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Preface

We would like to present, with great pleasure, the inaugural volume-10, Issue-6, June 2024, of a scholarly journal, *International Journal of Environmental & Agriculture Research*. This journal is part of the AD Publications series *in the field of Environmental & Agriculture Research Development*, and is devoted to the gamut of Environmental & Agriculture issues, from theoretical aspects to application-dependent studies and the validation of emerging technologies.

This journal was envisioned and founded to represent the growing needs of Environmental & Agriculture as an emerging and increasingly vital field, now widely recognized as an integral part of scientific and technical investigations. Its mission is to become a voice of the Environmental & Agriculture community, addressing researchers and practitioners in below areas.

Environmental Research:

Environmental science and regulation, Ecotoxicology, Environmental health issues, Atmosphere and climate, Terrestric ecosystems, Aquatic ecosystems, Energy and environment, Marine research, Biodiversity, Pharmaceuticals in the environment, Genetically modified organisms, Biotechnology, Risk assessment, Environment society, Agricultural engineering, Animal science, Agronomy, including plant science, theoretical production ecology, horticulture, plant, breeding, plant fertilization, soil science and all field related to Environmental Research.

Agriculture Research:

Agriculture, Biological engineering, including genetic engineering, microbiology, Environmental impacts of agriculture, forestry, Food science, Husbandry, Irrigation and water management, Land use, Waste management and all fields related to Agriculture.

Each article in this issue provides an example of a concrete industrial application or a case study of the presented methodology to amplify the impact of the contribution. We are very thankful to everybody within that community who supported the idea of creating a new Research with *IJOEAR*. We are certain that this issue will be followed by many others, reporting new developments in the Environment and Agriculture Research Science field. This issue would not have been possible without the great support of the Reviewer, Editorial Board members and also with our Advisory Board Members, and we would like to express our sincere thanks to all of them. We would also like to express our gratitude to the editorial staff of AD Publications, who supported us at every stage of the project. It is our hope that this fine collection of articles will be a valuable resource for *IJOEAR* readers and will stimulate further research into the vibrant area of Environmental & Agriculture Research.

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Agricultural Sciences	
Soil Science	Plant Science
Animal Science	Agricultural Economics
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Crop Production	
Cereals or Basic Grains: Oats, Wheat, Barley, Rye, Triticale, Corn, Sorghum, Millet, Quinoa and Amaranth	Oilseeds: Canola, Rapeseed, Flax, Sunflowers, Corn and Hempseed
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Vegetable crops or Olericulture: Crops utilized fresh or whole (wholefood crop, no or limited processing, i.e., fresh cut salad); (Lettuce, Cabbage, Carrots, Potatoes, Tomatoes, Herbs, etc.)	Tree Fruit crops: apples, oranges, stone fruit (i.e., peaches, plums, cherries)
Tree Nut crops: Hazlenuts. walnuts, almonds, cashews, pecans	Berry crops: strawberries, blueberries, raspberries
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Livestock Production	
Animal husbandry	Ranch
Camel	Yak
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Goats	Poultry
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Dairy Sheep	Water Buffalo
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Maple syrup	Forestry Growth
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Environmental science and regulation	Ecotoxicology
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Evaluation of *Trichoderma Asperellum* Mass Production and Shelf Life in Talc Formulation

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Abstract— *Anthracnose of chilli has been reported to cause more than 50 % of yield loss in Malaysia. The popular approach for disease management of chilli is by the integration of several practices such as cultural, mechanical, chemical and biological control. With the current awareness of the importance of healthy and natural product, more chilli farmers and consumers are showing interest on safer pest and disease control practices. In this study, Trichoderma asperellum has been identified as an excellent biocontrol agent against Colletotrichum spp, the causal agent of anthracnose disease. To be able to be used in the field, it was mass-produced and then formulated in talc. Studies on liquid substrates for mass production of T. asperellum and shelf life for the talc formulation were conducted to evaluate the spore viability. Results showed formulation added with 5% glycerol gave highest initial colony forming unit (CFU) (2.33x 10^8) of T. asperellum and retained the spore count at 1.12 x 10^6 after 120 days of storage.*

Keywords— Mass production, shelf life, talc formulation, Trichoderma.

I. INTRODUCTION

Plant diseases are one of the major concerns in cultivation worldwide consequential in loss of billions of dollars of farm produce. There is an urgent need to manage diseases to ensure a steady and constant supply of marketable products for the escalating world population. In disease management, the amplified use of chemicals has caused negative impact on environmental quality and resulted in the upward trend of many living forms which are resistant to the chemicals [1]. *Trichoderma* as a powerful fungal biocontrol agent against a range of phytopathogens has attracted considerable scientific attention. Several Trichoderma species such as *T. harzianum* have been used as BCA against *Colletotrichum,* the causal agent of anthracnose in greenhouse and field conditions [2]. Commercial success of biocontrol agent depends on its bioefficacy or shelf life but also the substrate for multiplication. The production of adequate quantities of high-quality inoculum is a key component of the biological control program [3]. Growth and sporulation of Trichoderma on cheap and suitable substrates would provide an economical method for mass production of biocontrol agents. A formulated product should be easy to be prepared and stable during transportation and storage. It should have abundant viable propagules with good shelf life. Various substances like talc have been used to formulate the biocontrol agents. As most of the previous studies have emphasized on use and mass production of *T. harzianum* and *T. viride* for the control of pathogens, whereas, other Trichoderma species have received comparatively less such as *T. asperellum*. Therefore, the purpose of this study is to determine the effect of different liquid substrate on mass production and shelf life of the talc powder formulation of *T. asperellum* at different time storage to ensure the viability of the spore.

II. MATERIALS AND METHODS

2.1 Biocontrol agent

Trichoderma asperellum was isolated from a healthy chilli plant rhizosphere cultivated in MARDI Organic Farm, Serdang, Selangor, Malaysia and was used against anthracnose disease of chilli in an *in vitro* experiment. The culture was maintained on potato dextrose agar slant. The identification of the *T. asperellum* was done through DNA sequencing and the sequence was submitted to NCBI GenBank with the given accession number (MW148407).

2.2 Mass multiplication of *T. asperellum*

Two types of broth as the liquid medium; Potato Dextrose Broth and Molasses-Brewer yeast were tested for mass production of *T. asperellum*. The broths were prepared in triplicates each in 250 ml Erlenmeyer flask. The medium was inoculated with 2 discs of 5 mm of 7 days old culture of *T. asperellum* and incubated in an incubator shaker for 14 days at 27±1ºC. The spore content in the broths were evaluated on the final day by using hemocytometer. Liquid medium with higher spore concentration was chosen to be used in mass-producing *T. asperellum* before being added to the talc powder.

2.3 Formulation development and shelf life of the final product

Upon harvest, the broth was added with glycerol before being mixed with the talc powder and carboxymethyl was added as the sticker agent. The talc was air-dried for less than 8% of moisture content. The final formulated products packed in a polythene bag of 500 g/ pack and then stored at room temperature. The spore count of the formulated products was evaluated every 30 days and assessed by serial dilution technique. The product was serially diluted up to 10^8 concentration and 1 ml was poured in sterilized petri plates. Thereafter, a selective medium (*Trichoderma* Selective Media) was poured at 20 ml/plate. Plates were rotated horizontally for uniform distribution of inoculum and incubated at 28±1 ºC for 48 hours and the numbers of the colony were counted [5].

2.4 Statistical Analysis

All data were subjected to a one way analysis of variance (ANOVA). Treatment means were compared using Duncan Multiple Range test at a significance level of $P<0.05$ using SAS.

III. RESULTS AND DISCUSSION

Table 1 showed molasses-brewer yeast broth yielded the highest concentration of *T. asperellum (10^8)* compared to the potato dextrose broth (10^7) after 14 days of the incubation period. This is similar to a study by [6] where molasses yeast extract broth was found beneficial for the maximum growth of *T. viride* compared to the potato dextrose broth. Our results were also in accordance with a study by [7] who found out the maximum colony growth of *T. polysporum* was obtained on sucrose followed by dextrose, glucose and maltose amended media. According to [8] cane molasses has the potential as a cost-effective carbon source that could serve as nutrients for industrial enzyme-producing microorganisms, especially filamentous fungi. [9] also produced biomass of fungal antagonists by liquid fermentation by using molasses and brewer's yeast medium. Yeast is known to be a superior nitrogen source for *Trichoderma* spore formation and it was chosen instead of an inorganic nitrogen. Yeast is required for microbial cultivation as it offers some additional growth factors like vitamins and amino acids [10]. Submerged liquid fermentation is the best way to mass produce *Trichoderma* for large scale production compared to the solid medium. Maximum growth and a greater percentage of survival during storage are important benefits for the commercial marketing of biocontrol agents. Many factors like medium and inoculum type [11], method of drying, the addition of protectants [12] and environmental conditions during storage [13] affect the viability of the formulation derived from liquid fermentation.

TABLE 1
COLONY FORMING UNIT (CFU) OF *T. ASPERELLUM* IN DIFFERENT LIQUID MEDIUM

Type of liquid medium	*T. asperellum* spore concentration (x 10^8/ml)	
	7 days	14 days
Molasses and Brewer yeast	0.34	1.03
Potato Dextrose Broth	0.36	0.46

To avoid possible contamination during storage, the whole biomass of *T. asperellum* were dried after mixing with talc (Figure A). The fungal biomass has to be desiccation tolerant besides having high spore viability. Glycerol can induce trehalose production and provide the desiccation tolerance in the osmoticum of the production medium. Table 2 showed talc formulation added with 5% glycerol had highest yield of cfu/g (2.34 x10^8) compared to formulation without glycerol and talc formulation retained its colony forming unit (cfu) on *Trichoderma* Selevtive Agar (TSM) of at least 3.6x 10^6 at room temperature after 120 days of storage (Figure B). Gradually decline of CFU in talc formulation were also determined in a similar study by [14] where the CFU count of *T. harzianum* in talc formulation was initially at 3.2 x 10^8 and gradually decline to 3x10^7 after 120 days of storage. [15] also found decreased CFU of *T. harzianum* from 2.0 x 10^8 cfu/g to 2.6 x 10^6 cfu/g after 80 days of storage at 10ºC temperature. Talc formulation of *T. harzianum* yielded at 2.2 x10^7 after 60 days of storage and this was found similar to our result where CFU of *T. asprellum* resulted at 2.1 x 10^7 at 60 days of storage at the room temperature [16]. The addition of glycerol in production medium prolonged the shelf-life of talc formulation as it helps to maintain a high moisture content in the formulation and protects the viable propagules from reduced water activity during the shelf life [17]. In their study, shelf life of formulation was extended to 7 and 12 months by addition of 3% and 6% glycerol to the production media, respectively, compared to formulation without glycerol which only prolonged the shelf life up to 4 to 5 months. A seed treatment of chickpea was carried out with *T. harzianum* with talc, kaolin and bentonite as carriers [18]. The study concluded the fungus had longer shelf life in talc however a significant decline of *Trichoderma* population also reported after 120 days. *T. harzianum* in talc-based powder formulation remained viable at temperatures ranging between 0 to 40ºC for 180 days [19]. The viability of formulated products during the first 6 months at room temperature would be sufficient for use under realistic conditions of storage, humidity and delivery as reported by [20]. Our *T. asperellum* talc formulation retained the spore viability at 10^6 at 120 days of storage and it complies to the minimum population of fungal bioagent in formulation for seed treatment which is more than 10^6 cfu/g [21]. A study by [22] also stated *Trichoderma* conidia in biocontrol products typically range from 1×10^5 to 1×10^9 colony-forming units (CFU) per gram of product.

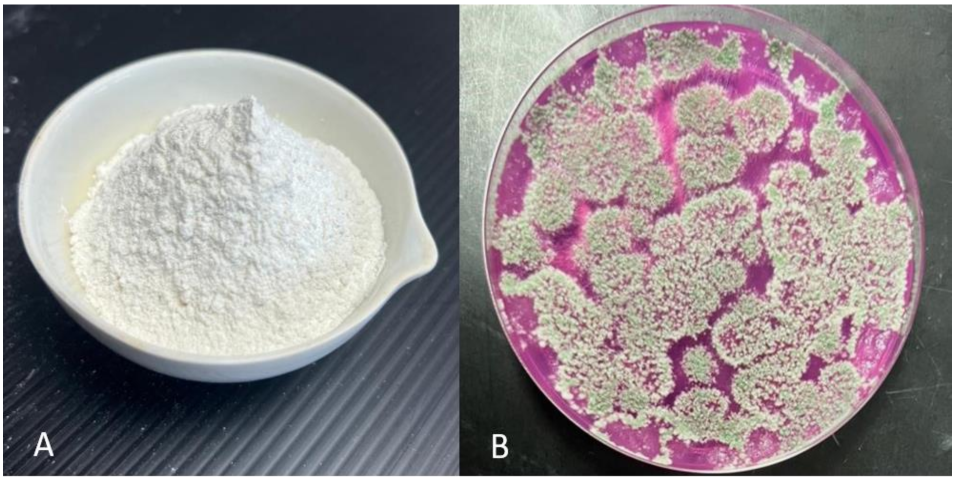

FIGURE: A) Talc formulation of *T. asperellum*; B) The colony of *T. asperellum* on TSM agar

TABLE 2
SHELF LIFE OF *T. ASPERELLUM* TALC POWDER FORMULATION AT DIFFERENT TIME STORAGE (x10^7)

	Day 0	Day 30	Day 60	Day 90	Day 120
Control	2.4b	1.4b	0.3b	0.18a	0.12a
3% glycerol	8.6b	5.8b	1.2a	0.26a	0.14a
5% glycerol	23.4a	11.6a	2.1a	0.84a	0.36a

Means with the same letter in a column are not significantly different (P<0.05) as determined by DMRT

IV. CONCLUSION

The present study indicated the suitability of different liquid medium and talc powder as carrier materials for the commercial preparation of *Trichoderma asperellum*. Microbial count for talc-based formulations of *T. asperellum* was highest initially at ambient temperature but a gradual decline was recorded with the increase in the storage time.

