EVALUATING ENVIRONMENTAL IMPACT OF FAIRTRADE CERTIFIED COTTON IN INDIA

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Global AgriSystem

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ACRONYMS AND ABBREVIATIONS

ρb	Bulk Density (of soil)
CAPI	Computer-Assisted Personal Interviews
CFT	Cool Farm Tool
CO_2e	Carbon dioxide equivalent
CSDDD	Corporate Sustainability Due Diligence Directive
DAP	Diammonium Phosphate
EC	Electrical Conductivity
ESG	Environmental, Social and Governance
FAO	Food and Agriculture Organization
FPO	Farmer Producer Organization
FOIC	Fairtrade Organic & In Conversion
FYM	Farm Yard Manure
GAPL	Global Agrisystem Pvt. Ltd
GHG	Greenhouse Gases
HHPs	Highly Hazardous Pesticides
ICS	Internal Control System
INR	Indian Rupee
IPM	Integrated Pest Management
MSP	Minimum Support Price
MSSRF	M.S. Swaminathan Research Foundation
NPK	Nitrogen, Phosphorus, and Potassium Fertilizers
OC	Organic Carbon
pH	Potential of Hydrogen
SOC	Soil Organic Carbon
SOM	Soil Organic Matter
USD	United States Dollar
WHO	World Health Organization
WP	Water productivity
WWF	World Wide Fund for Nature

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The project research team includes Dr. Ravendra Singh (Team Leader), Jatin Saini, Amisha Sharma, and Abhipsa Ray.

EXECUTIVE SUMMARY

This research report evaluates the environmental impact of the cotton cultivated by Fairtrade Certified farmers compared to the conventional methods of cotton cultivation. The study was conducted across six Indian states and nine districts, using the key environmental indicators identified in the Delta Framework[1]. The Delta Framework provides a set of indicators to evaluate the impact of certain cultivation practices and standards requirements, offering a comprehensive approach to understand the effects of practices followed by Fairtrade Certified farmers compared to that of conventional farmers. The primary objectives are to assess the environmental impact of cotton cultivated by Fairtrade Certified farmers, quantify the greenhouse gas (GHG) emissions and water usage associated with Fairtrade cotton farming, and provide a comparative analysis of key environmental indicators between Fairtrade Certified farmers and non-Fairtrade farmers (referred to as the "control group").

The analysis of this report has been divided into four groups of farmers in an attempt to identify the specific impact created by different farming practices. These groups are: The (A.) Fairtrade Organic & In Conversion (FOIC)[2] farmers group, which includes Fairtrade Organic farmers (farmers who are both Fairtrade and Organic certified) and Fairtrade in conversion farmers (farmers who are Fairtrade Certified and in the process of converting to organic). (B.) Fairtrade Organic farmers as a separate sub-set group of FOIC farmers following Fairtrade and organic certification (excludes Fairtrade in-conversion farmers). (C.) Control farmers, which includes Control conventional farmers- farmers following standard conventional agricultural practices and some Control organic farmers who practice organic farming practices without Fairtrade Certification, and (D.) Control conventional farmers as a separate sub-set of Control farmers who follow standard agricultural practices (excludes Control organic farmers).

A rigorous data collection methodology was employed to ensure the reliability and accuracy of the study. This rigour stemmed from using a well-defined sampling strategy and employing digital tools for real-time data collection, minimizing errors and biases. A systematic random sampling approach was utilized across six states in India—Tamil Nadu, Punjab, Gujarat, Madhya Pradesh, Telangana, and Odisha—covering nine districts with a sample size of 850 farmers. The study areas exhibit a wide range of agro-climatic and soil conditions, with average annual rainfall ranging from 400 mm to 1400 mm and the predominant soil types like Silty Clay Loam and Sandy Loam. The regions include both rainfed and irrigated areas, with some locations using a combination of both.

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[1] https://www.deltaframework.org

[2] At the time of the field research being undertaken, almost all Fairtrade Certified Farmers in India were either Fairtrade and Organic Certified or Fairtrade and In Conversion farmers. There was a negligible number of farmers who were following Fairtrade and Conventional farming practices

Data was collected using the Computer-Assisted Personal Interviews (CAPI) technique, facilitated by the KOBO Toolbox application, and supported by local field staff trained specifically for this study. The survey instruments were carefully adapted from the Delta Framework to suit local contexts and objectives, ensuring comprehensive data capture on sustainable agricultural practices in cotton farming. The samples for this study covered different age groups, genders, farms of different sizes, and literacy levels among the farmers. Any outliers in the data were carefully reviewed and excluded from further analysis if found justified.

This study focusses on the environmental indicators of the Delta Framework to evaluate the impact of Fairtrade Certified Cotton farmers in terms of their natural resource use and management and any emissions generated by their cultivation practices, thus offering a comprehensive approach to understanding the environmental effects created by Fairtrade Certified farmers compared to non-Fairtrade farmers. In addition, The Cool Farm Tool was used to calculate GHG emissions and water use efficiency. The Cool Farm Tool offers quantified, credible, and standardized metrics based on empirical research, a broad range of published data sets, and standard methodologies. A comparative analysis was conducted to identify and highlight the impact across farmers who are Fairtrade Certified versus farmers following conventional farming practices, focusing on key indicators such as pesticide and fertilizer usage, water productivity, and GHG emissions.

KEY FINDINGS

The analysis of the Delta Framework indicators among FOIC farmers (organic and in conversion) versus Control farmers (conventional and organic) reveals a marked difference in environmental sustainability and resource efficiency. FOIC farmers consistently demonstrate a negligible use of Highly Hazardous Pesticides (HHPs), with only 0.3% usage among FOIC farmers[3] and none among Fairtrade Organic farmers, compared to 1.9% in control farmers and 2.2% in control conventional farmers. The pesticide risk indicator further showcases the sustainable practices of FOIC farmers, with 96% avoiding chemical pesticides altogether, 69% using biopesticides, and 73% employing Integrated Pest Management (IPM).

Moreover, FOIC farmers have better water management results, with around 15% to 30% better irrigation than conventional methods. Analysis shows higher water productivity (i.e., output per water input), with a rate of 0.30 kg/m^3 in FOIC farmers and 0.32 kg/m^3 in

[3] *The finding of HHP in Fairtrade Certified Producer Organisations has triggered remedial measures being initiated at the concerned Producer Organisations; continuing to use these HHPs will otherwise result in suspension and finally decertification by FLOCERT. The condition on the ground would be monitored to ensure a more robust implementation of the Fairtrade Standards on Chemical Management.*

Fairtrade Organic, compared to 0.25 kg/m^3 in Control farmers and 0.25 kg/m^3 in Control conventional farmers. In terms of total water footprint, FOIC farms range at 4,410 litre/kg of seed cotton, and Fairtrade Organic farms at 3,821 litres/kg of seed cotton, which is around 27% lower than that consumed by the control farmers at 5,229 litres/kg, and control conventional at 5,156 litres/kg.

FOIC farmers significantly reduced their reliance on synthetic nitrogenous fertilizers. Only 5% of FOIC farmers and 0.6% of Fairtrade Organic farmers use synthetic nitrogenous fertilizers, whereas 79% of control and 91% of control conventional farmers use synthetic nitrogenous fertilizers. Reduced use of synthetic nitrogenous fertilizers contributes to enhanced soil quality and reduced environmental degradation.

The better management of land, water and input resources among FOIC and Fairtrade Organic farmers contributed to reduced GHG emissions, with FOIC and Fairtrade Organic farmers emitting an average of 1,025 kg CO_2e/ha and 862 kg CO_2e/ha respectively, versus 1,563 kg CO_2e/ha for Control farmers and 1620 kg CO_2e/ha for Control conventional farmers. Additionally, Fairtrade Organic farmers' GHG emissions per tonne of cotton seed (590 kg CO_2e/tonne of seed cotton) are approximately 61% lower than Control farmers, which is 1500 kg CO_2e/tonne of seed cotton. From an economic perspective, the study reveals that Fairtrade Organic farmers achieve higher yields and receive significantly higher prices for their cotton due to the organic differential, and Fairtrade Premium. These findings reinforce the benefits of adopting Fairtrade and organic farming practices to promote sustainability and enhance farmers' livelihoods.

In summary, cotton cultivated under Fairtrade and Organic certification is associated with more sustainable agricultural practices, better environmental outcomes, and improved resource efficiency while maintaining or enhancing productivity on average. As most FOIC farmers also follow Organic certification and cultivation practices, it has been beyond the scope of the current study to decouple the effects of both Certification systems. However, it should be noted that the Fairtrade Standards and Certification provide multiple avenues of support that contribute to the achievement and strengthen the implementation of Organic Certification. These findings highlight the effectiveness of Fairtrade and Organic certification in promoting environmentally responsible farming, especially when compared with conventional cotton cultivation practices.

01 INTRODUCTION

1.1. BACKGROUND

India is estimated to be the world's second-largest producer of cotton, with an estimated annual production of 343.47 lakh bales (5.84 million metric tonnes) during the cotton season 2022-23, which is 23.83% of world cotton production of 1,441 lakh bales (24.51 million metric tonnes). India is also the 2nd largest consumer of cotton in the world, with an estimated consumption of 311 lakh bales (5.29 million metric tonnes), accounting for 22.24% of the world cotton consumption of 1,399 lakh bales (23.79 million metric tonnes) (Ministry of Textiles | GoI. (n.d.)).

Cotton, a crucial cash crop in India, plays a significant role in the national economy and the livelihoods of millions. In addition to providing raw material for clothing, a fundamental necessity, cotton is a major contributor to the nation's economy and foreign exchange earnings by exporting raw cotton, yarn, fabrics, and finished products such as garments and knitwear. In India, there are ten major cotton-growing states divided into three zones: **North Zone, Central Zone, and South Zone**. The North Zone consists of Punjab, Haryana, and Rajasthan. The Central Zone includes Madhya Pradesh, Maharashtra and Gujarat. The South Zone comprises Andhra Pradesh, Telangana, Karnataka, and Tamil Nadu. Besides these ten states, cotton cultivation has gained momentum in the Eastern state of Odisha. Beyond these states traditionally growing cotton in large areas, there are also small areas of cotton production in states such as Uttar Pradesh, West Bengal & Tripura.

However, cotton cultivation also has a major environmental footprint. Cotton uses 24% and 11% (21) of the world's insecticides and pesticides respectively (Raja, B. P., 2022), which indirectly contributes to GHG emissions due to the high amount of energy necessary for their production, adding to the pressing global issue of climate change. Using nitrogen-based fertilizers in cotton farming not only leads to the release of nitrous oxide, a potent greenhouse gas but also accelerates the mineralization of soil organic carbon.

This acceleration increases carbon leakage, reducing the soil's ability to retain carbon. Furthermore, it diminishes the soil's water retention capacity, ultimately affecting soil health and resilience. Additionally, the energy-intensive processes involved in irrigation, pesticide, fertilizer production, and fuel for farm machinery use further add to the carbon footprint of cotton cultivation.

Although various sources of GHG emissions are associated with cotton cultivation, estimating a fixed GHG emission from cotton production is impossible due to a lack of uniform parameters, methods, zones and soils in the assessments. Table No. 1 lists previous studies on GHG emissions released in Cotton cultivation.

Table 1: *Previous Studies on GHG Emissions*

NAME OF STUDY	LOCATION	VALUE OF CO_2e	PARAMETERS
Exploring energy consumption and CO_2e emission of cotton production (Pishgar-Komleh, S.)[6]	Iran	1195 kg CO_2e /ha	Machinery, Diesel, fuel, Chemical fertilizers, Biocide
Analysis of Energy Input-Output of Farms and Assessment of Greenhouse Gas Emissions: A Case Study of Cotton Growers (Abbas, A.) [1]	Pakistan	1106 kg CO_2e / ha	Machinery, Diesel fuel, Chemical fertilizers, irrigation
Study of Greenhouse Gas Emissions of Better Cotton. (Better Cotton Initiative (2021))[2]	India	4076 kg CO_2e/ Ton lint (Better Cotton Farmers) 5158 kg CO_2e/ Ton lint (Control Group)	Ginning, Pesticides, fertilizers, Crop residue management, Transport, Field Operations, Irrigation
Cutting cotton carbon emissions (WWF-India. (2013)) [8]	Warangal, India	0.43 kg CO_2e/kg of seed (Better management practices),1.5 kg CO_2e/ kg of seed (Traditional cotton cultivation)	Pesticides, agrochemicals, Crop management, Livestock, manure management, Transport, energy use
Climate change and Cotton: impact, Adaptation and Estimating GHG emissions from cotton cultivation In India under Fairtrade, (MSSRF. (2022)) [9]	India	1.0 kg CO_2e/ kg of seed cotton (Fairtrade Farmers), 2.3 kg CO_2e/ kg of seed cotton (Control Group)	Irrigation, machine use, transport, pesticides, residue, fertilizers application

Fairtrade, an international network of non-profit organizations, seeks to promote fair and sustainable trade and production practices primarily in agricultural value chains in and from the global south. Fairtrade's mission is to connect disadvantaged producers and consumers, promote fairer trading conditions and empower producers to combat poverty, strengthen their position and take more control over their lives. Fairtrade Standards mandate better prices for producers, decent working conditions, sustainable farming practices, and community development.

