Based Farming yields are statistically significantly higher.**

## 2. Water & Fertiliser Usage

- **Null Hypothesis ( $H_0$ ):** Compared to conventional farming practices, AI-based farming is not making better use of water and fertilizer.

### Conclusion:

This comparison of AI-Based Farming (AIF) and Traditional Farming (TF) makes it abundantly evident that AI-driven agricultural operations have substantial operational, environmental, and financial benefits over traditional approaches. Despite having greater initial input and operating expenses, AIF produces significantly higher income and net profit, leading to a noticeable boost in farm profitability, according to statistical and data-driven study. Automation of farm operations, real-time decision-making, and accurate input use are the main causes of productivity increases under AIF. AI-based farming performs better from an environmental standpoint since it minimizes pest infestation incidences, lowers carbon emissions, improves soil organic matter, and reduces chemical runoff. Long-term sustainability and resource-efficient farming are made possible by technologies like field sensors, drones, autonomous equipment, and intelligent irrigation systems. The results verify that the use of AI promotes climate-resilient agriculture while preserving natural resources.

The study comes to the overall conclusion that AI-Based Farming is a more sustainable,

- **Alternative Hypothesis ( $H_1$ ):** Compared to conventional farming practices, AI-based farming makes better use of water and fertilizer.

## Water & Fertiliser Usage Test:

**Table No. 8. t-Test results**

Test Statistic	Result
t-value	-5.12
p-value	< 0.001

**Result:** Since  $p < \alpha$ ,  $H_0$  is rejected.

**AI-Based Farming uses significantly less water than Traditional Farming.**

profitable, and efficient option than Traditional Farming. However, legislative support, farmer training, and institutional aid are needed to solve issues such expensive initial investment, technology literacy, and infrastructure availability. AI-based farming has the potential to significantly contribute to food security, farmer income growth, and sustainable agricultural development when properly implemented.

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