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Analyzing the Pattern of Organic Farming in Gujarat and Madhya Pradesh: A Review

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Abstract— *This article explores the concept of organic agriculture, highlighting its core principles and outlining the certification process. Organic agriculture is a holistic approach to food production that prioritizes the well-being of soil, ecosystems, and individuals. It emphasizes natural processes, biodiversity, and minimal external inputs to cultivate healthy crops and promote environmental sustainability.*

The article also details the certification process for organic farms, outlining the steps involved in complying with organic standards and obtaining official certification.

Keywords— Organic agriculture, Sustainable agriculture, Organic farming principles, Organic certification, IFOAM principles of organic agriculture, Soil health, Biodiversity in agriculture.

I. INTRODUCTION

1.1 Organic Agriculture:

"Organic Agriculture" a generation framework that supports the well-being of soils, environments and individuals. It depends on biological forms, biodiversity and cycles adjusted to nearby conditions, or maybe than the utilize of inputs with antagonistic impacts. Organic Agriculture combines convention, development and science to advantage the shared environment and advance reasonable connections and a great quality of life for all included.

1.2 Principles of Organic Agriculture by IFOAM:

1.2.1 Principle of Health:

According to this principle the health of individuals and communities cannot be isolated from the well-being of biological systems. Solid crops created by sound soil will cultivate the well-being of creatures and individuals. Well-being is not basically the nonattendance of sickness, but the upkeep of physical, mental, social and environmental well-being. Resistance, strength and recovery are key characteristics of well-being.

1.2.2 Principle of Ecology:

Principle of Ecology states that generation is to be based on environmental forms and reusing. Through the biology of the particular generation environment, food and well-being are accomplished. E.g. in the case of crops this is the living soil; for creatures it is the cultivate environment; for fish and marine organisms, the aquatic environment.

1.2.3 Principle of Fairness:

The rule of fairness emphasizes on those who are included in natural agribusiness ought to treat human connections in such a way which guarantees fairness at all levels and to all parties – agriculturists, specialists, processors, wholesalers, dealers and customers. Destitution diminished, commitment for nourishment sway, great quality of life ought to get conveyed through organic agribusiness.

1.2.4 Principle of Care:

Organic agriculture specialists can increment proficiency and efficiency, but care ought to be taken that well-being and prosperity are not at chance of jeopardizing. This guideline states that safeguard and obligation are the key concerns in administration, advancement and innovation choices in natural horticulture. Science is essential to guarantee that natural agribusiness is sound, secure and biologically sound. In any case, logical information alone is not adequate. Viable involvement, amassed intelligence and conventional and innate information offer substantial arrangements, tried by time.

- **Certified organic**: Items carrying a image, symbol or other exchange stamp to appear that they are certified natural. This certification is given by different private bodies, independent bodies or NGO which may or may not be authorize to Government organic Program of that country. The least benchmarks required to get certification may shift nation to nation.
- **Claimed organic**: Some of the time without any certification individuals claimed their items as an organic. An organic claim is any claim that portrays a item as natural, or the fixings utilized to make an item as an organic without any certification.
- **Seen organic**: This is a common understanding between dealer and buyer. The buyer has seen by itself so it appears believe on item as an organic. Now and then it is called organic since it is tried by organic firms.
- **From forest:** Sometimes the produces which are straight forwardly gotten from woodland are moreover considered as an natural.
- **Virgin land:** If the land utilized for the getting produces have never been uncovered to any manufactured chemicals at that point such a land considered as a virgin land so the yields are considered as an natural.
- **Natural farming:** If rancher is utilizing characteristic sources which as of now exist in nature by default. E.g. bovine waste, leaf fertilizer, etc. Such produces are too called as an natural.
- **No inputs used:** Sometimes land is cleared out untreated without any inputs utilized. So the plants develop on their possess and produces are still considered as organic.

II. THE CERTIFICATION PROCESSES

To certify a farm, the farmer must undertake several additional activities alongside regular farming operations:

- **Study -** Familiarize oneself with organic standards, which detail the permitted and prohibited practices for all aspects of farming, including storage, transport, and sales.
- **Compliance -** Ensure that farm facilities and production methods adhere to these standards, which may require modifying facilities, changing suppliers, and other adjustments.
- **Documentation -** Maintain thorough paperwork that includes farm history, current setup, and typically, results from soil and water tests.

- **Planning -** Submit an annual production plan outlining every detail from seed to sale, including seed sources, field and crop locations, fertilization and pest control activities, harvest methods, and storage locations.
- **Inspection -** Undergo annual on-farm inspections, which involve a physical tour, record examination, and an oral interview.
- **Fee -** Pay a fee to the certification body for annual monitoring and for the certification mark, which is recognized in the market as a symbol of quality.
- **Record-keeping -** Keep detailed, daily records of farming and marketing activities, which must be available for inspection at any time.

Additionally, farmers must be prepared for short-notice or surprise inspections and may need to conduct specific tests, such as those on soil, water, or plant tissue, upon request.

2.1 Certification & Product Labeling

Certification aims to protect consumers from the misuse of the term "organic" and simplify the process of purchasing organic products. However, the organic labels made possible through certification often require additional explanation.

In many countries, organic legislation defines three levels of organic products. Products made entirely with certified organic ingredients and methods can be labeled "100% organic." Those with 95% organic ingredients can use the term "organic," and both of these categories may display the organic seal. A third category, containing at least 70% organic ingredients, can be labeled "made with organic ingredients." Products with less than 70% organic ingredients cannot advertise this on the front label but can list it in the ingredients statement.

2.2 Participatory Guarantee Systems (PGS) by the National Program for Organic Production (NPOP)

According to the International Federation of Organic Agriculture Movements (IFOAM) definition from 2008, "Participatory Guarantee Systems are locally focused quality assurance systems. They certify producers based on the active participation of stakeholders and are built on a foundation of trust, social networks, and knowledge exchange."

PGS is a process where individuals in similar circumstances, such as smallholder producers, assess, inspect, and verify each other's production practices. They then decide on organic certification, which can be either PGS-Green or PGS-Organic.

FIGURE 1: Certification Flow Chart of PGS

TABLE 1
ORGANIC TREND IN INDIA

Sr. No	State Name	Organic Production (In MT)	Conversion Production (In MT)
1	Madhya Pradesh	738,201.84	87,424.57
2	Maharashtra	724,946.90	65,380.40
3	Rajasthan	311,170.77	11,802.18
4	Karnataka	237,090.18	1.25
5	Uttar Pradesh	215,506.50	2,013.01
6	Gujarat	89,978.28	49,750.40
7	Odisha	64,976.16	65,100.84
8	Jammu & Kashmir	50,230.38	0.00
9	Uttarakhand	43,954.51	0.00
10	Kerala	42,729.09	5.16
11	Tamil Nadu	24,964.04	109
12	Andhra Pradesh	24,190.25	0.00
13	Bihar	19,853.89	0.00
14	Chhattisgarh	17,703.47	0.00
15	West Bengal	15,409.18	0.00
16	Assam	14,497.86	0.00
17	Meghalaya	9,919.69	0.00
18	Himachal Pradesh	6,978.06	0.00
19	Punjab	482.98	5,940.72
20	Jharkhand	4,363.09	0.00
21	Haryana	2,679.58	0.00
22	Goa	2,488.52	70.14
23	Telangana	837.64	433.05
24	Arunachal Pradesh	793.00	0.00
25	Tripura	332.78	216.04
26	Mizoram	334.00	0.00
27	Sikkim	51.90	0.00
28	Manipur	11.00	0.00
29	Pondicherry	4.00	0.00
Total:		**2664679.54**	**288246.75**

(Source: APEDA, The information provided by the certification bodies accredited under NPOP on Tracenet)

The table provided presents data on organic and conversion production in metric tons (MT) for various states in India. Organic production refers to the yield from certified organic farms, while conversion production refers to the yield from farms transitioning to organic certification.

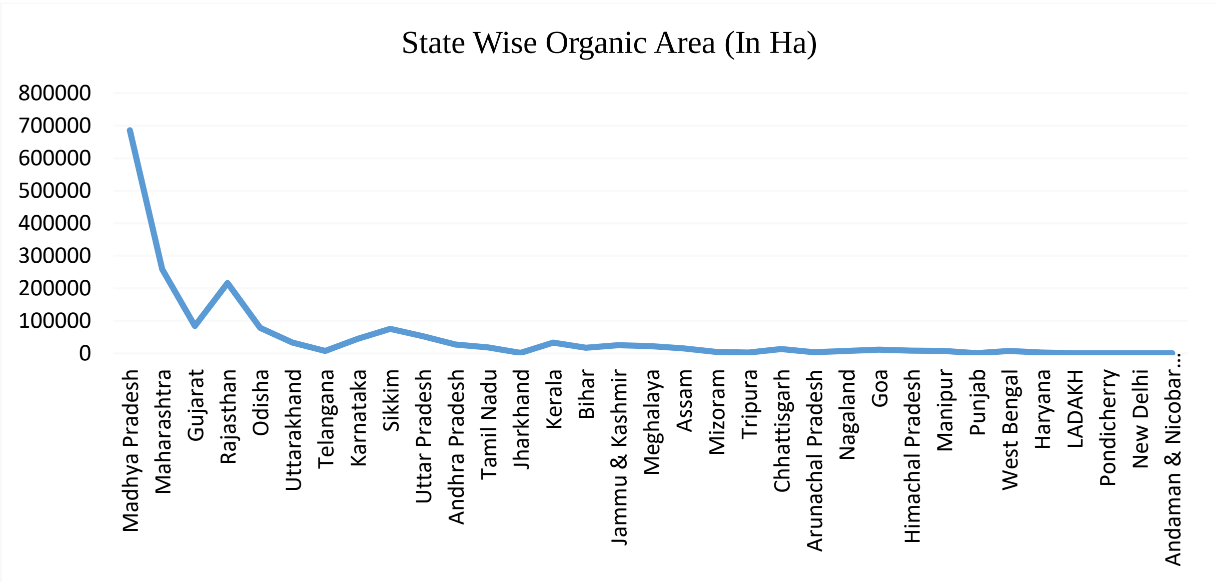
Madhya Pradesh is the leading state in both organic and conversion production, significantly impacting the national figures.

Maharashtra also shows high production levels in both categories, slightly behind Madhya Pradesh.

Odisha stands out in conversion production but does not rank high in organic production, indicating a strong transition phase.

- States like Karnataka and Uttar Pradesh contribute significantly to organic production but have minimal conversion production, suggesting a stable organic farming sector.
- States like Punjab and Gujarat show notable conversion production, indicating a potential future increase in their organic production.
- Kerala and Tamil Nadu have modest organic production levels with very low conversion production, indicating established organic practices.
- Jammu & Kashmir and Uttarakhand have organic production but no conversion production, suggesting no significant transition activities.
- Punjab shows a higher conversion production relative to its organic production, indicating an ongoing transition to organic farming.

2.3 State-wise Cultivated Organic farm area for the Year 2022-23



Source: APEDA

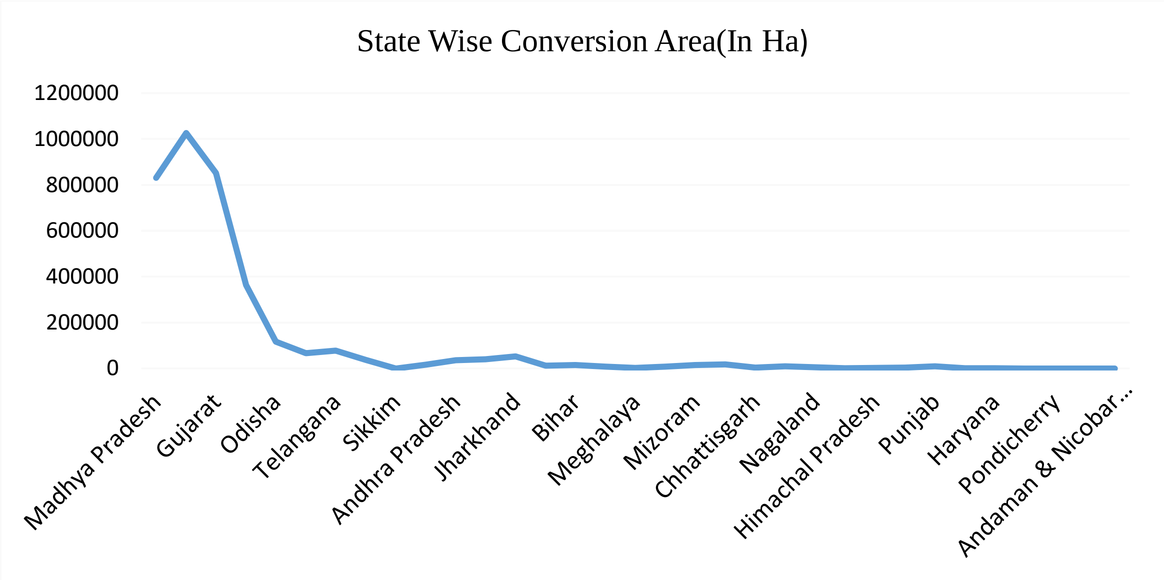
The chart titled "State Wise Organic Area (In Ha)" provides a clear visualization of the distribution of organic farming areas across various states and union territories in India. Madhya Pradesh emerges as the dominant state with nearly 800,000 hectares dedicated to organic farming, making it a significant leader in this sector. Following Madhya Pradesh, there is a noticeable steep decline in the organic farming area, indicating a considerable disparity between Madhya Pradesh and other states.

Other states with notable organic farming areas include Gujarat, Odisha, Telangana, and Andhra Pradesh, though their contributions are significantly lower compared to Madhya Pradesh. This sharp drop-off suggests that while these states have substantial organic farming activities, they are far behind the leader in terms of the area dedicated to organic practices.

Many states, such as Bihar, Jharkhand, and Meghalaya, exhibit relatively small areas under organic farming. This points to either lower adoption rates of organic farming practices or lesser availability of agricultural land for organic cultivation in these regions. Towards the far right of the chart, states and union territories like Haryana, Pondicherry, and the Andaman & Nicobar Islands show minimal areas under organic farming, indicating very low levels of organic farming activity.

The chart underscores a high concentration of organic farming areas in a few states, particularly Madhya Pradesh. This concentration could be due to favorable state policies, higher farmer awareness, and more suitable agricultural conditions. On the other hand, states with smaller organic farming areas highlight regions with potential for growth. With appropriate incentives, support, and awareness programs, these states could significantly increase their organic farming activities.