Fairtrade Standards work towards reducing environmental and social exploitation in cotton production. Regarding environmental sustainability, the Fairtrade System works with farmers to reduce or eliminate the use of toxic agrochemicals, supports the adoption of better soil, water, waste and energy management practices and enables farmers to adapt to changing weather patterns. The Fairtrade system also prohibits using genetically modified cotton seeds and encourages practices that protect the natural environment. Additionally, Fairtrade's Textile Standard and Programme, introduced in 2016, extends its coverage to all stages of the textile production chain, addressing unsafe and unfair labour conditions in cotton processing and textile factories.

1.2. OBJECTIVE AND SCOPE OF THE STUDY

The study aims to understand and measure the environmental impact of Fairtrade Certified cotton farmers on the field with a primary focus on GHG, water, and soil.

SCOPE OF THE STUDY

The scope of the study encompasses a comprehensive analysis of the impact of Cotton production by FOIC farmers across six Indian states—Odisha, Madhya Pradesh, Gujarat, Telangana, Tamil Nadu, and Punjab—spanning nine districts, including Balangir, Kalahandi, Khargone, Surendranagar, Kutch, Adilabad, Namakkal, Salem, and Muktsar. Utilizing the Delta Framework's indicators, the study measures farm-level environmental outcomes. This research method uses quantitative data from surveys to provide an in-depth understanding of the impact created by Fairtrade Certified cotton farmers.

DESCRIPTION OF STUDY AREAS:

The study area for the research encompasses a diverse range of regions across six Indian states, focusing on various districts within each state.

Table 2: *Description of the Study Area*

STATE	DISTRICTS	CLIMATE	AVG. ANNUAL RAINFALL MM (2022-23)	IRRIGATION TYPE	MAJOR SOIL TYPES
PUNJAB	Muktsar	Dry sub-humid with grassland type of vegetation	416.7	Irrigated	Silty Clay Loam, Clay loam
GUJARAT	Kutch	Arid to Semi-arid	722	Irrigated	Sandy Loam
	Surendranagar	High temperate with a moderate proportion of heat and cold	760 to 967	Irrigated	Sandy Loam
MADHYA PRADESH	Khargone	Tropical wet and dry or savanna climate	835	Irrigated	Silty Clay Loam
TELANGANA	Adilabad	Tropical wet and dry or savanna climate	1387.8	Rainfed	Clay, Sandy Clay
TAMIL NADU	Namakkal	Tropical savanna	763.5	Rainfed, Irrigated	Sandy Clay Loam
	Salem	Hot semi-arid	912.5	Rainfed, Irrigated	Clay, Sandy Clay
ODISHA	Kalahandi	Sub-tropical with hot and dry summer	1378.20	Rainfed	Silty Clay Loam
	Balangir	Tropical wet and dry or savanna climate	1229.47	Rainfed	Loamy Sand, Sandy Clay

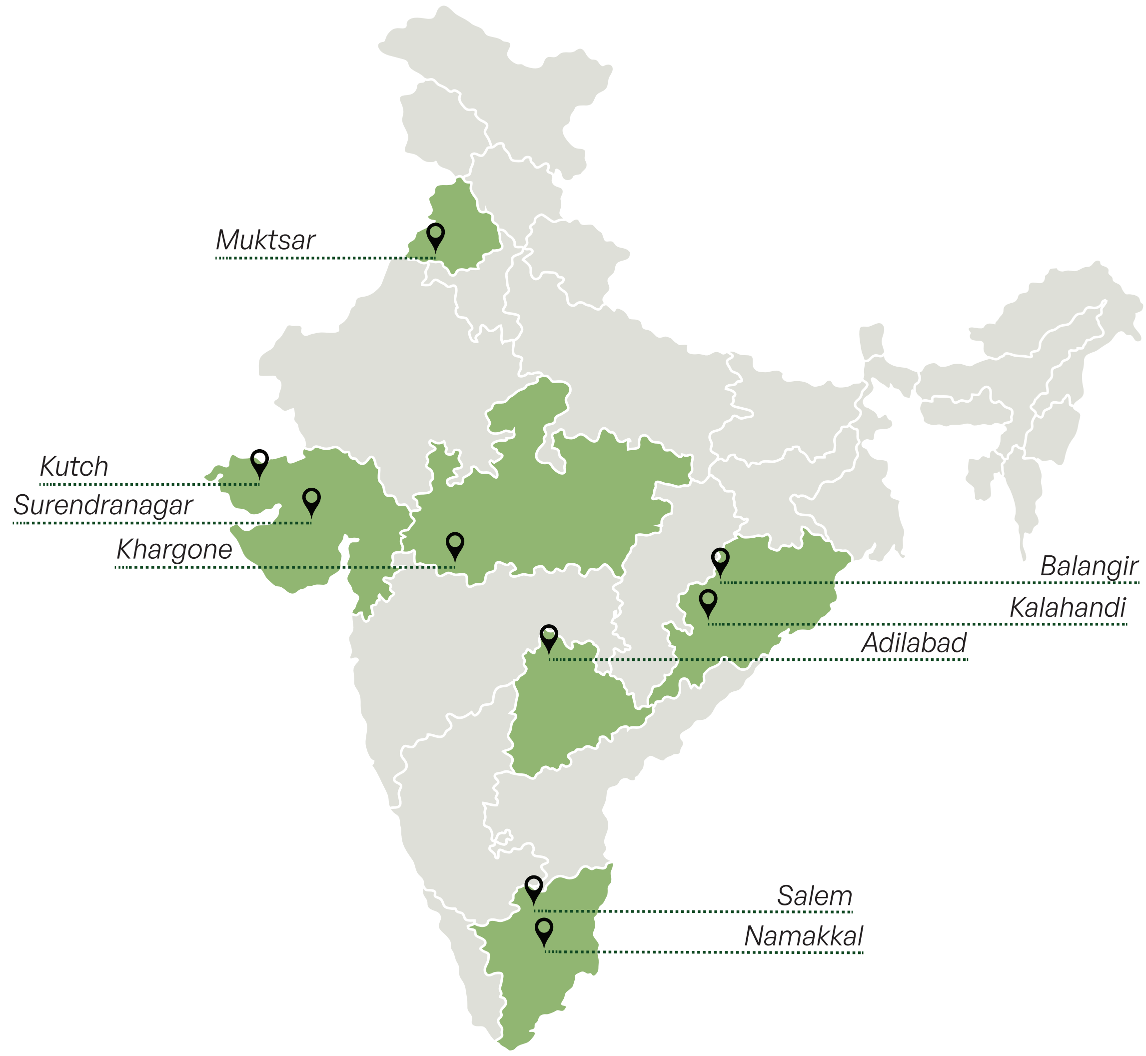

Figure 1: *Location of Study Area*

1.3. SIGNIFICANCE OF THE STUDY

Cotton cultivation is a major global agricultural activity, but it is fraught with significant environmental, social, and economic challenges. Conventional cotton farming practices are often associated with severe problems such as pollution, extensive water usage, reliance on chemical fertilizers, high levels of pesticide application and exploitation of labour. These practices harm the environment—through water scarcity, soil degradation, and loss of biodiversity—and affect the health and livelihoods of farmers and their communities. The intensive use of hazardous chemicals exacerbates GHG emissions, decreases soil health and soil water retention, increases soil and water toxicity and contributes to climate change, while inefficient water management further strains water resources.

Recently, there has been a heightened focus on regulatory frameworks and sustainability directives addressing these challenges. The European Union's strategies "Farm to Fork" and "Green Deal" describe politically approved pathways for more sustainability in agricultural production. One of the EU's subsequent directives, the Corporate Sustainability Due Diligence Directive (CSDDD) and the UN-led Paris Agreement have set ambitious goals for reducing environmental impact and promoting sustainability across global supply chains across industries, including agriculture and textiles. Furthermore, the Government of India's BRSR (Business Responsibility & Sustainability Reporting) mandates leading Indian companies to provide quantifiable metrics on sustainability-related factors. Similarly, the EU's Corporate Sustainability Reporting Standards Directive (EU CSRD) also requires an increasing number of companies to regularly report to government authorities about their environmental and social impact and what they do to reduce negative impact. These legal frameworks emphasize the need for transparency, accountability, and adherence to Environmental, Social, and Governance (ESG) criteria and the ability to report or provide respective data.

The detrimental impacts of conventional production methods underscore the urgent need for sustainable agricultural practices in cotton farming. Addressing these issues is critical for environmental conservation and ensuring the long-term viability of cotton farming as a livelihood for millions of farmers worldwide. Implementing sustainable practices mitigates environmental degradation, improves water management, and reduces reliance on harmful chemicals.

Moreover, these changes have significant social implications. Improving labour conditions, reducing exploitation, and enhancing farming communities' overall quality of life are essential for social sustainability. Economic benefits also arise from sustainable practices, as they can lead to better market opportunities, higher prices for sustainably produced cotton, and improved resilience against market fluctuations and climate-change-related risks.

The study is significant as it seeks to address environmental concerns by focusing on the impact of Fairtrade Certified cotton on the environment in India. Specifically, the study aims to evaluate the differences in impact between cotton cultivated by FOIC farmers and those practising conventional forms of agriculture, focusing on several critical areas.

USE OF HIGHLY HAZARDOUS PESTICIDES (HHPS)

The use of HHPs in conventional cotton farming presents severe health risks to farmers, workers, and local communities. The impact of HHPs on the environment includes persistent contamination of soil and water sources, leading to the loss of biodiversity and destruction of beneficial insect populations that act as natural pest enemies. HHPs also reduce the nutritional value of food and cause widespread harm to wildlife through direct exposure, pesticide drift, secondary poisoning, and runoff into local water bodies, including groundwater. This study examines whether FOIC farmers are encouraged to use safer, organic alternatives and have a lower dependency on these hazardous chemicals than their conventional counterparts.

SYNTHETIC NITROGENOUS FERTILIZERS

The reliance on synthetic nitrogenous fertilizers in conventional farming often leads to soil degradation, eutrophication and an increase in carbon emissions. This study explores practices followed by FOIC farmers, which promote organic or more sustainable fertilizer use, improved soil health, and contribute to more environmentally friendly farming methods.

WATER MANAGEMENT

Given cotton's water-intensive nature, inefficient water use in conventional farming can result in water scarcity and depletion of resources. This study evaluates the effectiveness of FOIC farmers in implementing efficient water management practices that can help conserve water and mitigate environmental impact.

GREENHOUSE GAS EMISSIONS (GHG)

The GHG emissions from conventional agriculture contribute significantly to climate change. The study investigates whether farming practices, as per Fairtrade Standards, emphasize sustainability and result in lower GHG emissions than conventional methods.

SOIL ORGANIC CARBON

Soil organic carbon (SOC) plays a crucial role by enhancing soil fertility, improving water retention, and contributing to carbon sequestration. Higher SOC levels boost crop yields and promote healthier soil ecosystems.

Along with the above parameters, the study also evaluated two economic parameters (i.e. **Farmgate Prices and Yield**) as economic parameters directly impacting sustainable agriculture practices. Analyzing these economic indicators will help substantiate the study on the environmental impact of Fairtrade Certification. This study examines how Fairtrade Certification impacts key income and economic resilience indicators, comparing the Farmgate prices received and the Yield of FOIC and Conventional farmers.

This study should help understand the potential benefits of Fairtrade Certification in promoting sustainable agricultural practices in cotton farming. The findings will contribute to the broader goals of environmental protection, and sustainable development. This is important as the global agricultural sector seeks to address growing environmental concerns and move towards more sustainable practices due to the accelerating environmental challenges, increasing regulatory pressure and market demands for sustainability.

02 APPROACH AND METHODOLOGY

2.1. RESEARCH DESIGN

This study adopts a robust research design leveraging the Delta Framework to evaluate the environmental impact of cotton cultivated by Fairtrade Certified farmers. The Delta Framework provides a comprehensive set of indicators that evaluate environmental impact at the farm level. Using Delta Framework, the study aims to deliver a detailed assessment of how the farming practices of Fairtrade Certified cotton farmers compare to conventional cultivation methods.

2.2. DELTA FRAMEWORK

The Delta Framework is designed to assess the sustainability of agricultural practices worldwide, with one particular focus on cotton farming. It encompasses a range of indicators that evaluate environmental, social, and economic impacts, making it a valuable tool for understanding comprehensive farm-level outcomes. The framework's versatility allows for its application across different commodities, potentially expanding its use to other agricultural sectors over time.

SELECTED INDICATORS FOR THIS STUDY

In this study, we used the following Delta Framework indicators to assess the environmental impact of Fairtrade practices on cotton farming:

Use of HHPs
Evaluate the extent to which farmers use highly hazardous pesticides, impacting both environmental and health outcomes.

Pesticide Risk Indicator
Assesses the risk associated with pesticide use, including potential environmental and health hazards.

Water Management
- Water Extracted for Irrigation: Measures the total amount of water used for irrigation purposes.
- Irrigation Efficiency: Evaluates how effectively water is used in irrigation.
- Water Productivity (WP): Assesses the yield achieved per unit of water used.

Topsoil Carbon Content
Measures the amount of carbon stored in the topsoil, which is crucial for soil health and carbon sequestration

Quantity of Fertilizers Used by Type
Examines the amount and type of fertilizers used.

GHG Emissions
Assesses the emissions produced by cotton farming from various related on and off-farm activities.