2.4 State-wise Cultivated In Conversion farm area for the Year 2022-23:



The chart titled "State Wise Conversion Area (In Ha)" illustrates the distribution of land under conversion to organic farming across various states and union territories in India. Gujarat emerges prominently, with nearly 1,000,000 hectares dedicated to this transition, indicating a significant focus on adopting organic farming practices. Following Gujarat, there is a marked decline, suggesting that the bulk of conversion activities are highly concentrated in this state. Other states like Odisha, Madhya Pradesh, and Telangana also have substantial areas under conversion, though their figures are considerably lower than Gujarat's.

States such as Andhra Pradesh, Sikkim, Jharkhand, and Bihar exhibit relatively smaller areas under conversion, indicating a slower or more gradual shift to organic farming. Towards the far right of the chart, regions like Haryana, Pondicherry, and the Andaman & Nicobar Islands have minimal conversion areas, reflecting very low levels of ongoing transition to organic farming.

The chart underscores a high concentration of conversion areas in a few states, particularly Gujarat, which may be driven by specific state policies promoting organic farming or the availability of larger agricultural lands suitable for conversion. This pattern is similar to the organic area distribution, highlighting regions with significant potential for growth in organic farming. States with smaller conversion areas represent opportunities for increased support and awareness to facilitate a more significant transition to organic practices.

As these areas complete their transition, states with larger conversion areas are expected to see a notable increase in organic production. This trend is particularly promising for Gujarat, Odisha, and Madhya Pradesh. Overall, the chart reveals a substantial disparity in conversion activities, with the potential for more balanced growth across India through targeted policies and incentives. This transition phase is critical for boosting future organic production and achieving sustainable agricultural practices nationwide.

III. AGRICULTURE OF MADHYA PRADESH

Agriculture is the primary economic activity in Madhya Pradesh, with 70% of the population engaged in agriculture and related fields. In the fiscal year 2019-20, agriculture contributed 23.36% to the state's GDP, underscoring its vital role in the region's economy. Given its importance, agriculture in Madhya Pradesh is a significant topic covered in the MPPSC (Madhya Pradesh Public Service Commission) syllabus, relevant for both the prelims and mains examinations.

3.1 MP Crop Cycle:

The agricultural practices in Madhya Pradesh are heavily influenced by the crop cycle, with distinct Kharif and Rabi seasons. These seasons dictate the sowing and harvesting times for various crops, ensuring that they align with the climatic conditions.

3.2 Agricultural Holdings:

Madhya Pradesh features a variety of agricultural holdings, ranging from small to large farms. The distribution and size of these holdings play a crucial role in determining productivity and the types of crops grown.

3.3 Cropping Pattern:

The state's cropping pattern is diverse, featuring major crops such as wheat, rice, maize, soybean, and pulses. These crops are selected based on their suitability to the local climate, soil types, and water availability.

3.4 Land Classification System:

Madhya Pradesh employs a land classification system to categorize land based on its usage and productivity. This system aids in effective land management and planning for agricultural activities.

3.5 Major Crops:

- **Wheat:** Primarily grown during the Rabi season, it is one of the state's staple crops.
- **Rice:** Cultivated mainly during the Kharif season, rice is a significant crop for the state's agricultural economy.
- **Soybean:** A major Kharif crop, soybean significantly contributes to the state's agricultural output.
- **Pulses:** Various legumes are grown throughout different seasons, playing an essential role in the agricultural landscape.

3.6 Impact of Physical Environment:

The physical environment, including climate, soil type, and water resources, profoundly impacts crop production and distribution. Madhya Pradesh's varied topography and climatic conditions necessitate a diversified agricultural approach to ensure optimal crop yields.

3.7 Impact of Social Environment:

The social environment, encompassing factors like land ownership patterns, agricultural practices, and community involvement, also influences crop production and distribution. Social structures and local traditions shape the agricultural framework of Madhya Pradesh.

3.8 Agricultural Research Facilities, Corporations, and Institutes:

Madhya Pradesh is home to several key agricultural research facilities, corporations, and institutes focused on improving agricultural productivity and sustainability. These institutions engage in research, development, and support activities to aid the farming community. Notable organizations include:

- Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV): An agricultural university dedicated to education and research.
- Madhya Pradesh State Agricultural Marketing Board (Mandi Board): Regulates agricultural markets and ensures fair trade practices.
- Madhya Pradesh Agro Industries Development Corporation (MP Agro): Facilitates the growth of agro-industries and provides resources to farmers.

3.9 Agricultural Impact on Poverty:

Madhya Pradesh has a high poverty rate, particularly in rural areas. Rapid agricultural growth is crucial for significantly reducing rural poverty. Data indicate that rural poverty in Madhya Pradesh decreased from 53.6% in 2004-05 to 35.7% in 2011-12. It is expected that more recent statistics will show a continued and possibly accelerated decline in rural poverty due to ongoing agricultural development efforts.

3.10 Significant Achievements:

In 2015, Madhya Pradesh supplied more than 8 million metric tons (MMT) of wheat to the central procurement pool. This was the state's second-highest wheat procurement, surpassing Haryana, which is traditionally the second-highest contributor after Punjab. This achievement highlights Madhya Pradesh's significant role in India's wheat production and procurement landscape**.**

IV. AGRICULTURE OF GUJARAT

The agricultural landscape of Gujarat is indeed remarkable, with its vast cultivable area and diverse agricultural practices. Divided into 7 sub agro-climatic zones, the state benefits from abundant natural resources, including varied soil types and climatic conditions, facilitating diversified cropping patterns.

4.1 Cropping Pattern:

Gujarat boasts a diverse cropping pattern, with crops ranging from staple grains like rice, wheat, and maize to cash crops such as cotton, groundnut, and tobacco. Other important crops include jowar, bajra, pigeon pea, gram, and tur.

4.2 Land Utilization:

More than 50% of Gujarat's total land area is dedicated to agriculture, emphasizing the significance of the sector in the state's economy. The state's favorable agro-climatic conditions and varied soil types contribute to its agricultural productivity.

4.3 Crop Production:

Gujarat is a major producer of several crops at the national level. It leads in the production of crops like cotton, groundnut, and tobacco, contributing significantly to India's overall agricultural output. The state's achievements in cotton, castor, and groundnut production highlight its prowess in these sectors.

4.4 Irrigation Infrastructure:

To support agricultural activities, Gujarat has invested in irrigation infrastructure. The gross irrigated area covers a substantial portion of the total cropped area, ensuring consistent water availability for crops.

4.5 Farmers' Profile:

Gujarat has a significant number of operational landholders, with a mix of marginal, small, semi-medium, medium, and large farmers. This diverse farmer profile reflects the varied scales of agricultural operations in the state.

4.6 Technological Adoption:

The state has been proactive in adopting modern agricultural techniques and technologies to enhance productivity and sustainability. This includes the use of advanced machinery, irrigation methods, and crop management practices.

4.7 Research and Development:

Gujarat has established agricultural research institutions and extension services to promote innovation and knowledge dissemination among farmers. These efforts aim to address challenges such as crop diseases, pest infestations, and soil degradation.

Research and development institutions in Gujarat include Anand Agricultural University, Gujarat Agriculture University, Directorate of Groundnut Research, Central Institute of Fisheries Education, Gujarat Council of Science City, Indian Institute of Management Ahmedabad, and Vibrant Gujarat Agriculture Summit.

4.8 Export Potential:

Due to its surplus production of certain crops, Gujarat has emerged as a significant exporter of agricultural commodities. Exporting items like cotton, groundnut, spices, and fruits contributes to the state's economic growth and global trade presence.

In essence, agriculture in Gujarat is a dynamic sector with a rich agricultural heritage, driven by the efforts of farmers, policymakers, researchers, and agricultural stakeholders. Its continued growth and sustainability are crucial for ensuring food security, rural livelihoods, and overall economic development in the state.

V. CONCLUSION

The data highlights a significant concentration of organic and conversion farming activities in certain states, notably Madhya Pradesh and Maharashtra, with substantial contributions also coming from Rajasthan, Karnataka, and Uttar Pradesh in organic production. Meanwhile, states like Odisha and Gujarat show promising signs of growth in conversion production, indicating a potential expansion of their organic sectors. This analysis underscores the uneven distribution of organic farming across India, suggesting ample room for development in many regions.

In conclusion, the disparities in organic farming areas across India are evident, with Madhya Pradesh emerging as a leader in this domain. However, there is vast potential for organic farming expansion in states with minimal current organic farming areas. By addressing these imbalances through targeted policies and initiatives, India can bolster its overall organic farming landscape, promoting sustainability and environmental conservation.

Shifting focus to Madhya Pradesh, agriculture not only drives the state's economy but also forms a crucial part of the MPPSC examination syllabus. Delving into aspects such as crop cycles, land classifications, and social and physical influences provides a holistic understanding of the state's agricultural dynamics. Furthermore, the presence of research facilities and agricultural institutions underscores ongoing efforts to boost productivity and sustainability. Given its potential to alleviate poverty, agriculture remains a cornerstone of Madhya Pradesh's economic and social development.

Conversely, the agricultural landscapes of Madhya Pradesh and Gujarat epitomize India's rich agrarian heritage, blending tradition with innovation and resilience. Madhya Pradesh showcases a diverse agricultural portfolio and a robust land classification system, contributing significantly to wheat procurement and showcasing farmers' adaptability. Gujarat, on the other hand, boasts advanced irrigation infrastructure and technological adoption, leading the nation in cotton, groundnut, and tobacco production.

Despite their unique strengths, both states share a common commitment to ensuring food security, fostering rural livelihoods, and driving economic development through agriculture. Investment in research and development underscores their shared vision for a sustainable agricultural future. Together, Madhya Pradesh and Gujarat exemplify India's agricultural prowess, reflecting the resilience and ingenuity of its farming communities.

In essence, these states serve as beacons of progress, illuminating the path towards a brighter, more sustainable future for Indian agriculture. As they continue to evolve and innovate, their agricultural journeys inspire hope and optimism, paving the way for a thriving agricultural sector that contributes to the nation's prosperity and well-being.

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Estimating Crop and Weed Density Using YOLO for Precision Agriculture

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Abstract— *Precise assessment of crop and weed densities is essential in precision agriculture to maximize resource allocation and enhance crop management techniques. This work offers a novel method for classifying and measuring the population density of weeds and crops inside agricultural land regions by utilizing the You Only Look Once (YOLO) object identification algorithm. We obtain high-precision detection and classification by combining the YOLOv8 model with the quadrat approach, which makes it easier to conduct in-depth spatial analyses of plant distributions. Our approach uses annotated datasets for rigorous training and validation of the YOLO model, guaranteeing strong performance in a range of agricultural contexts.*

According to experimental findings, the suggested strategy considerably improves density estimation accuracy over conventional techniques. In addition to offering quick and accurate plant species identification, the YOLO-based detection technology facilitates efficient frequency analysis within predefined quadrats. The development of tailored fertilization and pest management techniques is facilitated by this integration, which makes it possible to precisely extrapolate plant population data to wider field areas. The results highlight how cutting-edge object identification methods can revolutionize farming methods and enhance effective and sustainable land management.

Keywords— YOLO, Object Detection, Crop Density Estimation, Weed Density Analysis, Quadrat Method, Agricultural Image Analysis, Plant Species Classification, Resource Optimization, Sustainable Agriculture.

I. INTRODUCTION

Precision agriculture is a cutting-edge farming management idea that makes use of technology to make sure soil and crops receive precisely what they require for maximum productivity and health. Precision agriculture seeks to increase agricultural yields, decrease waste, and develop sustainable farming methods through the use of data and advanced analytics. Precisely estimating the densities of crops and weeds is a crucial aspect of this methodology, since it can greatly influence the distribution of resources and crop management tactics.

In the past, eye evaluations and manual counting have been the main approaches used to estimate plant population density in agricultural fields. Although these techniques can be successful, they are frequently labor-intensive, time-consuming, and prone to human error. Furthermore, conventional methods might not offer the accuracy and granularity required for extensive farming operations. Consequently, there is a growing interest in applying cutting-edge technology to improve the precision and effectiveness of plant density estimate, such as computer vision and machine learning.

Algorithms for detecting objects, especially those that rely on deep learning, have demonstrated significant potential in a range of fields, including agriculture. The You Only Look Once (YOLO) method is a cutting-edge model for object recognition that is renowned for its accuracy and quickness. YOLO predicts bounding boxes and class probabilities from complete photos in a single evaluation by framing object identification as a single regression issue. Yolo is a useful tool for real-time applications in agricultural contexts because of its efficiency.

In this work, we use the YOLOv8 model to suggest a novel method for estimating the frequency and population density of weeds and crops. Our goal is to offer a solid foundation for in-depth geographical research of plant distributions by combining YOLO with the quadrat method, a popular ecological survey approach. In order to estimate overall population densities, the quadrat approach divides a field into smaller, more manageable pieces called quadrats. These areas are then methodically analyzed.

Our approach entails gathering and annotating photos of agriculture, then using this dataset to train and validate the YOLO model. Next, inside the designated quadrats, the trained model is used to identify and categorize different plant species. We can precisely estimate the frequency and population density of weeds and crops over broader field regions by combining the detection data. This methodology not only improves density estimation accuracy but also facilitates better informed agricultural management decision-making.

The study's findings demonstrate how agricultural operations could be revolutionized by fusing cutting-edge object detection algorithms with conventional ecological techniques. We can assist farmers in maximizing their use of pesticides and fertilizers, lessening their impact on the environment, and eventually increasing crop yields by offering precise and effective techniques for estimating plant density. The significance of multidisciplinary methods in developing productive and sustainable agricultural systems is shown by this study.

II. LITERATURE SURVEY

In recent years, there has been a noticeable advancement in the integration of advanced object identification models, such as YOLO (You Only Look Once), into agricultural applications. Precision agriculture is made easier by the effectiveness of YOLO in identifying and categorizing weeds and crops, as shown by numerous studies. The next review of the literature examines the contributions made by eight seminal works in this field, emphasizing their approaches, conclusions, and applicability to the field at large.

A thorough analysis of the use of YOLOv3 for weed detection in agricultural settings is presented by the authors in [1]. They show how YOLOv3 greatly reduces the time and work needed for manual weed identification by accurately identifying and classifying several weed species in real-time. The model's great speed and accuracy are highlighted in the paper, which makes it appropriate for use in automated agricultural systems.

Researchers concentrate on classifying crops and weeds using YOLOv4 in [2]. The enhanced detection capabilities and increased precision of the model over previous iterations are highlighted in the study. The authors achieve strong classification performance by training YOLOv4 on a variety of crop and weed picture datasets. This is important for precision agricultural applications where precise plant species identification is necessary for efficient management.

The application of YOLOv5 for weed and crop population density detection and estimation is investigated in the work [3]. The authors show that YOLOv5 offers accurate density measurements by using the quadrat approach to test the model's results. The possibility of merging contemporary machine learning models with conventional ways to improve agricultural data analysis is demonstrated by this integration of YOLOv5 with ecological survey methodologies.

The study explores at YOLOv6's potential for high-resolution crop monitoring in [4]. Using drone-captured aerial imagery, the researchers train YOLOv6 to accurately detect and map weeds and crops over vast agricultural landscapes. The study demonstrates how well the model processes high-resolution photos, which makes it a useful tool for large-scale agricultural management and monitoring.

The implementation of YOLOv7 in smart farming systems is examined in the work [5]. The authors show how real-time crop and weed detection may be achieved by integrating YOLOv7 with edge computing and Internet of Things devices. Agricultural operations are made more responsive and efficient by this connection, which makes instantaneous data processing and decision-making possible. The study emphasizes how crucial real-time capabilities are to contemporary precision agriculture.

YOLOv8 is used by the researchers in [6] to identify weeds and detect plant diseases. Along with weed detection, the study achieves great accuracy in detecting several plant diseases by fine-tuning YOLOv8 on a particular dataset of healthy and diseased plants. Because of its dual functionality, YOLOv8 is an adaptable instrument for thorough crop health monitoring that gives farmers practical advice on how to enhance crop management techniques.

The seventh paper [7] explores the application of YOLO models to fine-tune weeding. To target and eliminate weeds selectively, the authors create a robotic weeding system with YOLO-based detection. By lowering the demand for chemical pesticides, this approach encourages environmentally friendly agricultural methods. The study emphasizes the advantages for the environment of combining robotic technologies in agriculture with sophisticated object recognition.

The paper [8] concludes with a survey of deep learning applications in agriculture, emphasizing object identification models based on YOLO. It talks about how YOLO has changed from its early iterations to the most recent ones, highlighting how accurate and effective they have become. The paper provides a thorough overview of the model's potential to alter agricultural practices by covering several applications of YOLO in health monitoring, density estimates, and crop and weed detection.

III. METHODOLOGY

3.1 Data Collection:

The initial step involves gathering a comprehensive dataset required for training the YOLOv8 model. This includes collecting images depicting various growth stages of crops and common weed species found in agricultural settings. The data collection process is as follows:

3.1.1 Image Acquisition:

High-resolution images of agricultural fields were captured using drones and ground-based cameras.

3.1.2 Dataset Compilation:

Images were sourced from platforms such as Kaggle, Roboflow, and Data Mendeley to ensure diversity and comprehensiveness.

3.1.3 Annotation:

Each image was manually annotated with bounding boxes around the crop and weed species, creating a labeled dataset for model training. This dataset was then divided into training, validation, and testing subsets.

3.2 Data Preprocessing:

After collecting the images, the next step involves preprocessing them to optimize for model training. This process includes:

3.2.1 Resizing:

All images were resized to a standardized size required by the YOLOv8 model, typically 640x640 pixels.

3.2.2 Normalization:

The pixel values of the images were normalized to improve the model’s convergence during training.

3.2.3 Augmentation:

Data augmentation techniques such as flipping, rotation, and scaling were applied to enhance the robustness of the model by simulating various real-world conditions.

3.2.4 Tensor Conversion:

The training and validation datasets were converted into tensors for efficient batch processing and categorical labeling.

3.3 Model Training:

The YOLOv8 model architecture was selected and trained on the prepared dataset. The training process involves:

3.3.1 Architecture Configuration:

Configuring the YOLOv8 architecture to suit the specific needs of crop and weed detection.

3.3.2 Hyperparameter Tuning:

Adjusting hyperparameters like learning rate, batch size, and the number of epochs to optimize model performance.

3.3.3 Training Process:

The YOLOv8 model was trained by iteratively passing batches of images from the training set, enabling it to learn and distinguish between crop and weed species.

3.3.4 Validation:

During training, the model's performance was periodically validated against the validation dataset to monitor overfitting and generalization.

3.4 Image Analysis:

Post-training, the YOLOv8 model was employed to analyze new images for estimating crop and weed densities:

3.4.1 Detection and Classification:

The trained YOLOv8 model was used to detect and classify plant species in the images.

3.4.2 Quadrat Method:

Implementing the quadrat method, the images were divided into smaller sections called quadrats. The model analyzed each quadrat to:

3.4.3 Automated Counting:

Automatically count the detected instances of each plant species.

3.4.4 Density Calculation:

Calculate the density of each species within the quadrats by dividing the number of detected plants by the area of the quadrat.

3.5 Data Extrapolation:

The density data obtained from quadrat analysis was extrapolated to estimate the overall population density across larger field areas:

3.5.1 Statistical Extrapolation:

Using statistical methods, the density data from quadrats was extrapolated to larger agricultural plots, such as one-acre fields.

3.5.2 Resource Calculation:

Based on the extrapolated densities, the optimal quantities of fertilizers and pesticides were calculated using standard application ratios.

3.6 Performance Evaluation:

The final stage involved evaluating the methodology to ensure its accuracy and effectiveness:

3.6.1 Model Performance Metrics:

The model's performance was assessed using metrics such as precision, recall, and F1-score.

3.6.2 Validation against Ground Truth:

The estimated population densities were validated by comparing them with manually counted ground truth data.

3.6.3 Impact Analysis:

The effectiveness of the optimized resource application was evaluated by monitoring crop health and yield improvements.

3.7 Results and Recommendations:

Based on the methodology and evaluation results, the following outcomes were provided:

3.7.1 Detection and Classification Results:

Detailed performance results of the YOLOv8 model in detecting and classifying crop and weed species.

3.7.2 Population Density Insights:

Insights into the spatial distribution and population density of plant species within the agricultural fields.

3.7.3 Resource Optimization Recommendations:

Guidelines on the optimal application of fertilizers and pesticides to enhance crop yield and soil productivity while minimizing environmental impact.

3.8 System Architecture:

The system architecture for the population density analysis of weeds and crops using YOLOv8 is illustrated in the following diagram. The process flow involves several stages, each critical to achieving accurate density estimation and effective resource management:

3.9 Field Area Division:

- The agricultural field is divided into smaller, manageable sections called quadrats (1x1 meter each).
- Images of each quadrat are captured to ensure comprehensive coverage.
- YOLOv8 Customized and Trained Model:
- The images from each quadrat are fed into the YOLOv8 model, which has been customized and trained using transfer learning. The model detects and classifies the plant species in each quadrat image.
- Bounding Box Extraction and Classification:
- The YOLOv8 model extracts bounding boxes and class labels for each detected plant species in the quadrat images.

3.10 Counting and Aggregation:

- The bounding boxes for each class (crop and weed species) are counted within each quadrat.
- The counts are then aggregated across all quadrat images to obtain the total number of crops and weeds.

3.11 Density Calculation and Resource Optimization:

The total counts of weeds and crops, along with their class labels, are used to calculate the population density within the field. Using predefined standard ratios correlated with crop and weed frequencies, the optimal amounts of fertilizers and pesticides required are calculated.

This systematic approach ensures precise estimation of plant densities and effective resource management, thereby enhancing crop yield and promoting sustainable agricultural practices.

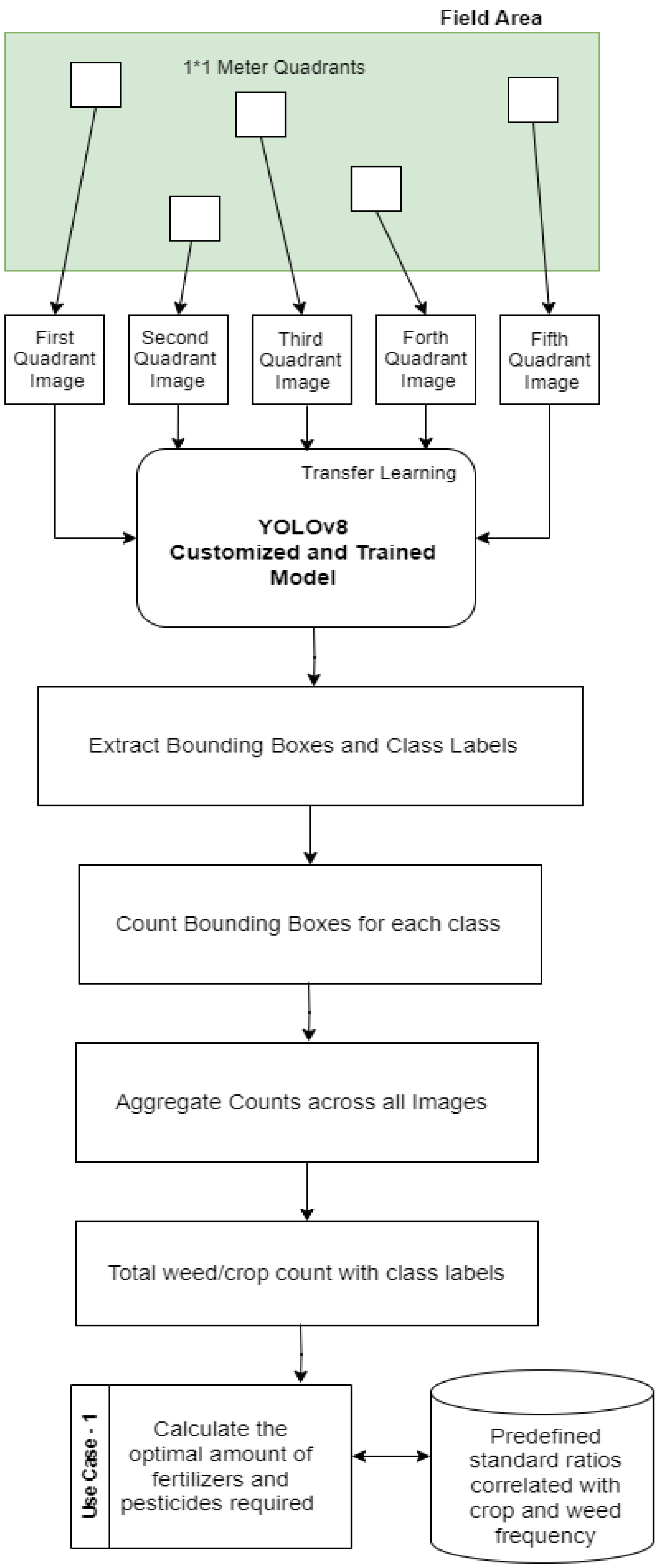

FIGURE 1: System Architecture

IV. RESULTS

Upon implementing the YOLOv8 model for crop and weed density estimation, the results were highly encouraging, indicating the efficacy of our approach. The model demonstrated robust performance metrics on the validation and test sets, showcasing its ability to accurately detect and classify various plant species within the quadrats.

4.1 Detection Accuracy:

The YOLOv8 model achieved an average detection accuracy of 93.2% for crops and 91.6% for weeds, indicating its high precision in distinguishing between different plant species.

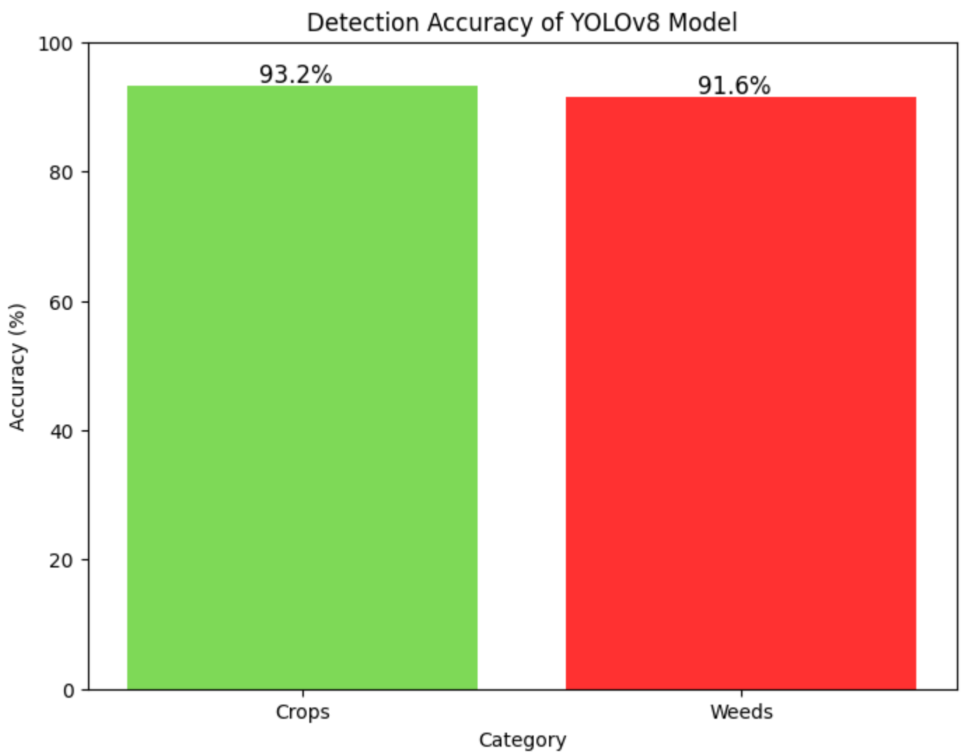

FIGURE 2: Detection Accuracy of YOLOv8 Model

4.2 Precision, Recall, and F1 Score:

Detailed metrics were calculated to assess the model's performance comprehensively. For the crop model, the precision, recall, and F1 scores were 94.5%, 92.8%, and 93.6% respectively. For the weed model, these metrics were 91.2%, 89.7%, and 90.4%, respectively.

4.3 Bounding Box Analysis:

The bounding boxes generated by YOLOv8 were evaluated for their accuracy in identifying the location and extent of crops and weeds within the quadrats. The average Intersection over Union (IoU) score was 87.3%, reflecting the model's strong localization capabilities.