Yield (Average)
Measures the average yield of seed cotton as yield results can help determine whether sustainable practices provide comparable outcomes to conventional methods, motivating farmers to adopt environmentally friendly practices.

Price (At Farmgate)
Assesses the price farmers receive for their cotton. In addition to yield, analyzing farm gate prices can reveal if sustainable practices provide comparable economic benefits that will ultimately promote environmentally friendly practices.

EXCLUDED INDICATORS

As the study focuses on the environmental impact only, the non-environmental indicators of the Delta Framework were not considered for the study. Out of all the seven environmental indicators, the "Forest, Wetland, and Grassland Conversion" indicator was dropped due to unavoidable challenges in collecting geospatial data at the study areas. Due to time and budget constraints, the data was collected through interviews with farmers at their homes instead of their fields, which prevented the collection of accurate geo-location information necessary to assess land use changes effectively.

Other than the "Forest, Wetland, and Grassland Conversion" indicator, the other indicators of the Delta Framework which were outside the scope of the study are:

- ***Gross Margin from Crop Production***
- ***Proportion of Workers Earning a Legal Minimum Wage***
- ***Incidence of Child Labour***
- ***Incidence of Forced Labour***
- ***Women's Empowerment***
- ***Number of fatalities and non-fatalities on the farm by sex***

Despite these exclusions, the study provides valuable insights into the environmental impact of cotton cultivated by Fairtrade Certified farmers compared to Non-Fairtrade Certified farmers, contributing to a better understanding of sustainability in cotton farming.

2.3. COOL FARM TOOL

The Cool Farm Tool is an advanced software designed to systematically assess and monitor GHG emissions, water efficiency, water productivity, water use and biodiversity in agriculture. Developed through empirical research and industry collaboration, the Cool Farm Tool offers a comprehensive platform for assessing the environmental impact of farming practices (Cool Farm Tool) [3].

The tool is particularly useful for analyzing key sustainability indicators in agricultural operations. For GHG emissions, it provides detailed calculations of emissions associated with various farming activities and practices. The Cool Farm Tool measures water usage, efficiency, and productivity regarding water management. Additionally, it evaluates water footprints, offering insights into the total water required to produce a given quantity of crops.

APPLICATION IN RESEARCH

In this study, the Cool Farm Tool is employed to assess and compare the environmental impact of Fairtrade Certified farmers versus non-Fairtrade farmers. By utilizing this tool, the study aims to:

Quantify GHG Emissions:

The tool helped determine the GHG emissions associated with different cotton farming practices, highlighting the impact of practices followed by Fairtrade Certified cotton farmers.

Evaluate Water Efficiency and Productivity

The Cool Farm Tool is used to analyse water management practices, systematically assessing how efficiently water is used and how productive the water use is across various farming systems.

Assess Water Footprints

The Cool Farm Tool is used to analyse water management practices, systematically assessing how efficiently water is used and how productive the water use is across various farming systems.

By incorporating the Cool Farm Tool into this study, a robust and precise assessment of environmental impacts is ensured, supporting a comprehensive analysis of the impact of cotton cultivated by Fairtrade Certified farmers.

2.4. DATA COLLECTION METHODS

Effective data collection is crucial for obtaining accurate and reliable information on sustainable agricultural practices in cotton farming. This section outlines the methods and procedures for collecting data, including desk research, sampling strategies, data collection instruments, training, quality control measures, and considerations of assumptions and limitations.

DESK RESEARCH ON SECONDARY DATA

Desk research was used to collect information and industry data on cotton cultivation globally and in India, delving into the significant environmental and social challenges associated with cotton cultivation. The desk review examined the extensive use of pesticides and synthetic nitrogenous fertilizers, contributing to pollution and health risks. The review also explored the Delta Framework's methodologies and indicators for standardizing sustainability reporting, providing a structured approach to assessing environmental impacts.

SAMPLING STRATEGY FOR PRIMARY DATA COLLECTION

A systematic random sampling approach was utilized to ensure the representativeness and reliability of the primary data collection. This method was chosen to minimize biases and ensure every individual within the target population had an equal chance of selection, enhancing the generalization of the study findings. The samples were selected through sampling intervals, i.e., by dividing each village's population under the study area by sample size. The formula used to decide the sampling interval is:

$$k = N/n$$

Where k is the sampling interval, N represents the total population of farmers at the village level, and n represents the sample size. A random number was selected from the whole numbers between 0 and k+1 as a starting number, and samples were selected by adding the sampling interval 'k'. The value of 'k' varied in each study area depending on the population and sample size.

Sample Size and Distribution

81 samples from Punjab, 100 from Gujarat, 91 from Madhya Pradesh, 260 from Odisha, 109 from Telangana, and 209 from Tamil Nadu have been collected. The total sample size for the survey was 850, of which 592 were Fairtrade Certified farmers (referred to as FOIC) and 258 non-Fairtrade Certified farmers or control farmers. FOIC farmers included both Fairtrade Organic (469) and Fairtrade In-conversion farmers (123), while Control farmers consisted of conventional farmers (223) and non-Fairtrade Organic farmers (35).

Of the 850 samples, 210 soil samples were collected, of which 71% represented FOIC farmers, and 29% represented control farmers. 445 survey samples were uploaded to Cool Farm Tool to calculate GHG emission and water management parameters.

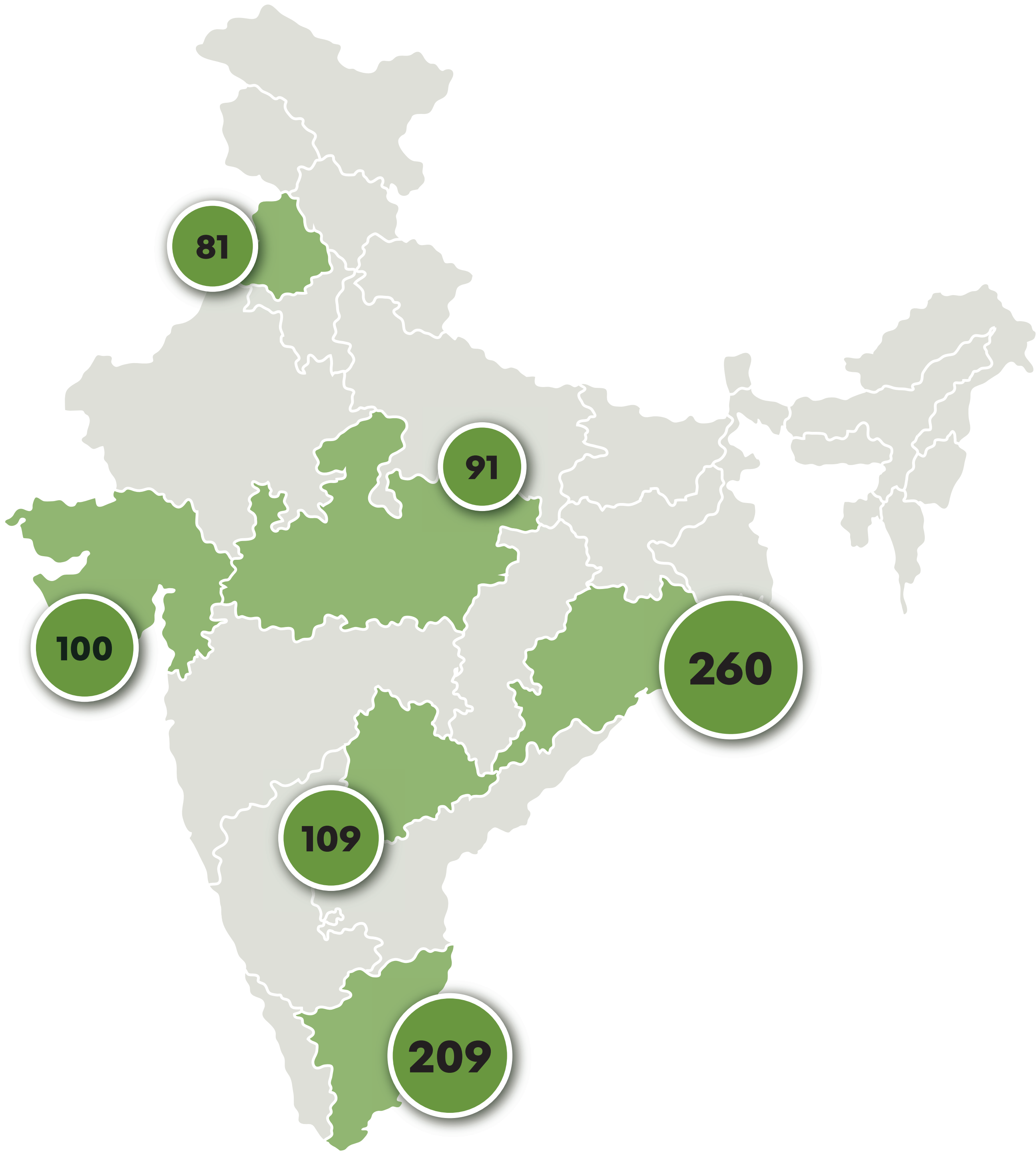

Figure 2: *State wise sample size*

Table 3: *Sample Distribution for the Study*

	FOIC FARMERS			CONTROL FARMERS			GRAND TOTAL
	Organic	**In Conversion**	**Total**	**Conventional**	**Organic**	**Total**	
SURVEY SAMPLES	469	123	592	223	35	258	850
SOIL SAMPLES	122	28	150	54	6	60	210
COOL FARM TOOL SAMPLES	232	69	301	124	20	144	445

DATA COLLECTION INSTRUMENTS

The questionnaire for this study was developed by adapting questions from the Delta Framework to suit better the study's local context and specific objectives. By adopting the framework-based questions, we ensured that the survey effectively captured relevant data on sustainable agricultural practices in cotton farming. This approach allows us to accurately assess and compare the impacts of cotton produced by FOIC farmers against cotton cultivated through conventional practices, addressing key areas such as pesticide use, water management, soil health, and GHG emissions.

Data for the survey was collected using the "Computer-assisted Personal Interviews" (CAPI) technique. The Kobo Toolbox application was employed to gather data from the field, as it offers a scalable, robust, reliable, secure, and powerful data collection tool. The data collection took place online and offline, using this app by local field staff deployed at the sites. The interviews were conducted in the farmers' local language. Several linguistic experts translated the questionnaire into the regional languages of the study areas. The designed questionnaires were uploaded onto the application, and smartphones and tablets were used to collect farmers' data. The soil samples were collected by field investigators trained by soil scientists to use scientific instruments.

TRAINING AND PILOTING

GAPL deployed its staff members, including the Team Leader, Project Manager, and Research Associate, who possess extensive experience in conducting surveys. The team provided guidance and training to the enumerators on conducting field interviews. A senior soil scientist was also deployed to train the field enumerators for soil sample collection. The training sessions included pilot testing and data collection, employing a classroom model for effective learning.

QUALITY CONTROL

To ensure data quality during the survey, the following measures were undertaken:

Ensuring primary data collection is carried out under the supervision of local supervisors.

Conducting daily data checks and downloading data daily to ensure completion of daily collection of targeted samples and backend data checking.

Enumerators have been given feedback to help them collect accurate data when asked open-ended questions.

The field data collected daily was synced and pushed to a safe and secure agency server for data quality review regularly, and all qualitative data was stored in specific folders.

After gathering the data, carefully check and correct any mistakes to ensure the information is accurate and dependable for the analysis.

These measures resulted in a high-quality dataset, free from errors and inaccuracies, setting the stage for meaningful analysis in line with the project's goals.

ASSUMPTIONS OF THE STUDY

- It is assumed that the **conversion rate of seed cotton to Lint is 35%**, based on the industry average, which ranges between 30% and 40%.
- The conversion rate from **USD to INR is assumed ₹1 = 0.012031$** based on the average exchange rate from August 2023 to February 2024. This rate was used to ensure consistency in financial comparisons and calculations throughout the study.
- The information provided by the farmers regarding their farming practices, inputs, and outputs is assumed to be reliable and truthful.
- The **volume of water utilized in the cotton field** of all samples has been calculated with an **approximation approach** by considering factors such as the horsepower of motors, operational time, and the depth of groundwater.
- The Cool Farm Tool uses field data to estimate GHG emissions according to predefined rules and assumptions. The results from the Cool Farm Tool are assumed to be reliable and appropriate for our analysis.

LIMITATIONS OF THE STUDY

1

SOIL SAMPLING EXCLUSION

Soil samples could not be collected from Tamil Nadu due to the onset of new crop sowing. When sowing begins, farmers engage in activities such as irrigation and fertilizer application, which can significantly alter the soil composition and impact the accuracy of the results. Therefore, collecting samples during this period would not have provided a reliable representation of the soil's condition.

2

NO RECORD OF ELECTRICITY USAGE FROM A FEW STATES

In some states where electricity is free, farmers do not keep records of their electricity usage. So, the energy consumption for non-irrigational electricity usage couldn't be assessed.

3

WATER USAGE MEASUREMENT

Accurate measurement of the volume of water used by farmers was not feasible; instead, it has been calculated with an approximation approach by considering factors such as horsepower of motors, operational time, and the depth of water bodies.

4

DEPENDENCE ON FARMERS' MEMORY

The reliance on self-reported data by farmers over the last crop cycle was a limitation, as it depends on their memory and willingness to provide accurate information.