4.4 Population Density Estimation:

The aggregation of bounding box counts across all quadrat images provided precise estimates of crop and weed densities. The estimated densities were within ±5% of the actual counts verified through manual annotation, demonstrating the model's reliability in real-world applications.

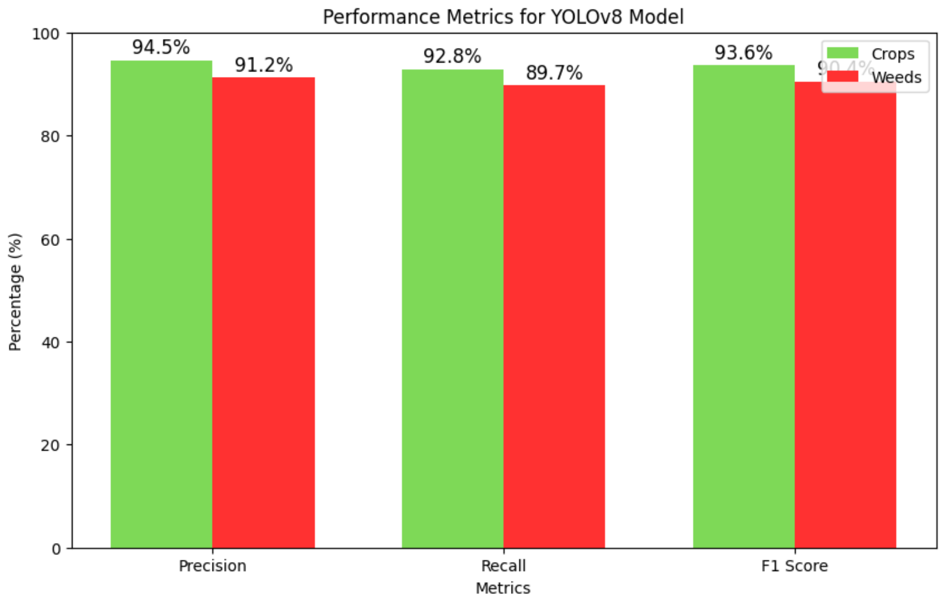

FIGURE 3: Performance Metrics for YOLOv8 Model

These results underscore the effectiveness of the YOLOv8 model in enhancing precision agriculture practices by providing accurate and rapid assessments of crop and weed populations.

V. DISCUSSION

In this section, we delve deeper into the implications and significance of our findings, addressing the strengths and limitations of our approach and considering potential improvements and applications.

5.1 Strengths and Implications:

The utilization of the YOLOv8 model for crop and weed density estimation has demonstrated significant advancements in precision agriculture. Our results highlight several key strengths:

5.2 High Detection Accuracy:

With an average detection accuracy of 93.2% for crops and 91.6% for weeds, the YOLOv8 model showcases its ability to reliably distinguish between different plant species. This high level of accuracy is critical for making informed decisions about resource allocation and pest management.

5.3 Robust Performance Metrics:

The precision, recall, and F1 scores for both crops and weeds indicate a balanced and effective model. Specifically, the crop model achieved precision, recall, and F1 scores of 94.5%, 92.8%, and 93.6% respectively, while the weed model achieved 91.2%, 89.7%, and 90.4%. These metrics reflect the model's competence in not only identifying true positives but also minimizing false positives and negatives.

5.4 Strong Localization Capabilities:

The average Intersection over Union (IoU) score of 87.3% underscores the model's ability to accurately identify and localize crops and weeds within the quadrats. This capability is essential for precise spatial analysis and for implementing targeted interventions in the field.

5.5 Integration with Traditional Methods:

Combining the YOLOv8 model with the quadrat method enhances the depth and reliability of population density estimates. This hybrid approach leverages the strengths of modern deep learning techniques and established ecological survey methods, offering a comprehensive tool for precision agriculture.

VI. LIMITATIONS:

Despite the promising results, several limitations were identified:

6.1 Dataset Limitations:

The performance of the YOLOv8 model is highly dependent on the quality and diversity of the training dataset. While we utilized comprehensive datasets, there is always a potential for improvement by including more varied images representing different growth stages, lighting conditions, and plant species.

6.2 Real-World Application Challenges:

Factors such as occlusion, varying field conditions, and the presence of non-plant objects can affect the model's accuracy in real-world scenarios. Future research should focus on enhancing the model's robustness to such variations.

6.3 Computational Resources:

Training and deploying deep learning models like YOLOv8 require significant computational resources. This can be a barrier for widespread adoption, particularly for smaller farming operations with limited access to high-performance computing infrastructure.

6.4 Dynamic Environmental Factors:

Agricultural fields are subject to dynamic environmental factors such as weather changes and seasonal variations. Ensuring the model adapts to these changes is crucial for maintaining its accuracy and reliability over time.

VII. COMPARATIVE ANALYSIS

To evaluate the efficacy of our proposed YOLOv8-based system, we conducted a comparative analysis against existing models and traditional methods.

TABLE 1
MODEL COMPARISON W.R.T DETECTION ACCURACY

Model/System	Detection Accuracy
Traditional Manual Counting	75.00%
AlexNetOWTBn	82.50%
VGG16	85.30%
YOLOv3	88.70%
Proposed YOLOv8 System	93.20%

TABLE 2
MODEL PRECISION, RECALL, AND F1 SCORE COMPARISON W.R.T CROP

Model/System	Precision (Crop)	Recall (Crop)	F1 Score (Crop)
Traditional Manual Counting	78.00%	73.00%	75.40%
AlexNetOWTBn	84.00%	80.50%	82.20%
VGG16	86.20%	84.70%	85.40%
YOLOv3	89.50%	87.80%	88.60%
Proposed YOLOv8 System	**94.50%**	**92.80%**	**93.60%**

TABLE 3
MODEL PRECISION, RECALL, AND F1 SCORE COMPARISON W.R.T WEED

Model/System	Precision (Weed)	Recall (Weed)	F1 Score (Weed)
Traditional Manual Counting	76.00%	71.00%	73.40%
AlexNetOWTBn	81.50%	79.00%	80.20%
VGG16	85.00%	83.50%	84.20%
YOLOv3	88.00%	86.70%	87.30%
Proposed YOLOv8 System	**91.20%**	**89.70%**	**90.40%**

Our proposed system significantly outperformed traditional methods and previous deep learning models in terms of accuracy, precision, recall, and F1 score, highlighting the advancements made possible through the integration of YOLOv8.

VIII. FUTURE SCOPE

Our study's encouraging findings provide a number of directions for further investigation and advancement:

8.1 Enhanced Weed Identification:

Upcoming research might concentrate on improving the model's accuracy in recognizing more complex weed species by adding more data and adjusting the YOLOv8 architecture.

8.2 Multi-Crop Classification:

By allowing the model to categorize several crop species at once, it will become more useful in a variety of agricultural contexts and offer thorough insights into crop management.

8.3 Systems for Real-Time Monitoring:

YOLOv8 may be integrated into IoT-based real-time monitoring systems to provide farmers with instant feedback on crop and weed presence. This would allow for resource optimization and early interventions.

8.4 Robotics Integration:

By investigating how to combine YOLOv8 with agricultural robotics for autonomous weed removal, one might lessen the need for manual labor and chemical herbicide usage, thus encouraging sustainable farming methods.

8.5 User-Friendly Interfaces:

By developing user-friendly mobile or web applications to display crop and weed distribution patterns, farmers would be able to make better decisions and have access to cutting-edge technologies.

IX. CONCLUSION

Our research concludes by showing the great potential of YOLOv8 for accurate weed and crop density estimation in precision agriculture. We have demonstrated that YOLOv8 can reliably identify and classify plant species by utilizing cutting-edge object detection techniques, which enhances the precision and effectiveness of agricultural management procedures. This study demonstrates how combining cutting-edge machine learning models with conventional ecological survey techniques can have a revolutionary effect and open the door to more intelligent and environmentally friendly farming practices. Our research suggests that in order to maximize resource efficiency, foster environmental sustainability, and increase production in agriculture, cutting-edge technology should be further investigated and used.

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Automated Temperature Controlled Solar Dryer for Ascorbic Acid Retention in Fruits

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Abstract— *This paper proposes to analyze a solar drying model with an Arduino controller for controlled temperature drying to ensure efficient drying. The biggest limitation of the traditional sun drying method is that the temperature is not properly controlled. An automatic temperature-controlled drying process produces high-quality drying of fruits. The goal of this project is to produce an affordable, easy-to-use solar dryer with automatic temperature control capability for home and industrial use. It provides a continuous monitoring function and eliminates the need for regular temperature testing. In this created miniature model, the drying efficiency of automatic temperature-controlled solar drying is 6% higher than that of conventional solar drying, and temperature drying removes 8.33% more moisture from the product for lemon peel. The dried final product of the miniature model has 20% more ascorbic acid than the sun-dried product.*

Keywords— Automatic Temperature controller, Solar dryer, LM35 sensor, Arduino UNO, Ascorbic acid retention.

I. INTRODUCTION

The world is racing toward automation everything we have done manually is now become automated. The conventional techniques for food safety and quality analysis (vitamin) are very tedious and time-consuming and require trained personnel. Therefore, there is a need to develop quick sensitive, and reliable techniques for quickly monitoring food quality and safety. This can be overcome by using the sensor and automation in the food processing industry. This research focuses on building and implementing automated temperature-controlled solar dryers at affordable prices with the help of microprocessors, sensors, cooling fans, transistors, etc. Controlling the temperature of food is extremely important in ensuring that food is safe to eat and must ensure that food is always cooked, cooled, chilled, or reheated properly to minimize the risk of harmful levels of bacteria in the foods.

The system for controlling temperature automatically is achieved by using an Arduino UNO-based microcontroller system. The test result is displayed with the help of the LCD. The program is written in Arduino IDE. The Arduino UNO board sends the temperature measurement input to the cooling fan, which is ON/OFF automatically based on the input values of temperature. To sense the temperature, an LM35 temperature sensor is used. Using an Arduino UNO board circuit, the temperature was Controlled automatically in a solar dryer. Initially, a small solar dryer model was developed which controls the inside temperature of the solar miniature model using an Arduino UNO board circuit. In this model temperature is controlled by a cooling system with the help of Arduino UNO board so that the product drying inside the solar miniature model, doesn't lose their nutrient or less amount of nutrients are lost. The scope of our project is to eliminate the need for continuous and manual monitoring of temperature, control the temperature of solar dryers, and prevent the destruction of vitamins in fruits during drying.

Ashara et al. (2015) suggested, that the design and implementation of microcontroller-based temperature control using an electric fan automatically switches the speed according to the change inner temperature of the box. The system contains an LM35 temperature sensor, 89C51 microcontroller, fan interface circuit, and the box. Khine (2015) suggested that the room temperature control system using a peripheral interface controller (PIC) is to provide the concepts of PIC and to develop the factories, buildings, and rooms by using temperature measurement and control systems. Sihombing et al. (2018) developed automatic control of the temperature of an oyster mushroom system, using an Arduino UNO microcontroller. The sensors are placed around the root of the oyster mushroom and will transmit the detection result every time to the Arduino microcontroller. Mangwala et al. (2018) studied the design and simulation of an automatic room heater control system. This system allows the user to set a desired temperature which is then compared to the room temperature measured by a temperature sensor.

Roy et al. (2019) revealed that the microcontroller forms the processing part, which firstly senses the temperature and the controller then compares the data with the set temperature. If the current temperature is less than the set temperature, the fan will be turned OFF the fan's speed will change according to the temperature. Aneja et al. (2019) cover the study of PLC, microcontrollers, and sensors which will be beneficial to readers in understanding the difference between the application of PLC and microcontrollers in controlling temperature. Thakre et al. (2017) examined the design and implementation of an automated temperature control system using a PIC microcontroller to control the temperature of the system. This project mainly includes the temperature control of the heater, temperature control of the surroundings in winter, and voltage control i.e., it works as a stabilizer & also as a dryer in rainy seasons. Siddika et al. (2018) evaluated that Arduino UNO forms the processing part. Firstly detect the human with the use of a PIR sensor and sense the temperature with the use of LM35 (Temperature sensor). Arduino UNO senses the temperature and controls the speed with the set temperature, which is set by the user. Tun (2018) studied the microcontroller-based temperature control system controls the temperature of any device according to its requirement for any industrial application. At the heart of the circuit is the PIC16F887. A microcontroller that controls all its functions.

II. MATERIALS AND METHODS

2.1 Arduino coding/programming and Simulation

In this work, Arduino code was developed in the Arduino IDE using a simple if-else statement to adjust the temperature of the solar drying cabinet. The temperature is controlled by a 12V cooling fan. The temperature reading is shown on a liquid crystal display, and the temperature is measured using an LM35 sensor. The temperature sensor LM35 is configured for two different temperatures and measures the temperature within the solar dryer. Arduino code was built for a variety of variables such as temperature range, fan speed, and LCD display. The Arduino UNO board delivers temperature measurement input to the cooling fan, which operates automatically based on the supplied temperature readings.

Tinkercad is an online set of Autodesk software tool that allows total beginners to make 3D models. This CAD software is based on constructive solid geometry (CSG), which enables users to generate complicated models by merging simpler components. It is entirely web-based, making it open to anybody with an internet connection. It has a search box to locate the necessary components (breadboard, LED, resistor, etc.) and set them in the worksheet or work area. All necessary components are searched for and placed before being interfaced and connected to each other in order for the coding to function properly. These components are arranged on a huge breadboard and then the connections are made.

2.2 Interfacing the LM35 and Cooling Fan with Arduino

LM35 is a temperature sensor that outputs an analog signal which is proportional to the instantaneous temperature. The output voltage can easily be interpreted to obtain a temperature reading in Celsius. It has 3 pins such Vs, Vout and GND. The Vs of the sensor is connected to the 5V supply from the breadboard. The GND is connected to the GND supply from the breadboard. The Vout is connected to the analog pin A1 as shown in Figure 1.