5

IMPACT OVERLAP

Since most FOIC farmers are either practising organic cultivation or are in the process of converting to organic farming, the study cannot decouple the impact of the Fairtrade package of practices from the impact of the organic package of practices at this stage. Instead, it reflects the overall environmental impact of cotton produced by FOIC farmers, encompassing both fully organic and those in conversion.

6

NATIONAL AVERAGES

This study represents national averages on key indicators, which may mask regional variations in agricultural practices and environmental impacts. Because of the diverse climate, soil types, and socio-economic conditions across different regions of India, the findings may not fully capture the local nuances. Consequently, significant variations in outcomes and sustainability impacts cannot be reflected in the national averages used in this study.

7

LIMITED SAMPLE SIZE

Due to the limited number of samples, disaggregation data at the state or district level could not be done. Additionally, Fairtrade farmers included in the study were at different stages of Fairtrade and Organic Certification—ranging from fully Organic and Fairtrade Certified to various stages of Organic conversion and having just initiated their Fairtrade Certification. This variation in certification stages could introduce discrepancies in the data, affecting the overall comparability of the results.

8

LENGTH OF QUESTIONNAIRE

The questionnaire used in this study was quite extensive, encompassing all necessary aspects to gather comprehensive data. However, its length posed challenges, as keeping farmers engaged throughout the process was difficult.

9

REPRESENTATION OF NON-FAIRTRADE ORGANIC FARMERS

The sample size for Non-Fairtrade Organic farmers and Fairtrade in conversion farmers was relatively small compared to other categories. This limited representation may have affected the ability to draw more robust comparisons and conclusions.

10

TIMING OF DATA COLLECTION

During this study, many farmers were busy harvesting their crops, which made securing their participation in lengthy interviews challenging.

11

GEOSPATIAL DATA COLLECTION

One of the key environmental indicators, "Forest, Wetland, and Grassland Conversion," could not be covered as geospatial data collection was impossible because interviews were conducted at farmers' homes rather than in the fields. This limited the ability to gather precise geo-location information necessary for assessing land use changes.

03 DATA ANALYSIS

3.1. SOCIO-DEMOGRAPHIC PROFILES OF FARMERS

AGE DISTRIBUTION

The age group with the highest representation is 40-50 years old, with both Fairtrade-certified farmers and the Control farmers group showing a significant percentage within this range, the age distribution for both groups is relatively wide, with representation from the 20-30 age group up to the 70+ age group. While both groups share similarities in age distribution, there are some notable differences:

The 20-30 age group has a higher percentage in the Control group compared to Fairtrade-certified farmers. The 60-70 and 70+ ag groups have a slightly higher percentage in the Fairtrade-certified farmers 70 group compared to the Control.

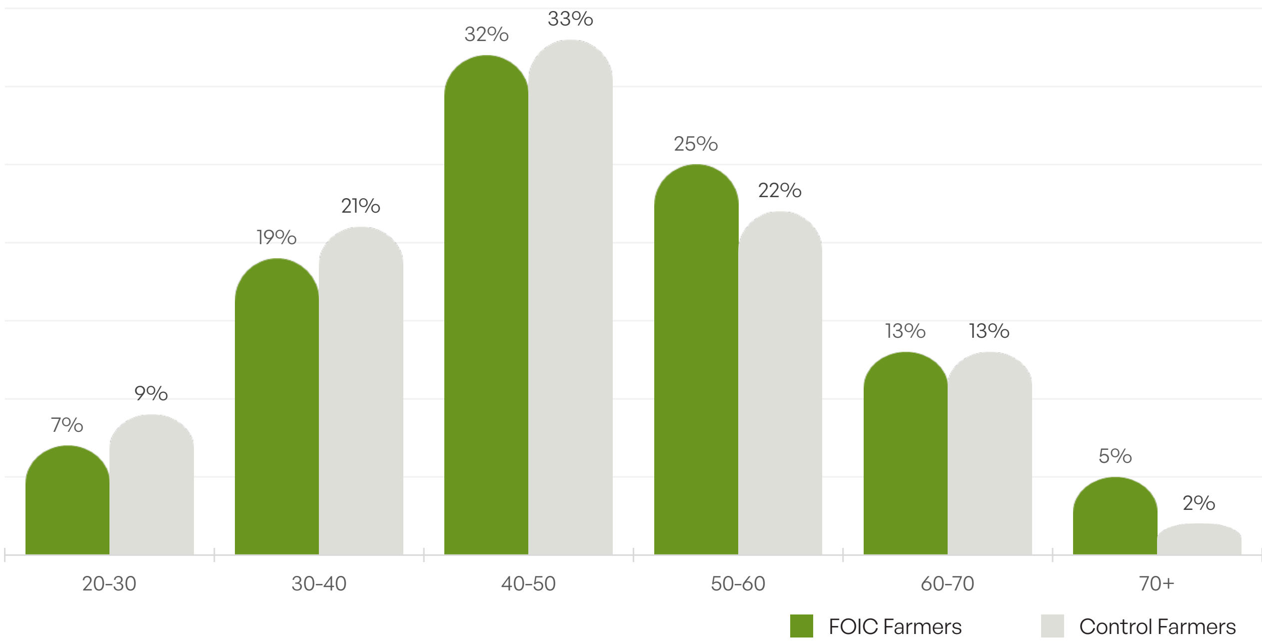

Figure 3: *Age Distribution*

GENDER DISTRIBUTION

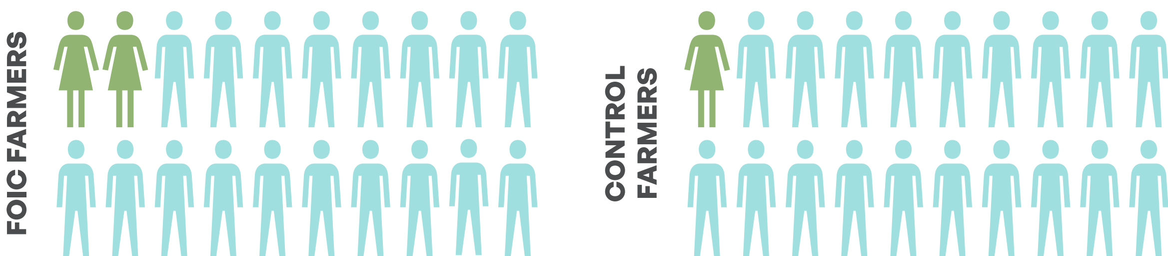

Figure 4: *Gender Distribution*

The proportion of female farmers is 10% among Fairtrade-certified farmers and 5% among Control farmers.

EDUCATIONAL QUALIFICATION

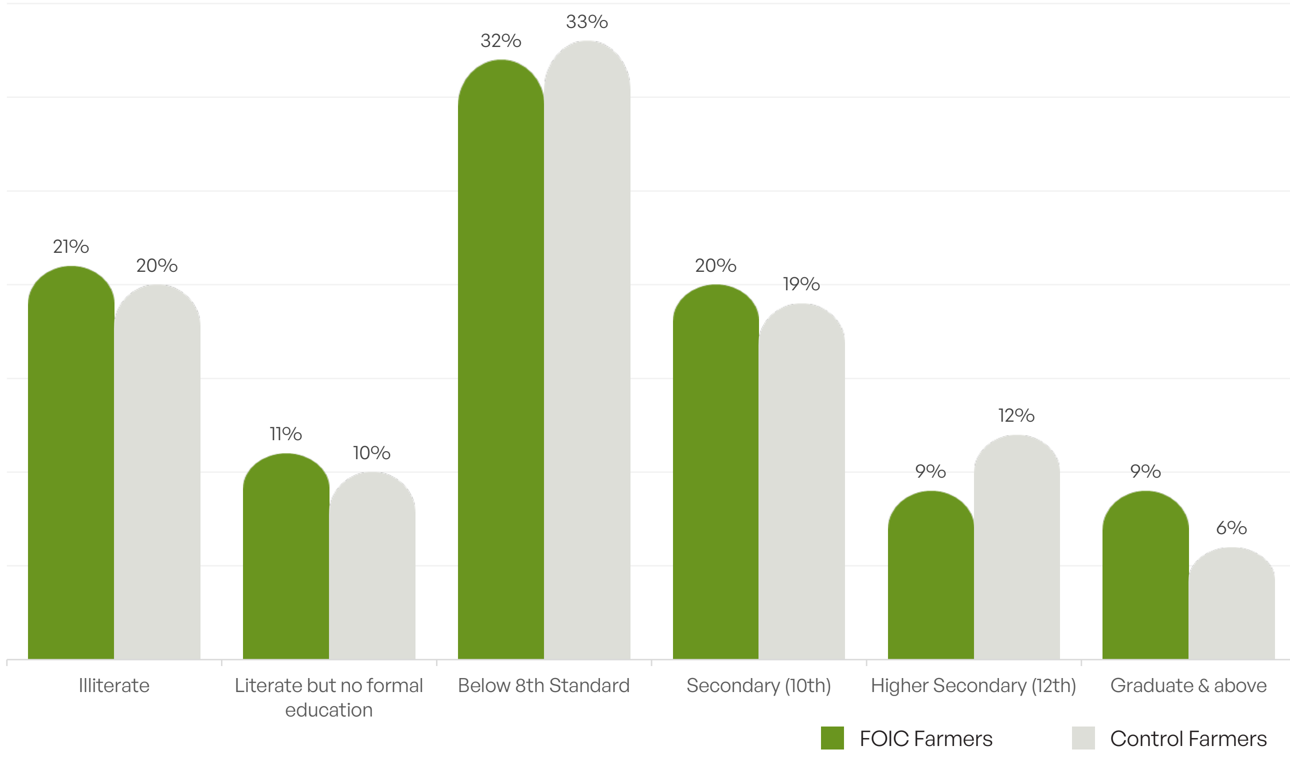

Figure 5: *Educational Qualification*

There is a comparable educational attainment between Fairtrade-certified farmers and the Control farmers group across most levels. However, a slightly higher number of the Fairtrade- certified farmers have done graduation and above, while Control Farmers demonstrated a slightly higher rate in higher secondary education.

LAND HOLDING OF FARMERS

Both groups primarily consist of small-scale farmers (1-2 ha), with a slight majority in the Control group. While marginal farmers (<1 ha) and semi-medium (2-4 ha) are significant in both groups, the Control farmers have a higher proportion of Marginal Farmers and Fairtrade-certified farmers have a higher proportion in Semi-Medium. The distribution across medium land holding is relatively similar between the two groups

Figure 6: *Land Holding of FOIC Farmers*

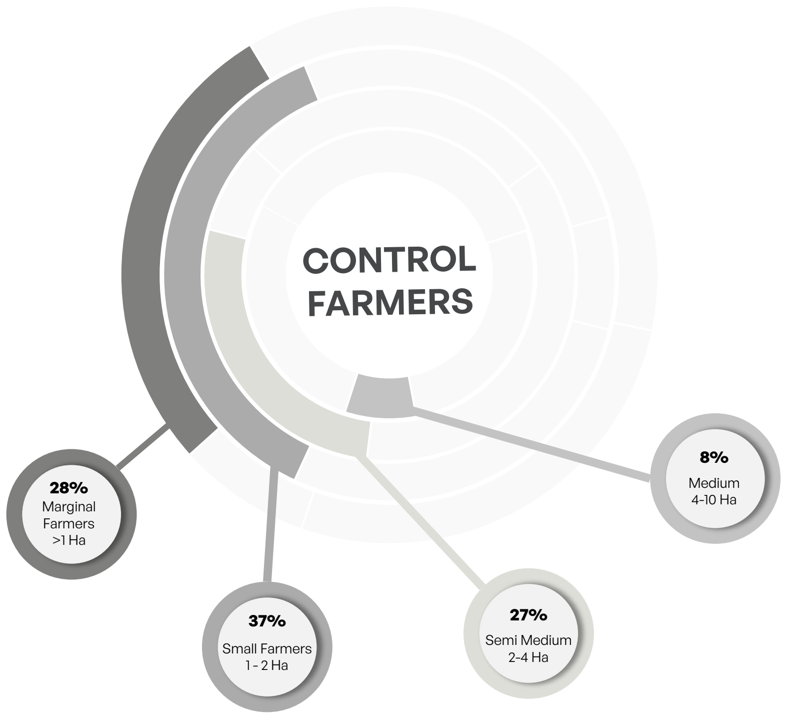

***Figure 7:** Land Holding of Control Farmers*

The highest percentage of farmers (33% in the control group, 32% in the FOIC group) are middle-aged, 40-50 years, followed by the age group of 51-60 years. The Control group has a higher percentage in the 20 to 30 age group than the FOIC farmers. Regarding gender distribution, FOIC farmers have a higher proportion of female farmers, with 10% being women compared to only 5% in the Control group. This indicates greater gender inclusivity among FOIC farmer samples.

Regarding educational qualifications, many farmers were found to be illiterate (21% in the FOIC group and 20% in the control group). Around 10% of farmers in both groups reported being literate without formal education. The highest percentage of farmers in both groups (32% in the FOIC group and 33% in the Control group) had formal educational qualifications below the eighth standard. Only 9% of the FOIC farmers group were graduates, compared to 6% of the control group.

Both FOIC and Control groups of farmers primarily consist of small farmers (1-2 ha), with a slight majority in the Control group, where 37% of farmers fall into this category compared to 35% in the Fairtrade group. Marginal farmers (<1 ha) are more prevalent in the Control group, with 28% compared to 23% in the Fairtrade group.