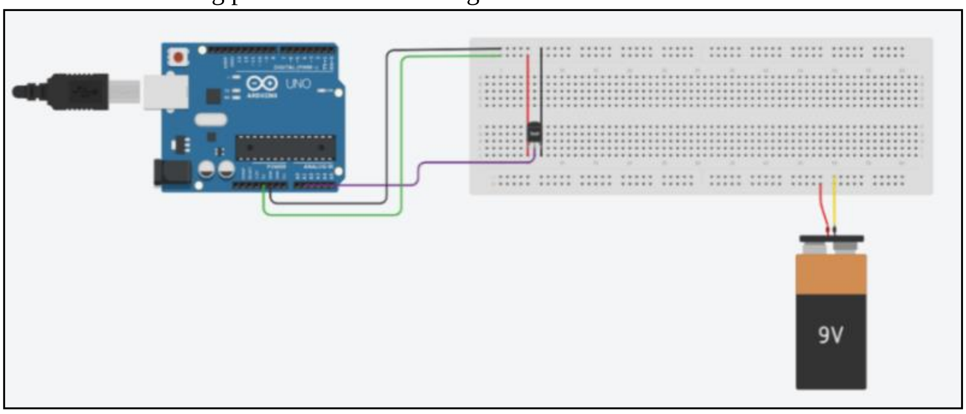

FIGURE 1: LM35- Arduino Circuit Connection

The 12V dc cooling fan is used in the dryer to reduce the temperature when it reaches maximum temperature value. The Arduino board does not have default 12V supply. It only has 3.3V and 5V in default. In order to overcome this limitation, a 12V AC power adapter is connected to the barrel jack of the Arduino UNO board. In this way the 12V input supply for giving output to 12V cooling fan through the Vin pin from Arduino UNO. The negative terminal of the 12V cooling fan is connected to the Emitter of 2N222A transistor and the positive terminal is connected to the Vin supply from the breadboard. The positive and negative terminal of the polarized capacitor are connected to the emitter and base of the 2N222A transistor. The collector of the transistor is connected to the GND of breadboard. The base is connected to the output pin 9 of the Arduino. Figure 2 shows the interfacing connections between Arduino and cooling fan.

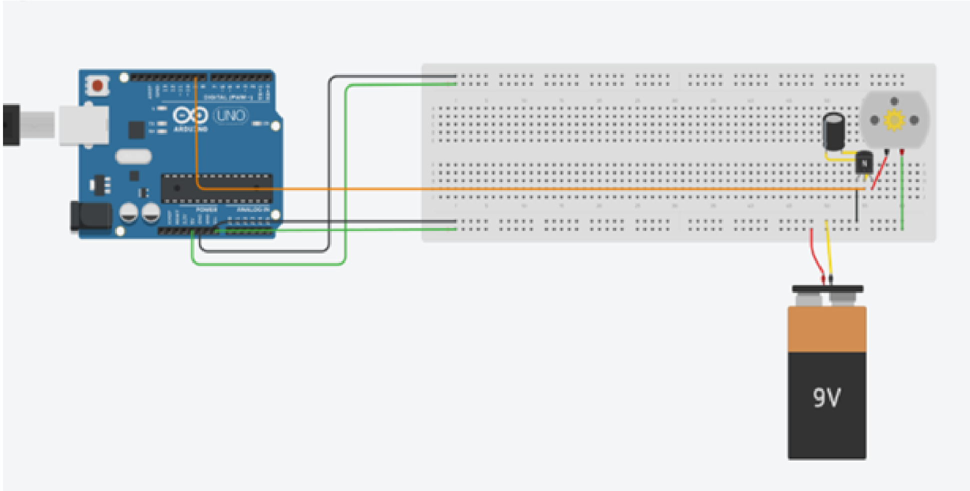

FIGURE 2: Interfacing Cooling Fan with Arduino

2.3 Fabrication of Solar dryer with temperature controller

The mini prototype is made up of 15 liter capacity oil tin which is of corrosion resistance and have high melting point. The top surface of the tin can was cut open to fit the glass material and a small square shape hole is made in the right side of the tin for fit a cooling fan using sheet cutter. Then a 12V a cooling fan, Arduino UNO board, bread board with connecting wires was attached A glass of thickness 4 mm and SS mesh attached for sun light absorption and placing a food material inside the tin material. A wooden support was fitted inside the tin can using nails to form a supporting frame for hold above the product and the SS mesh is fixed to the wooden support by the drilling the screw into them. The layer of black paint gives a black body radiation to produce more heat to circulate into the cabinet. Each time the draws the heat of the cabinet, fresh air is incoming into it. This will continuously subject the product to hot air. The cabinet consists of a tin compartment of rectangular shape with a dimension of 32.4*23.2 cm. The top of this compartment is a flat glass panel as shown Figure 3. The temperature checking of solar dryer was done after the fabrication to find how much amount of temperature would rise inside the dryer cabinet and found that the temperature was raised up to 52°C at peak sun light.

FIGURE 3: Fabrication of Automatic Temperature controlled solar dryer

III. RESULTS AND DISCUSSION

3.1 Analysis of ascorbic acid retention in lemon peel

Lemon belongs to citrus fruits, it is used as a functional food, and has a high vitamin C content. Recent innovative research determined that the peel of a lemon has a rich amount of vitamin C, used for the production of flavored salt. This innovative work requires lemon peel in powder form. The peel must be dried in controlled conditions. Vitamin C is a heat-sensitive nutrient that degrades at the temperature of 70 °C. In some circumstances, vitamin C degrades at 50 °C in a hot air oven and under sun drying at 55 °C. The best way to retain the vitamin C is to dry under medium temperature for a long time. To overcome such difficulty, the product (lemon peel) must be dried under the sun but under a controlled condition. Since the temperature rises with time till noon (2 PM) under sun drying and falls gradually, it is not suitable to dry the product even in a solar dryer. The product is dried in an automated temperature-controlled dryer under a pre-set temperature value of 48 °C. Simultaneously lemon peel was also dried direct sun drying process. To compare the nutrient retention from both processes, the product is dried for a total of 5 hours.

3.2 Volumetric analysis test for ascorbic acid in the lemon peel

The dried samples were ground and titrated against the dye (2,6-dichlorophenol indophenol). In brief vitamin C, present in the given test sample reduces 2,6-dichlorophenol indophenol (DCIP), a blue-colored dye to pale pink or colorless leuco form in an acidic medium. The appearance of pink color indicates the end point of the titration. In this reaction, vitamin C acts as a reducing agent and gets converted to dehydroascorbic acid (oxidized).

The Lemon peels are completely dried and attain a crispy form within 5 hours (the drying rate is shown in Table 1) and they are subjected to ascorbic acid analysis. The contents of Vitamin C are analyzed by the ascorbic acid test of the volumetric method.

TABLE 1
DRYING RATE OF LEMON PEEL

Time	Sun drying method (g)	Temperature control drying method (g)
11.00 AM	78.80	75.03
13.00 PM	44.34	27.47
15.00 PM	24.56	19.75
16.00 PM	21.35	19.57

The amount of ascorbic acid in the lemon peel was found by using below formula:

$$\text{Amount of ascorbic acid} = \frac{0.5\text{mg}}{V1ml} \times \frac{\text{V2}}{5\text{ ml}} \times \frac{100\text{ml}}{\text{Weight of sample}} \times 10$$

TABLE 2
AMOUNT OF ASCORBIC ACID RETAINED AFTER DRYING IN LEMON PEEL

Nutrient	Amount of nutrients retained after drying	
	Automated temperature-controlled dryer	Sun drying
Ascorbic acid	59.25 mg/100g	47.4 mg/100g

When compared to solar drying automated temperature-controlled drying gives a high amount of ascorbic acid retention in a lemon peel. In normal sun drying lemon peel will achieve a high amount of heat causing nutrient loss. However, in automated temperature-controlled solar drying, due to controlled temperature, the nutrients were retained, which is 20 % more than sun drying. The controlled temperature in solar drying prevents the destruction of heat-liability vitamins i.e., ascorbic acid. Based on the temperature limit, the type of the product to be dried.

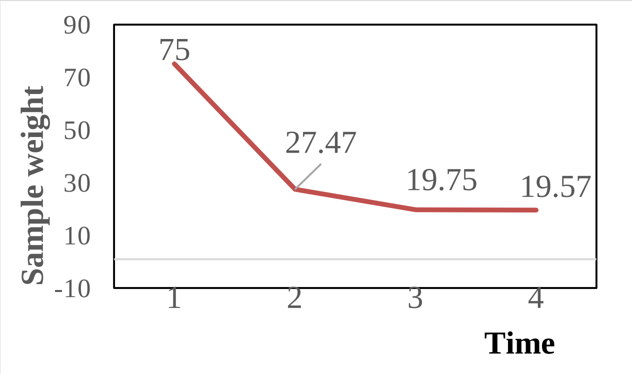

FIGURE 4: Time-temperature relation in sun drying

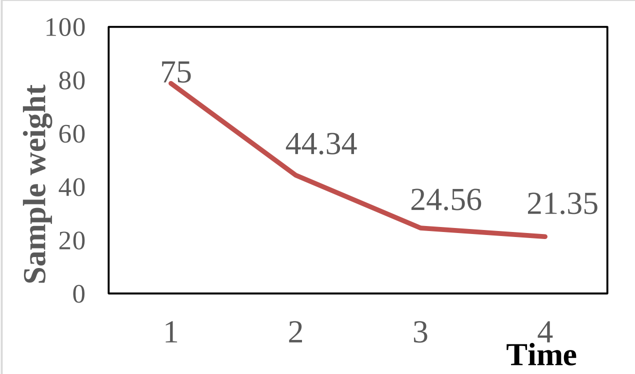

FIGURE 5: Time-temperature relation in temperature-controlled dryer

The graph shown in Figure 4 and Figure 5 describes the drying time- sample weight relationship. It shows that the weight of the product decreases gradually with an increase in time.

The graph shows the drying time-temperature relation between normal sun drying and temperature-controlled drying. From Figure 4 and Figure 5, it is evident that the drying rate is faster in temperature-controlled dryers as compared to normal sun drying.

FIGURE 6: Lemon Peel before and after Automated temperature-controlled drying

IV. CONCLUSION

In this miniature model, the temperature is controlled using a cooling fan, so that can be used to dry a heat-sensitive product without/with minimum nutritional destruction. This seems to be a robust way of handling only temperature control on an automatic basis. In this research, the citrus fruit peel is dried in an automated temperature-controlled method compared to sun drying and other electrical dryers. It is noted that the drying efficiency of the automatic temperature-controlled drying is 6% greater than the normal temperature drying. Because of the controlled temperature in solar drying which prevents the destruction of heat-liability vitamins i.e., ascorbic acid. The nutrients retained in automatic temperature-controlled solar drying are 20% more than in sun drying.

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Profile Characteristics of the Farmers about Sustainable Practices of Redgram based Farming System

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Abstract— *The present study was conducted in Kalaburagi district of North Eastern Karnataka, during the year 2018-19. Kalaburagi district was purposively selected because the district is the pulse bowl of the state with highest area. The study was conducted in eight villages selected from four talukas of Kalaburagi district which included 30 farmers from each selected village thus making a sample of 240 farmers using random sampling method. Ex-post-facto research design was employed for conducting study. Data was collected by using a detailed interview schedule employing personal interview method and analyzed using mean, standard deviation, frequency and percentage. The analysis of profile characteristics of farmers indicated that little over half (52.50 %) of the farmers were in middle age group (31-50 years), had high school education (25.00 %), belonged to nuclear family (55.42 %), medium size of land holding (63.33 %), had more than 20 years of farming experience (55.83 %), medium annual income (42.08 %), low cropping intensity (41.25 %), medium material possession (46.67 %), low livestock possession (48.33 %), medium extension orientation (42.08 %), medium mass media utilization (42.08 %), medium level of innovativeness (52.92 %), medium level of achievement motivation (42.92 %), medium scientific orientation (47.92 %), medium risk orientation (55.42 %) and medium management orientation (41.67 %).*

***Keywords—* Profile characteristics, Redgram Based Farming System, Sustainable Practices.**

I. INTRODUCTION

Legumes rank second in importance to cereals as human food sources because they contain protein almost comparable to what is derived from animal and fish meat. Legumes, regarded as poor man's meat, are the cheapest sources of protein among the underprivileged that cannot afford animal and fish proteins Mula and Saxena (2010). Redgram is a nutritious food being rich in protein and well-known for its usefulness in increasing soil fertility, preventing soil erosion and in suppressing weeds in upland farms. It has a wide adaptability to different climates and soils.

Redgram (*Cajanus cajan* (L) mill.sp.) is commonly known as arhar, pigeonpea, tur, togari, gango pea and no eye pea. It is an important and old crop of the country. It is the second most important pulse crop only after chickpea. Redgram is an important pulse crop grown in the tropics and subtropics. It finds important place in farming systems adopted by small holding peasants in large number of developing countries. Redgram is considered to be origin of peninsular India. It is a short annual crop in India and as a perennial in many other countries, where pods are harvested at regular interval. The crop has deep root system and hence highly drought tolerant. It is a protein rich staple food contains about 22.30 per cent protein, which is almost three times that of cereals. Redgram supplies a major share of protein, requirement of vegetarian population of the country. Redgram is mainly consumed in the form of split pulse as Dal, which is an essential supplement of cereal based diet (Nene and Sheila, 1990, Tuwafe *et al*., 1993).

India is the largest producer, consumer and importer of redgram in the world. India occupies 79.00 per cent of world redgram area and accounts for 67.00 per cent of world production of redgram. In India, redgram occupies an area of 4.44 million hectares and production of about 4.28 million tonnes, having a productivity of 967 kg/ha (INDIASTAT, 2017). It is mainly grown in Maharashtra, Karnataka, Madhya Pradesh, Telangana, Uttar Pradesh and Andhra Pradesh. Maharashtra (1.24 million hectares) is the leading producer of redgram followed by Madhya Pradesh (0.64 million hectares). In Karnataka, redgram is largely grown in northern parts, especially in Kalaburagi district and is called as pulse bowl of Karnataka. 'Kalaburagi Tur Dal' received Geographical Indication (GI) Tag (No. 593) from government of India during the year 2019. The state occupies an area of about 8.85 lakh hectares with the production of 7.62 lakh tonnes, having an average productivity of 861 kg/ha (INDIASTAT, 2017). Kalaburagi has an area of about 3.28 lakh hectares with production of 3.77 lakh tonnes and a productivity of 1209 kg/ha (Anonymous, 2017).