3.2. ANALYSIS BASED ON DELTA FRAMEWORK INDICATORS

This section covers the comparative analysis of indicators of the Delta Framework among four groups – (a) FOIC farmers (both Fairtrade Organic Certified and in-conversion farmers), (b) Control Farmers (both conventional farmers and organic farmers who are not certified by Fairtrade), (c) Fairtrade Organic certified farmers (Farmers who are under Fairtrade certification and also organic certified) and (d) Control conventional farmers.

The analysis focuses on comparing these four groups across various Delta Framework indicators.

USE OF HIGHLY HAZARDOUS PESTICIDES (HHPS)

The first indicator is the use of Highly Hazardous Pesticides. This indicator assesses the use of HHPs (20), such as Fipronil, Aldicarb, Benomyl, Carbendazim, Carbofuran, Dicofol, Endosulfan, Etoprophos, Lindane, etc. in cotton production. HHPs are of particular concern due to the severe adverse effects they can cause to human health and the environment, especially in developing countries where protective personal equipment is mostly unavailable, costly, and uncomfortable, where pesticides and application equipment are stored in homes, and where accidental or unintentional exposure to pesticides is common (Delta Framework Sustainability Indicators (2022))

***Table 4:** Percentage of Farmers Using HPPs*

CATEGORY OF FARMERS	FARMERS USING HHPS	SAMPLE SIZE
FOIC FARMERS*	0.3 %#	592
FAIRTRADE ORGANIC FARMERS	0 %	469
CONTROL FARMERS **	1.9 %	258
CONTROL CONVENTIONAL FARMERS	2.2 %	223

**FOIC Farmer samples include Fairtrade Organic Certified and Fairtrade in-conversion farmers*

***Control samples include Non-Fairtrade Organic farmers and Conventional farmers*

#Fairtrade response: The finding of HHP in Fairtrade Certified Producer Organisations has triggered the initiation of remedial measures at the concerned Producer Organisations. The condition on the ground would be monitored to ensure a more robust implementation of the Fairtrade Standards on Chemical Management.

Above table depicts the research finding that 2.2% of the conventional farmers in the control group use HHPs, the highest among the four groups. Only 0.3% of FOIC farmers use HHPs. These farmers reported using Fipronil, Beta-cyfluthrin, and Imidacloprid, which have been identified as highly hazardous pesticides by FAO and WHO. Although Fairtrade Standards prohibit the use of HHPs, some farmers reported the use of these HHPs, highlighting the need for greater sensitization and enforcement. The finding of HHP in Fairtrade Certified Producer Organisations has triggered the initiation of remedial measures at the concerned Producer Organisations; continuing to use these HHPs will otherwise result in suspension and decertification by FLOCERT. The condition on the ground would be monitored to ensure a more robust implementation of the Fairtrade Standards on Chemical Management. Importantly, no Fairtrade Organic farmers reported the use of HHPs.

PESTICIDE RISK INDICATOR

Sustainable farming systems incorporate the core principles of ecological pest management. This indicator is designed to track improvements in farm pesticide hazard/risk profile, serving as a measure and diagnostic tool to assess the adoption of effective and ecological pest management practices. [4]

A significant number of farmers in all groups—96% of FOIC and Fairtrade Organic farmers[4] , 64% of control farmers, and 60% of control conventional farmers are not using chemical pesticides.

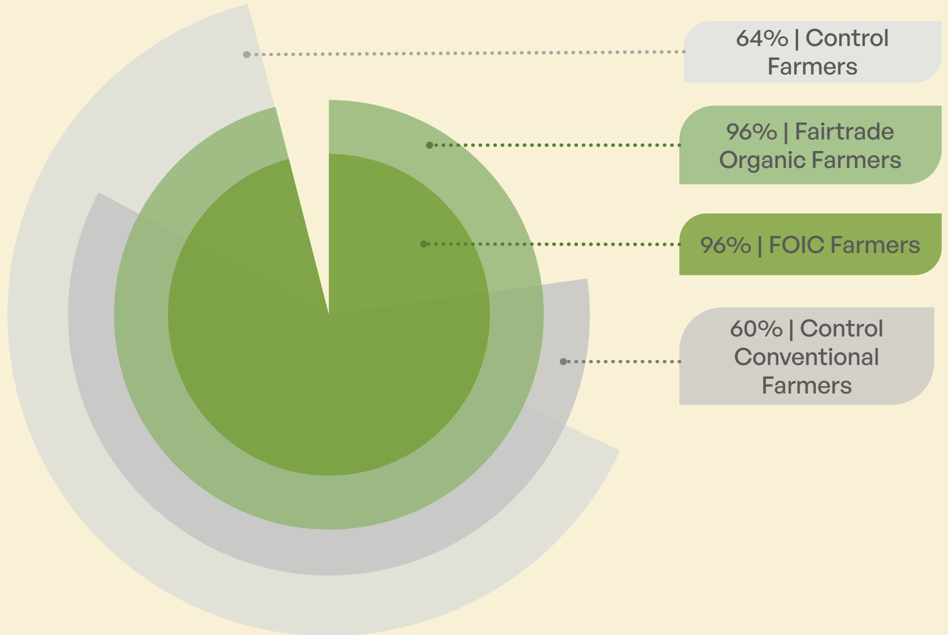

Figure 8: *Farmers not using Chemical Pesticides*

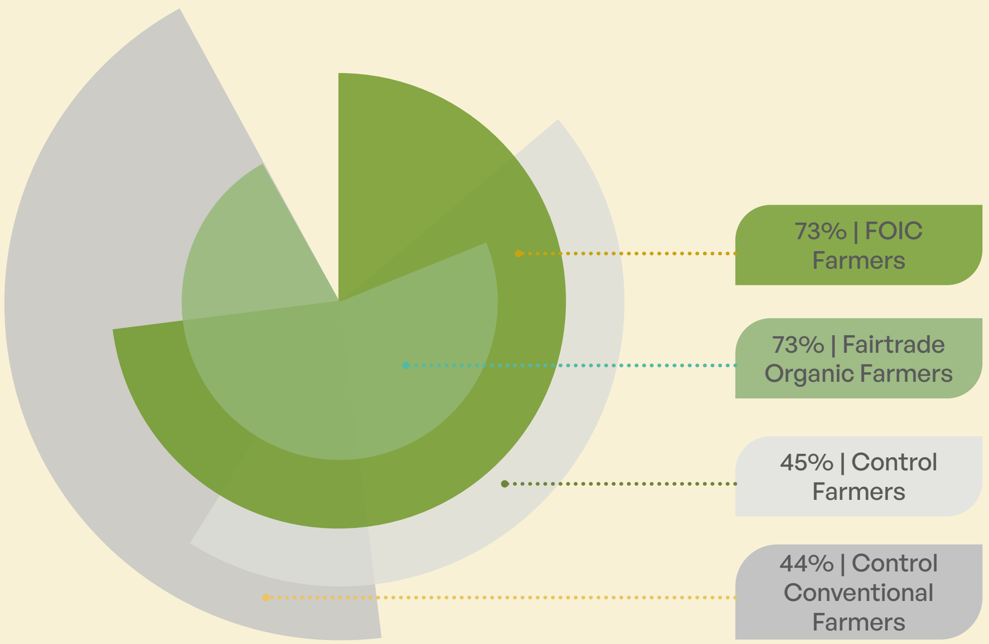

Figure 9: *Farmers using Intergrated Pest Management*

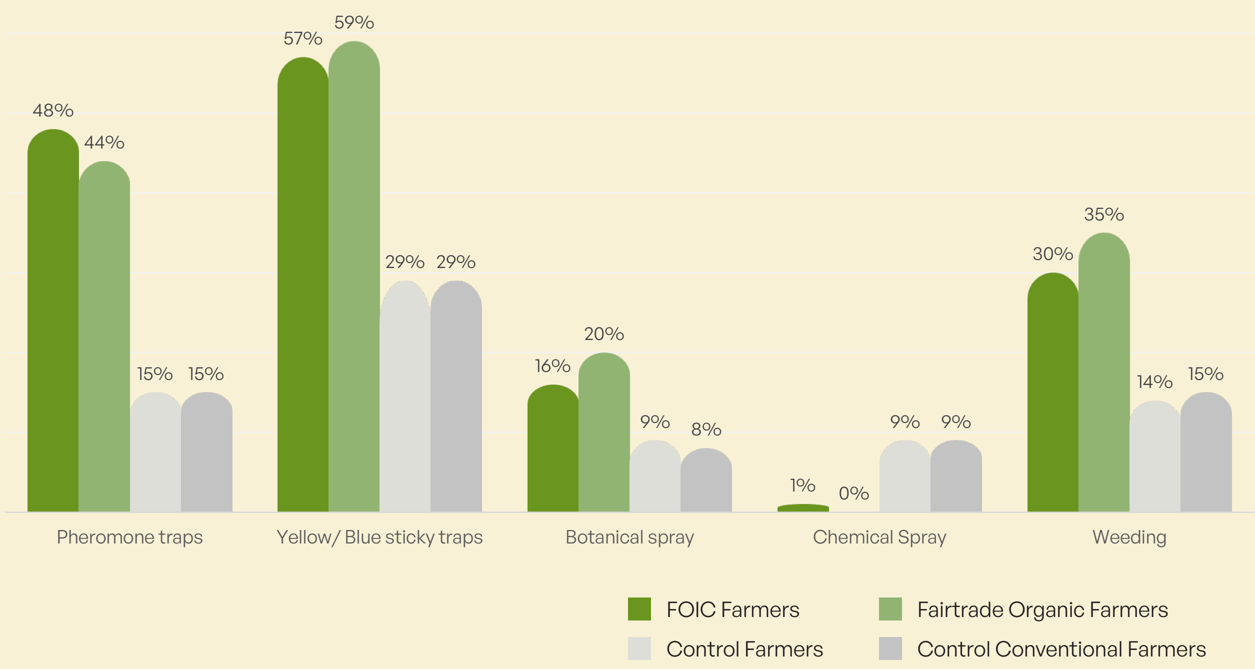

Figure 10: *IPM Methods of pest control used by Farmers*

Botanical Spray: Plant-based compound used for crop protection, e.g., Neem

Figure 11: *Farmers Using Home-Made / Other Biopesticides*

[4] *As per organic certification requirements 100% of the farmers should not be using chemical pesticides. This is a reason for concern and needs further investigation.*

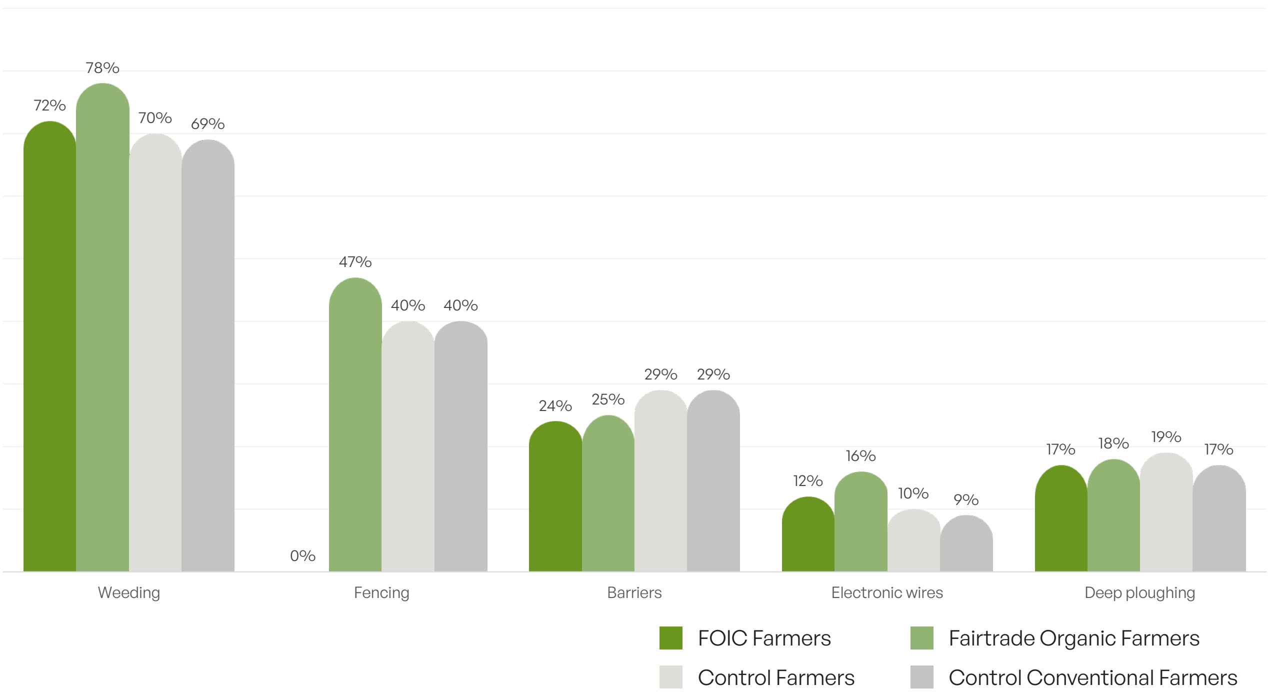

***Figure 12:** Mechanical Methods of Pest control used by farmers*

Instead of chemical pesticides, many farmers are opting for alternative methods such as biopesticides, Integrated Pest Management (IPM), and mechanical methods for crop protection. This trend indicates a growing awareness and adoption of more sustainable and environmentally friendly practices in pest management, enhancing ecological sustainability and protecting farm workers and the environment. Specifically, the data shows that 69% of FOIC and 70% of Fairtrade Organic farmers use homemade or biopesticides, compared to only 35% in the control group. Additionally, 73% of FOIC farmers have adopted IPM, compared to just 45% of the control group. These figures suggest that Fairtrade training, in combination with adopting organic practices of excluding synthetic pesticides, is significantly encouraging farmers to embrace sustainable practices. This transition benefits the environment and promotes healthier farming communities by minimizing exposure to harmful chemicals and fostering more sustainable agricultural practices.