Sustainable practice encompasses the elements of productivity, profitability, health safety and the environment. Thus, sustainable practice is the need of the hour because of the urgency to develop farming techniques, which are sustainable from environments, production and socio-economic point of view. There is now an urgent demand for creative and innovative conservation and production practices that would provide farmers with economically viable and environmentally sound alternatives in their agricultural production systems Desai and Pujari, (2007). Sustainable farming is gaining momentum in India because it is adoptable and eco-friendly. Growing awareness of consumers to use safe and healthy food and need to address less effect of chemicals in agriculture production, restoration of soil health and fertility has played a key role in the emergence of sustainable agriculture sector since last two decades. Hence, it is evident that redgram crop command greater importance for attaining a better position in the world market, which would inturn contribute to our national income. At the same time, there is a need to concentrate on certain specific sustainable practices which are eco-friendly and cost effective. Since, the issues of higher cost of cultivation due to increased use of fertilizers and pesticides, decreasing trends of yield and other environmental issues are gaining paramount importance, greater emphasis is thus being laid on sustainable practices in the recent past. With this brief background the present study was conducted to know the profile characteristics of farmers about sustainable practices of redgram based farming system.

II. MATERIALS AND METHODS

The present study was conducted in Kalaburagi district of Karnataka state during the year 2018-19. Kalaburagi district was purposively selected because the district is the pulse bowl of the state with highest area. Out of seven talukas from the Kalaburagi district four talukas were selected purposively based on highest area under redgram cultivation. The talukas selected for the study were Aland, Chittapur, Jewargi and Kalaburagi. A list of villages where redgram is grown as principal crop is prepared in consultation with the officials of Department of Agriculture. Two villages from each talukas were selected based on maximum area under redgram cultivation. The villages selected for the study were Madan Hipperga and Narona from Aland taluka, Kalgi and Dandothi from Chittapur taluka, Yedrami and Nelogi from Jewargi taluka and Kamalapur and Srinivas Saradagi from Kalaburgi taluka. Thus a total of eight villages were selected from four talukas. Considering all farmers in the selected villages, the criteria for selection of farmer as a respondent is that, he should successfully cultivate redgram crop. Along with redgram one or the other intercrops and enterprises like dairy (minimum two milch animals), sheep/goat farming (minimum of four sheep's/goat/unit), poultry rearing *etc*. From the each selected village, a separate list of redgram based farmers was prepared in consultation with officials of Department of Agriculture. From the list prepared, 30 farmers were selected randomly by using simple random sampling technique. Thus, the study sample comprised of 240 respondents. Ex-post-facto research design was employed for conducting study. Data was collected by using a detailed interview schedule employing personal interview method. The responses were scored, quantified, categorized and tabulated using percentage, mean and standard deviation.

III. RESULTS AND DISCUSSION

3.1 Profile characteristics of the farmers about sustainable practices of redgram based farming system

3.1.1 Age

Age is an important factor as it reveals the maturity of an individual to take decisions for achieving his needs. From the Table 1 it could be inferred that, little over half (52.50 %) of the farmers were in middle age group (31-50 years) followed by 29.59 per cent of the farmers were in old age group (above 50 years) and 17.91 per cent of the farmers were in young age group (up to 30 years). The probable reason for this could be that, the middle aged farmers were actively involved in the farm activities, are enthusiastic and had more work efficiency than older ones. Further individuals of middle age group have more physical vigour and share more family responsibility than the younger ones. They also have a strong desire to be an earning member and contribute their share to the income of their family. The findings are in line with the findings of Sunitha (2015).

TABLE 1
DISTRIBUTION OF FARMERS BASED ON THEIR PROFILE CHARACTERISTICS

Sl. No.	Characteristics	Categories	Frequency	Percentage
1.	Age	Young (up to 30 years)	43	17.91
		Middle (31-50 years)	126	52.50
		Old age (>50 years)	71	29.59
2.	Education	Illiterate (Can't read and write)	58	24.17
		Primary school (1 to 4th Std)	27	11.25
		Middle school (5th to 7th Std)	29	12.08
		High school (8th to10th Std)	60	25.00
		Pre-University (11th to12th Std)	30	12.50
		Graduate and above	36	15.00
3.	Type of family	Nuclear (Single couple and unmarried children)	133	55.42
		Joint (More than one couple and married children living together)	107	44.58
4.	Land holding	Marginal farmer (Up to 2.50 acres)	0	0.00
		Small Farmers (2.51 to 5.00 acres)	71	29.59
		Medium Farmers (5.01 to 25.00 acres)	152	63.33
		Big Farmers (Above 25.00 acres)	17	7.08
5.	Farming experience	Less than 10 years	30	12.50
		10 to 20 years	76	31.67
		More than 20 years	134	55.83
6.	Annual income	Low (< 46858.11)	91	37.92
		Medium (46858.11 – 124051.89)	101	42.08
		High (> 124051.89)	48	20.00
		Mean = 85455.00	**SD = 90816.20**	
7.	Cropping intensity	Low (< 6.44)	99	41.25
		Medium (6.44 – 11.92)	73	30.42
		High (> 11.92)	68	28.33
		Mean = 9.18	**SD = 6.11**	
8.	Material possession	Low (< 4.75)	77	32.08
		Medium (4.75 – 6.35)	112	46.67
		High (> 6.35)	51	21.25
		Mean = 5.55	**SD = 1.88**	
9.	Livestock possession	Low (< 3.50)	116	48.33
		Medium (3.50 – 9.03)	80	33.33
		High (> 9.03)	44	18.33
		Mean = 6.27	**SD = 6.51**	
10.	Extension orientation	Low (< 5.72)	74	30.84
		Medium (5.72 – 8.26)	101	42.08
		High (> 8.26)	65	27.08
		Mean = 6.99	**SD = 2.99**	
11.	Mass media utilization	Low (< 7.41)	88	36.67
		Medium (7.41 – 10.08)	101	42.08
		High (> 10.08)	51	21.25
		Mean = 8.75	**SD = 3.15**	
12.	Innovativeness	Low (< 10.29)	62	25.83
		Medium (10.29 – 12.30)	127	52.92
		High (> 12.30)	51	21.25
		Mean = 11.30	**SD = 2.36**	
13.	Achievement motivation	Low (< 9.49)	76	31.67
		Medium (9.49 – 11.07)	103	42.92
		High (> 11.07)	61	25.42
		Mean = 10.28	**SD = 1.85**	
14.	Scientific orientation	Low (< 7.77)	48	20.00
		Medium (7.77 – 9.23)	115	47.92
		High (> 9.23)	77	32.08
		Mean = 8.50	**SD = 1.72**	
15.	Risk orientation	Low (< 2.98)	51	21.25
		Medium (2.98 – 4.01)	133	55.42
		High (> 4.01)	56	23.33
		Mean = 3.50	**SD = 1.21**	
16.	Management orientation	Low (< 11.11)	84	35.00
		Medium (11.11 – 12.96)	100	41.67
		High (> 12.96)	56	23.33
		Mean = 12.04	**SD = 2.17**	

3.1.2 Education

Education is one of the important factors that influence the knowledge of individuals. It is clear from the Table 1 that one fourth (25.00 %) of the farmers were educated up to high school level followed by illiterates (24.17 %), studied degree and above (15.00 %), pre-university (12.50 %), middle school (12.08 %) and primary school education (11.25 %), respectively. The probable reason for this could be attributed to the availability of free basic education and the educational infrastructure in the study area. Few of them opted higher education reflecting on their affordability and interest to learn more and gain good knowledge. Similar findings were reported by Suresh Kumar (2009).

3.1.3 Type of family

From the Table 1 it is observed that over half (55.42 %) of the farmers belonged to nuclear family followed by 44.58 per cent of the farmers belonged to joint family. This might be due to changing values of family system. The results were in consonance with the findings of Sidram (2015) who reported that majority of farmers belonged to nuclear family.

3.1.4 Land holding

It could be noticed from the Table 1 that majority (63.33 %) of the farmers belonged to medium size of land holding followed by 29.59 per cent of the farmers belonged to small size of land holding and least 7.08 per cent of the farmers belonged to big size of land holding. This could be due to the transfer of ancestral land holding from generation to generation, interest of farmers to continue in the farming occupation as the source of income. Similar findings were observed with Sharma e*t al.* (2017) and Vidhi Motiwale (2018).

3.1.5 Farming experience

It is evident from the Table 1 that over half (55.83 %) of the farmers had more than 20 years of farming experience followed by 31.67 per cent of the farmers had 10 to 20 years of farming experience and only 12.50 per cent of the farmers had less than 10 years of farming experience. The probable reason for this could be that, the farmers who had farming experience of more number of years were interested and knowledgeable in sustainable cultivation practices of redgram based farming system. The findings were in accordance to the findings as reported by Biradar (2012).

3.1.6 Annual income

The economic position of the farmers as presented in the Table 1 revealed that one third (42.08 %) of the farmers belonged to medium annual income category followed by low (37.92 %) and high income group (20.00 %) categories. The possible reason might be that majority of farmers 5 to 25 acres of land holding indicating better economic conditions of the redgram based farmers their dependency mainly on agriculture production and adoption of different enterprises. The findings were in accordance to the findings as reported by Sharma *et al.* (2017).

3.1.7 Cropping intensity

It was evident from the Table 1 that one third (41.25 %) of the farmers belonged to low cropping intensity followed by medium (30.42 %) and high (28.33 %) cropping intensity categories. The incidence of low cropping intensity might be due to more dependence on rainfed water by the farmers. Similar results regarding cropping intensity were observed in the findings of Krishnamurthy (2015).

3.1.8 Material possession

The data in the Table 1 revealed that nearly half (46.67 %) of the farmers had medium material possession, followed by low (32.08 %) and high (21.25 %) material possession. Nowadays mobile phones are common medium of mass media owned by the people. Probable reason for above findings is due to the changing needs of the family members and also for the comfort of transportation, they possess two wheelers. Pertaining to farm implements, sprayers and wooden plough are the implements used by the redgram based farmers to carry out different agricultural operations in their fields. Findings are in accordance with findings of Tanweer Ahmed (2015)

3.1.9 Livestock possession

It was observed from the Table 1 that nearly half (48.33 %) of the farmers had low level of livestock possession followed by (33.33 %) medium and high (18.34 %) of livestock possession, respectively. It is due to the fact that cattle waste like cow dung and urine are the main inputs in farm yard manure and vermicompost, which are used in sustainable farming. Further, dairy being the subsidiary occupation for the redgram based farmers had contributed to above trend of findings. The results are in line with the results of Ningareddy (2005).

3.1.10 Extension orientation

The results showed from the Table 1 that over one third (42.08 %) of the farmers had medium level of extension orientation followed by low 30.84 per cent and high 27.08 per cent of the farmers belonged to extension orientation, respectively. As per the study some of the farmers are opinion leaders and innovators in their respective village which leads them to keeping good extension contact with the experts in regular interval. Since they were opinion farmers they attended different extension programmes and trainings regularly and promoting the sustainable agriculture practices to fellow farmers also. The results are in conformity with findings of Sunilkumar (2004) and Sajeev and Saroj (2014).

3.1.11 Mass media utilization

The finding from the Table 1 showed that, over one third (42.08 %) of the farmers had medium mass media utilization followed by low 36.67 per cent and high 21.25 per cent of the farmers belonged to mass media utilization respectively. Mass media utilization enhances the ability of farmers to get more information about current affairs as well as information on recent agricultural technology or innovation and in turn widens the mental horizon of the farmers to accept and adopt the practices. The results are in conformity with the findings of Nagesh (2006).

3.1.12 Innovativeness

The findings presented in the Table 1 revealed that little over half (52.92 %) of the farmers had medium level of innovativeness followed by 25.83 per cent were low and 21.25 per cent of them had high level of innovativeness. Innovativeness plays a greater role in the individual’s personality. The person with higher innovativeness can do things rapidly and more precisely than others. This also may be attributed to the fact that majority of the farmers had education up to high school and pre university/diploma. Generally, higher the formal education level, more the innovations. In such conditions, respondents try to seek more information and try out new ideas and technologies within their budget and limits and also farmers who are prone to innovations will try to gather information regarding the new technology from various aspects, they wanted to learn new ways of farming, improved cultivation practices and adopt those technologies at faster rate with maximum accuracy. Similar findings were reported by Maraddi (2006) and Sidramayya (2013).

3.1.13 Achievement motivation

Data pertaining to achievement motivation in the Table 1 revealed that one third (42.92 %) of the farmers had medium level of achievement motivation followed by 31.67 per cent and 25.42 per cent of the farmers belonged to low and high level of achievement motivation categories, respectively. The probable reason could be that achievement motivation is basic character which motivates and helps an individual to do anything. It is a psychologically internalized condition which drives an individual to aspire for higher level of earning and living. The findings are in line with the findings of Maraddi (2006) and Sidram (2008).

3.1.14 Scientific orientation

The results presented in the Table 1 indicated that nearly half (47.92 %) of the farmers possessed medium level of scientific orientation followed by high 32.08 per cent and low 20.00 per cent scientific orientation category. The probable reason could be that, scientific orientation is the orientation of farmer to adopt new technologies in a scientific way. Redgram being a traditional crop, farmers were found to be equally adopting traditional and conventional methods been observed in major redgram growing areas due to unscientific usage of irrigation. The problem of soil salinity is severe in black soil, which is the major soil profile in the study area. This fact has prompted the farmers to adopt sustainable practices to reduce the problem of soil salinity. Similar observation was made by Sidram (2008).

3.1.15 Risk orientation

Findings of risk orientation depicted in the Table 1 that over half (55.42 %) of the farmers were having medium level of risk orientation followed by 23.33 per cent had high and 21.25 per cent belonged to low level of risk orientation. The probable reason could be that farmers in these categories might have made up their mind to take risk and have put efforts to adopt new agricultural technology for sustainability of their farming systems. It could be due to the fact that risk taking is a must for farmers to earn money to lead a better life. The results were supported by the findings of Sharma *et al.* (2017).