WATER MANAGEMENT

This set of indicators assesses how effectively irrigation water is utilized on the farm. It includes the total amount of irrigation water used, the efficiency of water delivery (comparing water withdrawn or diverted from sources to the water used), and the amount of marketable biomass produced relative to the irrigation water used. [4]

For calculating these water-related parameters, the study employed the Cool Farm Tool, a widely recognized resource for assessing and improving the environmental impact of agricultural practices. This approach enabled a uniform and comprehensive analysis of water use efficiency among the study's participants.

Additionally, one of the crucial components for assessing the water management indicator is understanding the volume of water extracted for irrigation. However, collecting this data directly from farmers proved challenging, as farmers did not have precise water usage records. To address this, the study utilized key variables to estimate the volume of water used for irrigation: the depth of water extraction, the horsepower of the irrigation motor, and the duration for which the motor was operated. These variables were consistently applied across all farmers in the FOIC and control groups and all locations where water was extracted for irrigation.

Key parameters of water management are:

WATER PRODUCTIVITY KG /M³

Water productivity measures the efficiency of water used in agricultural production. It is the ratio of the amount of agricultural output to the amount of water used to produce that output. Essentially, it indicates how much crop is produced per unit of water use. High water productivity means more crops are produced with less water, a key goal in sustainable agriculture, especially in water scarcity areas.

IRRIGATION EFFICIENCY LITRE/LITRE

The study used the Cool Farm tool to calculate the irrigation efficiency. According to the Cool Farm tool, irrigation efficiency is defined as gross water added (not including rainwater) divided by the plant's total water requirement. Therefore, a lower irrigation efficiency value indicates higher efficiency, reflecting more effective use of water resources with less waste. It's important to note that rainfall does not affect the irrigation efficiency results. However, irrigation efficiency is zero in purely rainfed areas, as no additional water is supplied to the crop besides natural rainfall.

TOTAL WATER FOOTPRINT

Total water footprint means litres of freshwater required to produce one kilogram of seed cotton.

***Table 5:** Water Management Results*

CATEGORY OF FARMERS	FOIC FARMERS*	FAIRTRADE ORGANIC	CONTROL**	CONTROL CONVENTIONAL
SAMPLE SIZE	301	232	144	124
WATER PRODUCTIVITY KG / M³	0.30	0.32	0.25	0.25
IRRIGATION EFFICIENCY LITRE/LITRE	0.40	0.39	0.65	0.72
TOTAL WATER FOOTPRINT LITRE/KG	4410	3821	5229	5156

**FOIC samples include Fairtrade Organic Certified and Fairtrade in-conversion farmers*

***Control samples include non-Fairtrade Organic farmers and Conventional farmers*

The analysis of water management practices reveals notable differences between Fairtrade and Control farmers:

WATER PRODUCTIVITY

Fairtrade Organic farmers showcase the maximum water productivity at 0.32 kg/m^3, while FOIC farmers follow at 0.30 kg/m^3. Control and Control Conventional farmers have a 0.25 kg/m^3 water productivity which is lower than the FOIC farmers. Both Fairtrade groups have better results than the Control groups in every region, demonstrating that they produce more cotton per unit of water used, which indicates better management of water resources.

IRRIGATION EFFICIENCY

FOIC farmers exhibit better irrigation efficiency than Control and Control Conventional farmers. While the irrigation efficiency of both groups under the Fairtrade certification is almost the same (0.4), the control groups have irrigation efficiency of 0.65 for control and 0.72 for control conventional. As already discussed above, irrigation efficiency is represented by the ratio of gross irrigation to crop water requirements, and the lesser values indicate that the crop is less dependent on irrigation and potentially more reliant on other water sources, such as rainfall. FOIC farmers added less irrigation water than the crop's total water requirements. The irrigation efficiency has been calculated for areas receiving water from local/groundwater bodies and rainfall. Irrigation efficiency for rainfed-only areas is not considered in this analysis, as crops meet their water requirement solely through natural rainfall only, and no additional water is supplied to the crop aside from natural rainfall; therefore, irrigation efficiency is zero for these regions.

TOTAL WATER FOOTPRINT

The total water footprint analysis reveals significant differences in the water usage patterns among the various farmer groups. Fairtrade Organic farmers exhibit the lowest total water footprint at 3,821 litres per kilogram of cotton, closely followed by FOIC farmers at 4,410 litres per kilogram. In contrast, the Control and Control Conventional groups demonstrate much higher water footprints, with 5,229 and 5,156 litres per kilogram, respectively.

Reasons for Water Footprint Differences

HIGHER YIELD OF SEED COTTON

As per the survey data, Fairtrade and Organic Certified farmers generally achieve higher seed cotton yields. This higher yield directly impacts water productivity, as more cotton is produced per unit of water used. As a result, these farmers' water footprint per kilogram of cotton is lower.

REDUCED IRRIGATION LEVELS

As per the field research data, FOIC farmers tend to irrigate their farms less frequently than control farmers. This reduced irrigation can contribute to better water use efficiency, as it minimizes wastage and optimizes the use of available water resources, leading to a lower total water footprint.

The data underscores the efficiency and sustainability of water management practices among FOIC and Fairtrade Organic Certified farmers compared to Control farmers. These findings highlight the benefits of adopting Fairtrade and organic practices, which promote better environmental outcomes and contribute to the sustainable use of water resources in agriculture.

TOPSOIL CARBON CONTENT

This indicator assesses the Soil Organic Carbon (SOC), which is the main component of the Soil Organic Matter (SOM), in the top layer of the soil (0 - 10/30 cm) over time. SOM is increasingly being recognized for its contribution to nutrient cycling, water retention, biological function, and optimizing crop growth. It is the foundation of soil health, which is the ability of the soil to sustain the productivity, diversity, and environmental services of terrestrial ecosystems. (Delta Framework Sustainability Indicators (2022))

To assess the topsoil carbon content, an extensive soil testing program was done involving 210 soil samples collected from various farms within the study area. Out of 210 samples, 150 samples were of FOIC farmers, and out of those 150, 122 were of Fairtrade Organic farmers. The total samples of the control group were 60, out of which 54 were control conventional farmers.

LABORATORY FINDINGS

SOC percentages below 0.5% are considered low, while values between 0.5% and 0.75% are categorized as medium. Percentages above 0.75% are deemed high, indicating better soil health. Compared to these benchmarks, the OC percentages observed in our study for all groups are above 0.75% with no significant difference.

ADJUSTING SOC WITH BULK DENSITY

It is essential to adjust the SOC with bulk density to determine its value in kg/ha, which is widely used as an index of soil health. The weight of soil mainly depends upon the soil depth and porosity, as well as texture, structure, and organic matter content. These parameters are the governing factors for bulk density (ρb). Therefore, ρb must be considered for determining the soil weight as it nullifies the effect of soil porosity, structure and texture when interpreting data on SOC observed under different interventions.

The adjusted SOC content, which accounts for bulk density, reveals that the SOC content for FOIC farmers is 11.8 tonnes per hectare. For Fairtrade Organic farmers, it is 10.85 tonnes per hectare, while for control farmers, it is slightly higher at 11.88 tonnes per hectare. For control conventional farmers, it is highest at 12.4 tonnes per hectare.

As for comparison with wider SOC studies/experience in the country, the computed values, by and large, are near the SOC reported for soils from different parts of the country. The observed SOC content calls for the addition of different organic manures to maintain soil health on a sustainable basis.

Table 6: SOC Results

CATEGORY OF FARMERS	SAMPLE SIZE	OC %	SOC CONTENT TONNES/HA
FOIC FARMERS*	150	0.86%	11.8
FAIRTRADE ORGANIC FARMERS	122	0.80%	10.85
CONTROL FARMERS **	60	0.88%	11.88
CONTROL CONVENTIONAL FARMERS	54	0.89%	12.4
NORMAL RANGE		0.75-1%	

**FOIC samples include Fairtrade Organic Certified and Fairtrade in-conversion farmers*
***Control samples include non-Fairtrade Organic farmers and Conventional farmers*

In addition to SOC, two other soil tests were conducted to evaluate soil health comprehensively.

Table 7: Other Soil Results

	FOIC FARMERS*	FAIRTRADE ORGANIC	CONTROL**	CONTROL CONVENTIONAL	NORMAL RANGE
SAMPLE SIZE	150	122	60.00	54	
PH	6.70	6.5	7.10	7.07	6 - 8.5
EC (DS/M)	0.63	0.53	0.78	0.72	< 2

**FOIC samples include Fairtrade Organic Certified and Fairtrade in-conversion farmers*
***Control samples include non-Fairtrade Organic farmers and Conventional farmers*

Both FOIC farmers and the Control group have soil pH values within the normal range (6-8.5), with FOIC farmers showing a slightly better pH (6.70) than the Control group (7.10).

Soil Electrical Conductivity (EC) measures the concentration of water-soluble salts in the soil, a key indicator of mineral nutrients available to plants in the topsoil. This metric is crucial for assessing soil health as it influences crop yield and quality, plant nutrient availability, and soil microbial activity. High or low EC values can negatively impact crop growth. Elevated EC can create osmotic pressure that disrupts water uptake by the roots, potentially causing root damage or rot from pathogens like cotton rot fungus. Conversely, low EC values suggest insufficient levels of effective nutrients. Soil EC is affected by **planting practices, irrigation, land use, and applying fertilizers and manures.**

Intrinsic factors like soil minerals, climate, and texture also play a role. The Electrical Conductivity (EC) values for both groups are below the recommended limit (<2 dS/m), indicating good soil quality. The FOIC farmers and Fairtrade Organic farmers have a slightly better EC value (0.63 dS/m and 0.53 dS/m, respectively) compared to the Control farmers and control conventional farmers (0.78 dS/m and 0.72 dS/m respectively), which could be attributed to the high use of organic fertilizers and less irrigation.

QUANTITY OF FERTILIZER USED BY TYPE

The quantity and type of farm fertilizers are critical indicators of soil management practices and agricultural sustainability. The intensity of input use and its potential impact on soil health and environmental quality can be gauged by accounting for the types and amounts of synthetic nitrogenous fertilizers applied. This metric is a proxy for understanding farmers' approaches to soil fertility management and their efforts to optimize crop productivity while minimizing negative environmental effects, such as soil degradation and water pollution.

In this, the focus is only on synthetic nitrogenous fertilizers. Tracking the use of synthetic nitrogenous fertilizers provides valuable insights into pollution prevention strategies and helps identify areas where more sustainable practices could be implemented.

Below table reveals a marked difference in the use of synthetic nitrogenous fertilizers between FOIC farmers and Control farmers:

Table 8: Percentage of Farmers Using Synthetic Nitrogenous Fertilizers

CATEGORY OF FARMERS	FARMERS USING SYNTHETIC NITROGENOUS FERTILIZERS	SAMPLE SIZE
FOIC FARMERS*	5 %	592
FAIRTRADE ORGANIC FARMERS	0.6 %	469
CONTROL FARMERS **	79 %	258
CONTROL CONVENTIONAL FARMERS	91 %	223

**FOIC samples include Fairtrade Organic Certified and Fairtrade in-conversion farmers*
***Control samples include non-Fairtrade Organic farmers and Conventional farmers*

It was observed that 79% of the control farmers group and 91% of the control conventional farmers used synthetic nitrogenous fertilizers, compared to 5% of FOIC farmers. Moreover, the percentage of farmers using synthetic nitrogenous fertilizers in the Fairtrade Organic Certified group is just 0.6%. This sheer contrast underscores the reduced reliance on synthetic nitrogenous fertilizers and increased use of organic fertilizers among FOIC farmers. It can be attributed to the emphasis on sustainable farming practices within the Fairtrade framework. By avoiding synthetic nitrogenous fertilizers, FOIC farmers potentially reduce soil degradation, lower the risk of chemical runoff into water bodies, and decrease GHG emissions associated with fertilizer production and use. Furthermore, using organic fertilizers helps improve soil health and biodiversity, promoting a more sustainable and environmentally friendly agricultural practice.

Table 9: Major Synthetic Nitrogenous Fertilizers Used

SYNTHETIC NITROGENOUS FERTILIZERS	FOIC	FAIRTRADE ORGANIC	CONTROL	CONTROL CONVENTIONAL
DIAMMONIUM PHOSPHATE	2%	0.6%	30%	46%
UREA 46-0-0	4%	0.6%	43%	35%
NPK (10-26-26)	1%	0.6%	40%	48%

Below table delves into the details of the major synthetic nitrogenous fertilizers used by farmers, including Diammonium Phosphate (DAP), Urea, and NPK (10-26-26). Among FOIC farmers, only 2% use DAP, 4% use Urea, and 1% use NPK. In contrast, the usage rates among control farmers are significantly higher: 30% use DAP, 43% use Urea, and 40% use NPK. The lower percentage in the FOIC group is attributed to the increased reliance on organic fertilizers like vermicompost, farm manure, slurry, etc.

Table 10: Average Application of Synthetic Nitrogenous Fertilizers by Control Group

FERTILIZER'S NAME	APPLICATION RATE KG/HA
DIAMMONIUM PHOSPHATE 18-46-0	163
UREA 46-0-0	212
NPK (10-26-26)	161

Apart from the commonly used fertilizers, a small percentage of farmers in the control group also use other synthetic fertilizers. Specifically, 4% use Sulphur (0-0-0), 2% uses Ammonium Sulphate (21-0-0), Ammonium Phosphate Sulphate (20-20-0), NPK (19-19-19) and Zinc, 1% use Potassium Chloride (0-0-60). Additionally, less than 1% of the control group farmers use Sulphur-90, NPK (15-15-15), and NPK (12-32-16).

To reduce the reliance on synthetic nitrogenous fertilizers and promote more sustainable agricultural practices, several strategies are being employed by farmers:

RESIDUE COMPOSTING

Utilizing crop residues for composting can effectively recycle nutrients back into the soil, reducing the need for synthetic fertilizers.

USE OF COVER CROPS

Implementing cover crops or intercrops helps naturally enhance soil fertility and structure, which can decrease the need for synthetic fertilizer inputs.

ADOPTION OF ORGANIC FERTILIZERS

Shifting towards organic fertilizers can improve soil health and reduce environmental impacts compared to synthetic alternatives.

These practices contribute to more sustainable farming by minimizing environmental impacts, improving soil health, and lowering input costs and GHG emissions associated with synthetic fertilizers

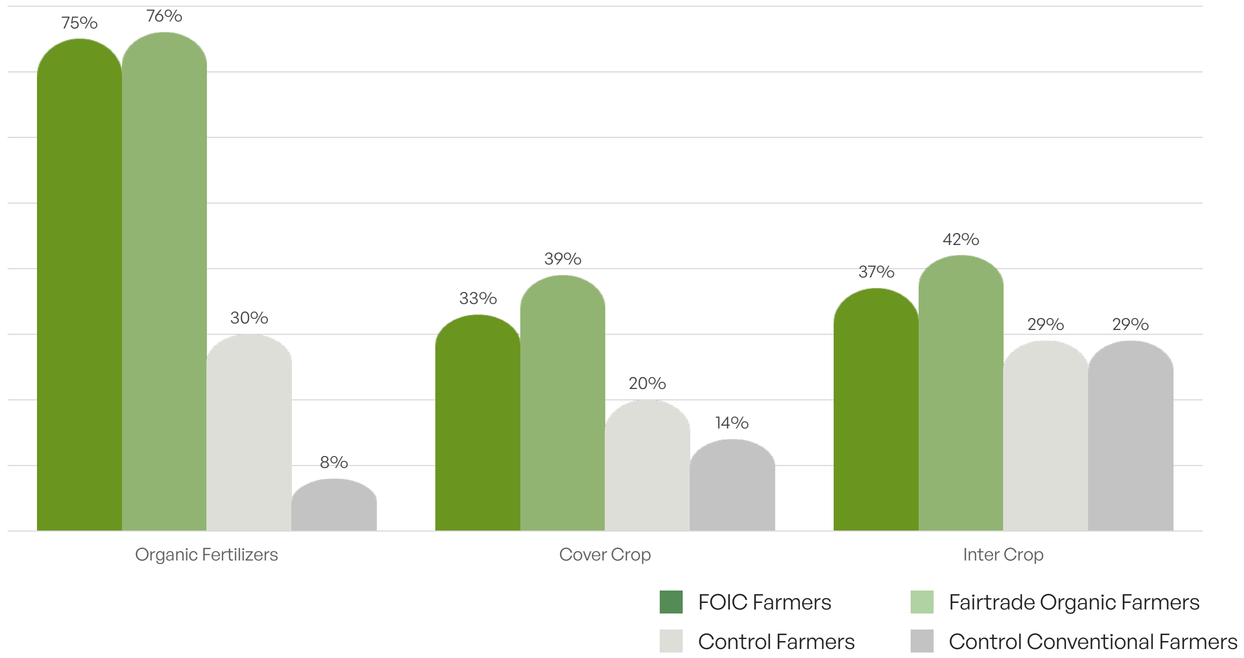

Figure 13: Fertilizer management measures adopted by farmers

A significantly higher percentage of FOIC farmers utilize organic fertilizers, cover crops, and intercropping methods than the Control group. These sustainable practices serve as alternatives to synthetic nitrogenous fertilizers and enhance soil fertility by improving soil organic carbon (SOC). Moreover, these sustainable practices also improve soil health and mitigate climate change by increasing carbon sequestration and reducing GHG emissions associated with traditional farming methods.

GREENHOUSE GAS EMISSIONS

GHG Emissions is a critical environmental indicator that assesses the impact of agricultural practices on climate change. High GHG emissions from farming activities contribute to global warming and climate instability. Assessing GHG emissions helps evaluate the environmental sustainability of agricultural practices and their contribution to climate change.

In this study, the Cool Farm Tool (CFT) has been utilized to assess GHG emissions. The tool is designed to evaluate emissions from different agricultural practices. The CFT provides a comprehensive analysis by calculating emissions from various sources, including soil management, fertilizer application, energy use, and transportation.

CO_2e (Carbon Dioxide equivalent) has been used as the unit of assessment for GHG emissions. It is the standardized unit that assesses the impact of different GHGs based on their global warming potential. It converts the quantities of various gases into an equivalent amount of carbon dioxide that would have the same impact on global warming, allowing for a consistent comparison of the climate impact of various gaseous emissions.

Results as per Cool Farm Tool

The analysis of GHG emissions among different farming practices shows a significant environmental advantage for FOIC farmers and Fairtrade Organic farmers compared to Control and Control Conventional farmers.

The data as per Table 11 indicates that Fairtrade Organic farmers have the lowest GHG emissions per hectare (862 kg CO_2e/ha), followed closely by FOIC farmers (1,025 kg CO_2e/ha). In contrast, Control and Control Conventional farmers exhibit much higher emissions, at 1,563 kg CO_2e/ha and 1,620 kg CO_2e/ha, respectively.

The trend is even more pronounced when examining emissions per kilogram of seed cotton. Fairtrade Organic farmers emit only 0.59 kg CO_2e per kilogram of seed cotton, while FOIC farmers emit 1.05 kg CO_2e/kg. These figures are significantly lower than those for Control (1.50 kg CO_2e/kg) and Control Conventional farmers (1.68 kg CO_2e/kg). This analysis underscores the environmental benefits of Fairtrade and organic practices, particularly in reducing GHG emissions, both per unit area and per unit of production.

Table 11: *GHG Emissions Results*

	FOIC*	FAIRTRADE ORGANIC	CONTROL**	CONTROL CONVENTIONAL
SAMPLE SIZE	301	232	144	124
KG CO_2E/HA	1025	862	1563	1620
KG CO_2E/KG OF SEED COTTON	1.05	0.59	1.50	1.68

**FOIC samples include Fairtrade Organic Certified and Fairtrade in-conversion farmers*

***Control samples include non-Fairtrade Organic farmers and Conventional farmers*

The analysis identified outlier samples from one region significantly influencing the overall GHG emission results. If these outlier samples are removed, the results for Fairtrade Organic remain unchanged; however, in this adjusted sample, FOIC farmers emit 844 kg CO_2e per hectare, while the Control group emits 1405 kg CO_2e per hectare, and the Control Conventional group emits 1442 kg CO_2e per hectare. With regards to emissions per kilogram of seed cotton, FOIC farmers had 0.6 kg CO_2e emissions per kilogram of seed cotton (as against Fairtrade Organic farmers 0.59 kg CO_2e) and 1.0 kg CO_2e emissions for the Control farmers and 1.1 kg CO_2e for Control Conventional farmers. These results highlight the lower carbon footprint associated with Fairtrade and organic practices in cotton farming compared to conventional methods. The reduced GHG emissions observed among FOIC farmers can be attributed to some key factors:

HIGHER TREE PLANTATION

FOIC farmers typically engage in more tree plantation activities, which is crucial in carbon sequestration. Trees absorb CO_2 from the atmosphere and store it, offsetting some of the emissions from farming activities. This practice contributes to lower carbon emissions, enhances biodiversity, and improves soil health.

REDUCED USE OF SYNTHETIC NITROGENOUS FERTILIZERS

The FOIC farmers adopted organic farming practices or used fewer synthetic nitrogenous fertilizers than control farmers. Synthetic nitrogenous fertilizers are a significant source of nitrous oxide (N_2O), a potent greenhouse gas. By reducing their reliance on synthetic nitrogenous fertilizers, FOIC farmers lower their overall GHG emissions. In contrast, the control group, which relies heavily on synthetic nitrogenous fertilizers, exhibits higher emissions per hectare and per kilogram of cotton seed.

Emissions by Sources per Hectare of Land

In this section, the average GHG emission from various sources on a per-hectare basis is examined. Emission from Crop Protection is not considered here because it was less than 1 kg/ha for all groups. Cool Farm Tool does not differentiate between the GHG impact of chemical and natural pesticides. The majority of FOIC farmers use homemade or bio-pesticides

Table 12: *GHG Emission by Source (kg CO_2e per ha & Percentage Contribution)*

	FOIC*		FAIRTRADE ORGANIC		CONTROL**		CONTROL CONVENTIONAL	
RESIDUE MANAGEMENT	377	27%	411	31%	405	22%	355	20%
FERTILISER PRODUCTION	151	11%	134	10%	245	13%	243	14%
FERTILIZER APPLICATION	224	16%	180	13%	507.5	28%	528	29%
ENERGY USE	661	47%	610	46%	660	36%	662.2	37%
OFF-FARM TRANSPORT	1.8	0%	1.7	0%	2.3	0%	2.1	0%
TOTAL	1414.8	100%	1336.7	100%	1819.8	100%	1790.3	100%
CARBON STOCK CHANGES	-390	-28%	-475	-36%	-257.6	-14%	-170.5	-10%

Carbon stock change is not considered or deducted while taking total and base for percentages

**FOIC samples include Fairtrade Organic Certified and Fairtrade in-conversion farmers*

***Control samples include non-Fairtrade Organic farmers and Conventional farmers*

RESIDUE MANAGEMENT

All groups show significant emissions from residue management, which involves the decomposition of crop residues. However, many FOIC farmers use composting more than Control farmers. This practice is beneficial as it recycles nutrients into the soil, reducing the need for chemical fertilizers. Although it contributes to emissions during composting, it ultimately helps reduce overall GHG emissions by improving soil health and reducing the need for synthetic inputs.

Table 13: *Residue Management Practices*

RESIDUE MANAGEMENT PRACTICES	FOIC*	FAIRTRADE ORGANIC	CONTROL**	CONTROL CONVENTIONAL
BURNED IN FIELD	4%	1%	23%	26%
INCORPORATED MULCHED	25%	29%	28%	26%
REMOVED FOR USE OR SALE	26%	20%	25%	26%
FORCED AERATION COMPOST (COMPOSTING WHERE AIR IS MECHANICALLY CIRCULATED)	8%	10%	8%	8%
LEFT UNTREATED IN HEAPS OR PITS	17%	14%	13%	12%
NON-FORCED AERATION COMPOST (COMPOSTING WHERE PILES ARE LEFT TO DECOMPOSE)	20%	24%	2%	2%

**FOIC samples include Fairtrade Organic Certified and Fairtrade in-conversion farmers*

***Control samples include non-Fairtrade Organic farmers and Conventional farmers*

FERTILIZER PRODUCTION

The production of organic and synthetic nitrogenous fertilizers is a significant source of GHG emissions. Although organic fertilizers generally produce lower emissions per kilogram, their higher application rates often diminish this advantage. Control farmers exhibit materially higher emissions compared to FOIC farmers. This difference is primarily because 29% of FOIC do not use any organic or synthetic fertilizer, whereas only 3.5% of control farmers fall into this category.

FERTILIZER USE

Emissions from soil and fertilizer use are significantly higher among control farmers, as 79% of control and 91% of control conventional farmers use synthetic nitrogenous fertilizers. In contrast, only 5% of FOIC farmers and just 0.6% of Fairtrade Organic farmers use synthetic nitrogenous fertilizers. Emissions from synthetic fertilizer use are higher than those from organic fertilizers, and most Fairtrade farmers are using organic fertilizers or none at all.

ENERGY USE

Emissions from using energy sources, such as electricity and fuel, for irrigation, machinery, and other farm activities. Energy use in field operations is a major source of emissions for all groups, with Control Conventional farmers showing slightly higher emissions.

OFF-FARM TRANSPORT

Emissions from transporting farm inputs and outputs, including cotton seeds and other agricultural products. Emissions from off-farm transport are minimal for all groups but slightly lower for FOIC farmers.

CARBON STOCK CHANGE

Carbon stock changes reflect carbon sequestration in soil and biomass. The negative values indicate a reduction in overall GHG emissions, with FOIC farmers sequestering more carbon than control farmers. This is due to higher tree plantation and among FOIC farmers.

YIELD

Yield is a crucial indicator in agricultural analysis as it measures the productivity of a crop. For cotton farming, yield is typically expressed in terms of the amount of Lint produced per unit area, such as kilograms per hectare (kg/ha). High productivity (yield) will likely enhance economic returns and alleviate pressure on scarce land resources, which could otherwise be linked to deforestation and the resulting loss of ecosystem services and biodiversity. The lint percentage of seed cotton is 35% for these calculations.

Table 14: *Yield of Lint*

CATEGORY OF FARMERS	YIELD OF LINT (KG/ HA)	SAMPLE SIZE
FOIC FARMERS*	547 (86-1730)	592
FAIRTRADE ORGANIC FARMERS	598 (86-1730)	469
CONTROL FARMERS **	530 (65- 1384)	258
CONTROL CONVENTIONAL FARMERS	534 (65-1087)	223
AVERAGE OF THE RESEARCH AREA STATES (2023-24)	465.92	-
NATIONAL AVERAGE (2023-24) (MINISTRY OF TEXTILES | GOI. (N.D.))	428.65	-

**FOIC samples include Fairtrade Organic Certified and Fairtrade in-conversion farmers*

***Control samples include non-Fairtrade Organic farmers and Conventional farmers*

Note: The values in the parentheses indicate the range for yields. The average yield of lint data (2023-24) for the study area and India have been taken from https://www.indiastat.com

The data reveals that all groups of farmers (FOIC, Fairtrade Organic, Control, and Control Conventional) outperform the national average lint yield of 428.65 kg/ha recorded for the 2022-23 season. The highest yield was observed in the Fairtrade Organic farmer group (598 kg/Ha), followed by the FOIC farmer group (547 kg/Ha). On average, Control group farmers had lower yields than the FOIC farmers group. The current findings on yield are consistent with the previous report on the Impact of Fairtrade Cotton Cultivation by MSSRF (2022), which recorded an average yield of lint cotton at 547 kg/Ha for Fairtrade Organic Certified farmers. However, it is important to note that the average yield for both the FOIC and Control groups is below the state average in some regions, surpassing the state average in others. The yield varies in study area states due to several factors such as type of soil, climate, variety of cotton sown, type of fertilizer and manure applied, duration of cropping period, and irrigation.

Implications of Yield Differences

Farmers from all groups show variability in their yields, with some achieving levels above state benchmarks and others falling below, but on average, Fairtrade Organic farmers have the highest yield. This variation influences the economic, environmental, and land use implications of their farming practices:

ECONOMIC BENEFIT

Higher yields typically lead to better economic returns for farmers. FOIC farmers are likely to experience greater financial benefits compared to control farmers. This enhanced productivity can improve livelihoods and economic stability for FOIC farmers.

LAND USE EFFICIENCY

Increased productivity reduces the pressure to expand agricultural land, helping to preserve natural ecosystems. With higher yields, FOIC farmers are more efficient in utilizing their available land, potentially reducing the pressures for deforestation and land conversion, which are often associated with biodiversity loss and degradation of ecosystem services.

ENVIRONMENTAL SUSTAINABILITY

By achieving higher yields through sustainable practices, FOIC farmers can demonstrate that it is possible to balance productivity with environmental stewardship. Practices leading to higher yields without exacerbating environmental issues can serve as models for broader agricultural sustainability initiatives.

PRICE (AT FARMGATE)

This indicator refers to the average price received per tonne of seed cotton. Price is a key measure of the economic health of the commodity sector. Analysing price trends over time and other economic variables can offer insights into price and income stability. The following table presents the results of the survey on cotton prices:

Table 15: *Cotton Price at the Farmgate*

CATEGORY OF FARMERS	AVERAGE PRICE OF SEED COTTON	
	₹ PER TONNE	$ PER TONNE
FOIC FARMERS*	73,600	885.5
FAIRTRADE ORGANIC FARMERS	74,900	901
CONTROL FARMERS **	70,900	853
CONTROL CONVENTIONAL FARMERS	71,000	854
MSP FOR COTTON MEDIUM STAPLE (2023-24) [10]	66,200	796.5
MSP FOR COTTON LONG STAPLE (2023-24) [10]	70,200	844.57

Conversion rate: ₹1 = 0.012031 $(average from August 2023 to Feb 2024)[5]

**FOIC samples include Fairtrade Organic Certified and Fairtrade in-conversion farmers*

***Control samples include non-Fairtrade Organic farmers and Conventional farmers*

The data reveals that FOIC farmers receive a significantly higher price for their cotton than non-Fairtrade farmers. This price premium directly benefits Fairtrade farmers, providing them with a better income. This difference can be attributed to the Fairtrade model, which includes a guaranteed minimum price and a Fairtrade Premium, ensuring farmers receive a fair return for their crop, which is only applicable when sales happen on Fairtrade terms.

[5] https://www.x-rates.com/average/?from=INR&to=USD&amount=1&year=2023

04 CONCLUSION

4.1. CONCLUSION

The findings of this study demonstrate that, regardless of changing demographics and agro-climatic conditions, the recommended cotton cultivation practices under Fairtrade and organic standards yield overall positive impacts for both farmers and the ecosystem.

The comparative analysis of Delta Framework indicators among FOIC farmers (both Fairtrade Organic Certified and Fairtrade in-conversion) and Control farmers (including Conventional and Organic non-Fairtrade) reveals several notable trends that underscore the environmental and economic benefits of Fairtrade and organic practices. The analysis spans various indicators such as pesticide use, water management, soil health, fertilizer application, greenhouse gas emissions, and yield, illustrating how Fairtrade and organic practices contribute to more sustainable and resource-efficient farming.

One key finding is that GHG emission is significantly lower among FOIC farmers, with Fairtrade Organic farmers showing the lowest emissions per hectare and per kilogram of cotton produced. This reduced carbon footprint is attributed to practices such as increased tree plantation, which aids in carbon sequestration, and a reduced reliance on chemical fertilizers, which are significant sources of greenhouse gases.

The use of highly hazardous pesticides (HHPs) is significantly lower among FOIC and Fairtrade Organic farmers, with only 0.3% of FOIC and no Fairtrade Organic farmers employing HHPs compared to 1.9% in the Control group and 2.2% in the Control Conventional group. This reduction indicates a significant decrease in health risks and environmental damage associated with the use of these substances. The Pesticide Risk Indicator also reveals that most farmers avoid chemical pesticides, favouring more sustainable alternatives like biopesticides and Integrated Pest Management (IPM). This trend underscores the effectiveness of both Fairtrade and organic practices in promoting environmentally friendly methods that protect farm workers and enhance ecological sustainability.

Water management practices further highlight the benefits of Fairtrade and organic farming. Fairtrade Organic farmers show the highest water productivity and efficiency, producing more cotton per unit of water used and exhibiting lower total water footprints than Control farmers. These outcomes are supported by the emphasis on sustainable water use in Fairtrade and organic practices, contributing to more efficient and environmentally conscious irrigation methods.

Soil health, as indicated by Soil Organic Carbon (SOC) levels, is relatively high across all groups, but FOIC farmers exhibit slightly lower SOC content than their Control counterparts. However, this minor difference does not undermine the broader benefits of Fairtrade practices. The reduced reliance on synthetic nitrogenous fertilizers among FOIC farmers—only 5% use such fertilizers compared to up to 91% in the Control Conventional group—reflects a commitment to organic practices that improve soil health and reduce environmental pollution.

Average Yield analysis generally shows that Fairtrade Organic farmers achieve higher productivity than the national average and outperform Control groups. However, at a regional level, there are instances where the yields of FOIC and Fairtrade Organic farmers fall below their state averages and those of Control groups. Despite these regional variations, the overall high yield and the added Fairtrade Premium underscore the economic advantages of integrating Fairtrade and organic practices.

The Fairtrade Standards and Certification provide multiple avenues of support that contribute to the achievement and strengthen the implementation of Organic Certification. One key area is the development of management systems at the Farmer Producer Organizations (FPOs), which aid in building the Internal Control Systems (ICS) for both Fairtrade and Organic Certification. Another significant convergence is the common requirement for the non-use of GMO seeds, a principle supported and reinforced through the Fairtrade Premium by many Producer Organisations.

Additionally, many producer organizations have used the Fairtrade Premium to develop infrastructure that supports organic farming practices, including establishing organic input centres for producing vermicompost and preparing neem-based pesticides. In some cases, it also contributes to investments in mechanical pest management systems and covers the costs associated with Organic Certification for certain groups, further demonstrating the support of the Fairtrade Certification system for achieving organic certification. This demonstrates how Fairtrade aligns with and actively facilitates the implementation of organic farming standards.

Fairtrade's emphasis on sustainable practices and the financial support provided through the Fairtrade Premium fosters the development and implementation of effective Organic farming systems. This synergy enhances environmental outcomes and ensures farmers receive better economic returns, illustrating the comprehensive benefits of integrating Fairtrade and Organic practices in cotton farming.

4.2. RECOMMENDATIONS FOR THE FUTURE RESEARCH

1

OPTIMAL TIMING FOR DATA COLLECTION

Future research should be scheduled so that the data collection and interviews are done when farmers are less engaged with critical farming activities, such as harvest or sowing, to ensure greater availability and participation. Additionally, timing is crucial in soil sample collection, as different seasons or farming stages can significantly affect soil conditions.

2

REPRESENTATION OF NON-FAIRTRADE ORGANIC FARMERS

To compare and decouple the impact of Fairtrade Certification, future research could work on a higher sample size of Non-Fairtrade Organic farmers. This would enable a more balanced comparison across different farming practices and more robust conclusions. To have more balanced and attributable conclusions would also reduce the potential for overclaiming in communication if effects could be attributed to either Fairtrade or Organic Certification. In light of the forthcoming EU Green Claims Directive, it will be essential to be precise and correct about any environmental claim made.

3

COLLECTING GEOSPATIAL DATA

Additional research could be done by incorporating field-based data collection or utilizing advanced remote sensing technologies to accurately capture geospatial data, particularly for indicators such as “Forest, Wetland, and Grassland Conversion,” which require precise geo-location information.

4

GHG MITIGATION IN COTTON FARMING

The study has quantitatively captured the GHG mitigation potential of cotton cultivated by FOIC farmers. This contributes to India’s low-carbon pathway and helps achieve carbon neutrality in the long term. This knowledge can be disseminated across all stakeholders, including regulatory administrative and academic institutions, for further replication and scale-up.

5

GHG REDUCTION PATHWAY

The lessons learnt from this study can be utilized to further reduce the GHG footprint of cotton cultivation by looking into relatively high emissive aspects such as energy use and residue management.

6

EXPLORING GREEN CREDITS

Given the distinctly lower GHG emissions of FOIC farmers, further explorations could be undertaken to evaluate the viability of generating green credits/carbon credits as nature-based solutions, considered top contributors to global climate action. This can bring additional revenue to the farmers over and above the Fairtrade Premium.

7

ENHANCING SOIL ORGANIC CARBON

The research highlighted slightly lower Soil Organic Carbon (SOC) levels among FOIC and Fairtrade Organic farmers than in Control groups. To address this, future initiatives should promote advanced soil health management to enhance SOC levels further.

8

OPTIMIZING WATER USE

The Fairtrade Organic farmers demonstrate higher water productivity and efficiency. Future efforts should emphasize implementing precision irrigation technologies and practices to build on this success. Encouraging the use of drip irrigation and developing rainwater harvesting systems can help optimize water use and reduce total water footprints in cotton cultivation.

ANNEXURES

Appendix

Water Management Results per kg of Lint:

	FOIC FARMERS*	FAIRTRADE ORGANIC	CONTROL**	CONTROL CONVENTIONAL
SAMPLE SIZE	301	232	144	124
WATER PRODUCTIVITY KG /M^3	0.1	0.11	0.08	0.08
TOTAL WATER FOOTPRINT LITRE/KG	12599	10916	14939	14730

*FOIC samples include Fairtrade Organic Certified and Fairtrade in-conversion farmers

**Control samples include non-Fairtrade organic farmers and Conventional farmers

GHG Results per kg of Lint without including emission from ginning

	SAMPLE SIZE	KG CO_2E/KG OF LINT
FOIC*	301	3.0
FAIRTRADE ORGANIC	232	1.7
CONTROL**	144	4.3
CONTROL CONVENTIONAL	124	4.8

*FOIC samples include Fairtrade Organic Certified and Fairtrade in-conversion farmers

**Control samples include non-Fairtrade organic farmers and Conventional farmers

GHG Results per kg of Lint including emission from ginning:

	SAMPLE SIZE	KG CO_2E/KG OF LINT
FOIC*	301	3.33
FAIRTRADE ORGANIC	232	2.03
CONTROL**	144	4.63
CONTROL CONVENTIONAL	124	5.13

*FOIC samples include Fairtrade Organic Certified and Fairtrade in-conversion farmers

**Control samples include non-Fairtrade organic farmers and Conventional farmers

Emissions from ginning are taken 0.33 kg CO_2e per kg of lint, this value is taken from "Study of Greenhouse Gas Emissions of Better Cotton" [2] where the average emission from Ginning in India is 8% of all emissions which is 4.076 CO_2e per kg of lint. 8% of 4.076 ≈ 0.33

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Notes

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Designed by: Hues & Splash (Samruddhi Nilawar)
Email Id: huesandsplash@gmail.com