3.1.16 Management orientation

It could be noticed from the Table 1 that one third (41.67 %) of the farmers belonged to medium management orientation followed by 35.00 per cent had low and 23.33 per cent belonged to high level of management orientation respectively. The probable reason could be that, this might be due to the fact that the NGO's and field extension personnel of private companies were working with many prospective farmers in different areas and those interactions might have helped the farmers to reorient their management orientation. Then personal explosive of the farmers to various professional situations like group discussion meeting, exhibitions, field days, krishimela *etc.*, might have also contributed to development of medium level of management orientation. The findings are in accordance with the studies conducted by Maraddi (2006) and Sidramayya (2013).

3.2 Individual component wise material possession

The data in the Table 2 revealed that with regard to household material large majority (97.91 %) of the farmers possessed mobile phone. The probable reason could be that, majority of the farmers possessed mobile phones, scooter, ceiling fan, mixer/grinder, refrigerator and bicycle. The least number of farmers had possessed was four wheeler. The reason for low possession of four wheeler was most of the farmers belonged to medium land holding and medium annual income category and the four wheeler cost of material is high (> 4 lakh). So there is a low possession regarding four wheelers. These results are in line with the results of Krishnamurthy (2015). With regard to farm implements large majority (90.00 %) of the farmers possessed sprayer. The probable reason could be that, majority of the farmers possessed sprayer, wooden plough, MB plough, harrow, tractor, seed cum fertilizer drill and thresher. The reason for none or low possession of seed cum fertilizer drill and thresher may be attributed to the fact that special skill is required for operation and cost of equipment is high (> 5 lakh) and non availability of equipment in local area. These results are in line with the results of Nagaraj (2012).

TABLE 2
DISTRIBUTION OF FARMERS ACCORDING TO THEIR INDIVIDUAL COMPONENT WISE MATERIAL POSSESSION

Sl. No.	Household materials	F*	%	Farm implements	F*	%
1.	Bicycle	48	20.00	Wooden plough	182	75.83
2.	Scooter	188	78.33	MB plough	41	17.08
3.	Four wheeler	4	1.67	Harrow	34	14.17
4.	Refrigerator	48	20.00	Seed cum fertilizer drill	25	10.41
5.	Mixer/Grinder	97	40.41	Sprayer/Duster	216	90.00
6.	Ceiling fan	174	72.50	Tractor	29	12.08
7.	Mobile	235	97.91	Thresher	10	4.17

F= Frequency, %= Per cent *= Multiple responses

3.3 Individual component wise livestock possession

The data presented in the Table 3 revealed that the possession of the livestock by the farmers. Majority (78.75 %) of farmers were having two to three bullocks, while 6.67 per cent were having more than three and only 2.08 per cent of farmers had less than two bullocks. While 10.41 per cent of the farmers were having two to three buffaloes, while 7.08 per cent and 1.25 per cent of farmers were having more than three and less than two buffaloes respectively. About (16.67 %) of farmers possessed two to three cows, whereas only 10.83 per cent and 8.33 per cent of farmers were having more than three and less than two cows, respectively. While 17.91 per cent of the farmers were having more than three sheep/goats, while, only 1.25 per cent of farmers were having two to three sheep/goat respectively. Whereas, only 8.75 per cent of the farmers were having more than three poultry birds, while 2.08 per cent of the farmers were having two to three poultry birds, respectively. This might be due to the fact that, bullocks are utilized to carry out farm operations like ploughing, harrowing, intercultivation operations, carrying cart *etc*. Cows and buffaloes like income generation by selling milk, selling of sheep and poultry birds in slaughter market, and the wastage of these animals utilized in FYM or vermicompost pit increase the farm income. The reason for non or low possession of sheep and poultry birds might be that farmers expressed they have problems in maintenance of sheep and poultry birds and they have only back yard poultry that too with local poultry breed. These results were in line with the results of Nagaraj (2012).

TABLE 3
DISTRIBUTION OF FARMERS ACCORDING TO THEIR INDIVIDUAL COMPONENT WISE LIVESTOCK POSSESSION

Sl. No.	Livestock possession	Less than two		Two to three		More than three	
		F	%	F	%	F	%
1.	Bullock	5	2.08	189	78.75	16	6.67
2.	Buffaloes	3	1.25	25	10.41	17	7.08
3.	Cow	20	8.33	40	16.67	26	10.83
4.	Sheep/goat	0	0.00	3	1.25	43	17.91
5.	Poultry birds	0	0.00	5	2.08	21	8.75

F= Frequency, %= Percent

3.4 Individual component wise extension orientation

It is noticed from the Table 4 that with respect to extension contact over half (56.25 %) of the farmers contacted Assistant Agricultural Officer whenever problem arise followed by 24.58 per cent of them never contacted, 15.00 per cent of them contacted once in 15 days and 4.17 per cent of them contacted once in a week to Assistant Agricultural Officer. About majority (62.08 %) of the farmers never contacted Agricultural Officer followed by 32.50 per cent of them contacted whenever problem arises. While (88.75 %) of the farmers never contacted Assistant Director of Agriculture followed by 11.25 per cent of them contacted Assistant Director of Agriculture whenever problem arise. The percentage of the farmers who never contacted KVK SMS Scientist was (64.58 %) followed by 27.92 per cent of them contacted whenever problem arise. It is found that (73.75 %) of them never contacted NGO's followed by 24.17 per cent of them contacted whenever problem arise. It is noticed that (72.92 %) of the farmers contacted private input agencies whenever problem arise, followed by 17.50 per cent of them contacted once in 15 days. The possible reasons for whenever problem arise contact with farm facilitators, Assistant Agriculture Officers and Agriculture Office could be their availability at village and hobli level, respectively. When problem arises contact was observed with Scientists of KVKs and University as they are providing technical know-how of management practices of redgram crop. Whereas, Private agency field staff were consulted as farmer required continuous supervision regarding maintenance. The results are in conformity with findings of Sunilkumar (2004).

TABLE 4
DISTRIBUTION OF FARMERS ACCORDING TO THEIR INDIVIDUAL COMPONENT WISE EXTENSION ORIENTATION

A. Extension contact:

(n=240)

Sl. No.	Extension personnel	Frequency of contact							
		Once in a week		Once in 15 days		Whenever problem arise		Never	
		F	%	F	%	F	%	F	%
1.	Assistant Agriculture Officer (AAO)	10	4.17	36	15.00	135	56.25	59	24.58
2.	Agriculture Officer (AO)	0	0.00	13	5.42	78	32.50	149	62.08
3.	Assistant Director of Agriculture (ADA)	0	0.00	0	0.00	27	11.25	213	88.75
4.	KVK SMS Scientist	0	0.00	18	7.50	67	27.92	155	64.58
5.	Representatives of NGO's	0	0.00	5	2.08	58	24.17	177	73.75
6.	Representatives of private input agencies	23	9.58	42	17.50	175	72.92	0	0.00

F= Frequency, %= Per cent

B. Extension participation

(n=240)

Sl. No.	Extension activities	Participated		Extent of participation					
				Regular		Occasional		Never	
		F	%	F	%	F	%	F	%
1.	Demonstrations	64	26.67	8	3.33	56	23.33	176	73.33
2.	Group meetings	139	57.92	13	5.42	126	52.50	101	42.08
3.	Field days	43	17.92	8	3.33	35	14.58	197	82.08
4.	Educational tours	18	7.50	5	2.08	13	5.42	222	92.50
5.	Field visits	40	16.67	7	2.92	33	13.75	200	83.33
6.	Training programmes	112	46.67	26	10.83	86	35.83	128	53.33
7.	Agriculture exhibitions	87	36.25	9	3.75	78	32.50	153	63.75
8.	Krishi mela	203	84.58	29	12.08	174	72.50	37	15.42

F= Frequency, %= Percent

With respect to extension participation majority (84.58 %) of the farmers participated in krishimela followed by group meetings (57.92 %), training programmes (46.67 %), agriculture exhibitions (36.25 %), demonstrations (26.67 %), field days (17.92 %) and field visits (16.67 %). Only 7.50 per cent of them participated in educational tours. Krishimela, demonstrations, field visits and field days help in developing confidence among the sustainable redgram based farmers. Krishimela organized by state agricultural university or agriculture department, is important extension activity to exchange ideas, problems and solutions related to sustainable farming. Krishimela is conducted every year at fixed month that enables the farmer's field and many of them might have participated in it. Similar could be reason for field visits. Also the eagerness of farmers in solving their problems and better exposure with officials working in extension organization and also their interest, faith and belief in the extension services provided by the Karnataka State Department of Agriculture and State Agriculture Universities. The results also implied that the regular participation in various extension activities was low, the reason might be the inconvenient timings of extension activities to farmers, they might have been busy in agricultural operations and allied activities, and might not known about the programme due to improper communication. The above findings were in accordance with the findings of study conducted by Sajeev and Saroj (2014).

3.5 Individual component wise mass media utilization

The results pertaining to mass media utilization presented in the Table 5 revealed that, only 11.67 per cent of farmers possessed radio, where in 3.33 per cent of them regularly listened agriculture programmes followed by 8.75 per cent of them who listened occasionally the agriculture programmes through radio and 7.92 per cent of the farmers listened general programmes regularly followed by 12.08 per cent listened occasionally general programmes through radio. This showed that less per cent of them listened to radio occasionally. Radios have become less popular obviously for the reasons that it has only the audio effect and the televisions with audio and visual effects have become affordable to all. The other reason may be that the listening behaviour of radio depends on individuals interests.

Large majority (96.67 %) of the farmers owned television as a most important form of media. When viewing behaviour analyzed it was noted that 14.17 per cent of them regularly viewed agricultural programmes followed by 32.50 per cent who viewed occasionally and 75.83 per cent of the farmers viewed general programmes regularly followed by 24.17 per cent viewed occasionally. So majority of the farmers used it for watching the general programme rather than the agricultural programmes. The reason could be that most of the agricultural programmes are being telecasted in the morning hours and the farmers could not spend time to watch television in the morning hours because usually the farmers go to their fields early in the morning and after completing all the field works in the evening hours. Also the people could prefer to watch general programme that are more entertaining than the agriculture programmes.

TABLE 5
DISTRIBUTION OF FARMERS ACCORDING TO THEIR INDIVIDUAL COMPONENT WISE MASS MEDIA UTILIZATION

(n=240)

Sl. No.	Mass Media	Subscriber/ Possessed		Programmes	Frequency of use					
					Regular		Occasional		Never	
		F	%		F	%	F	%	F	%
1.	Radio	28	11.67	Agriculture information	8	3.33	21	8.75	211	87.92
				General information	19	7.92	29	12.08	192	80.00
2.	Television	232	96.67	Agriculture information	34	14.17	78	32.50	128	53.33
				General information	182	75.83	58	24.17	0	0.00
3.	Newspaper	39	16.25	Agriculture information	11	4.58	33	13.75	196	81.67
				General information	66	27.50	48	20.00	126	52.50
4.	Farm Magazines	21	8.75	Agriculture information	2	0.83	22	9.17	216	90.00
				General information	0	0.00	0	0.00	0	0.00
5.	Mobile SMS	209	87.08	Agriculture information	28	11.67	95	39.58	117	48.75
				General information	183	76.25	57	23.75	0	0.00
6.	Kissan Call Centre	27	11.25	Agriculture information	0	0.00	37	15.42	203	84.58
				General information	0	0.00	0	0.00	0	0.00

Further the result also revealed that, only 16.25 per cent of the farmers subscribed for newspaper, while 4.58 and 27.50 per cent of the farmers were regular reader of agriculture and general programmes. About 13.75 and 20.00 per cent of the farmers were occasional reader of agriculture and general programmes respectively. Majority of them are not subscribed newspaper, as majority could get all the news from the television sets they possess.

In case of farm magazine, 8.75 per cent of the farmers subscribed of whom 0.83 per cent of farmers were regular readers; while 9.17 per cent of them were occasional readers of agriculture programmes. The possible reason for this might be lack of time and interest. Whenever they are in need of it they would barrow it from the other subscriber farmers.

Majority (87.08 %) of farmers possessed mobile SMS. In which 11.67 and 76.25 per cent of them regularly viewed; and 39.58 and 23.75 per cent of farmers occasionally viewed agricultural and general programmes, respectively. Most of the farmers are registered farmers to APMC, KVK and NGOs, they will be receiving the messages based on the seasons of the crop or market rate of the crop.

In case of kissan call center only 11.25 per cent of farmers were subscribed of whom 15.42 per cent of the farmers were occasional callers to the kissan call center. The farmers were asking the information about soil health card scheme, different varieties of crops to be grown in that area, spraying of insecticides to the crop and disease affected crops spraying the solutions would be asked in kissan call center.

The findings of the result are similar to the findings of Sharma *et al.* (2017).

IV. CONCLUSION

From the above discussion it could be concluded that majority of the farmers were in middle age group, had high school education, belonged to nuclear family, medium size of land holding, had more than 20 years of farming experience, medium annual income, low cropping intensity, medium material possession, low livestock possession, medium extension orientation, medium mass media utilization, medium level of innovativeness, medium level of achievement motivation, medium scientific orientation, medium risk orientation, and medium management orientation. Hence, the government and private organization should emphasis for up scaling these variables for their advantage in order to improve knowledge level of sustainable practices in redgram based farming system and also intensive training programs needs to be conducted by government and non-government agencies to improve the profile characteristics of redgram based farmers.

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Growth Dynamics of *Deshi* Cotton in Skip Row Intercropping Systems

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Abstract— *Field experiment was conducted during kharif season of 2018-19 at Agronomy Farm, College of Agriculture, Dhule with the objective of studying the growth parameters of deshi cotton in skip row planting with intercrops. Results showed that plant height of cotton was influenced due to different intercrops at all the growth stages, except at 30 DAS. Skip row planting of cotton + sesamum (2:1) recorded significantly the maximum plant height (150.20 cm) and was on par with remaining intercrops of green gram, black gram, soybean and sesamum except pearl millet. However, pearl millet reduced plant height of cotton (106.73 cm) drastically and shown its dominance. Leaf area per plant of cotton at flowering stage (60 DAS), sole cotton recorded the highest leaf area than with green gram and pearl millet as an intercrop. However, at fruiting stage (90 DAS), there was no difference in leaf area among both the sole cotton and with intercrop, except with pearl millet. In later stage (120 DAS), similar results were noticed with reduced leaf area with soybean as intercrop as compared to other intercrops and sole cotton. At the time of harvest, sesamum was the superior intercrop for sustaining cotton leaf area (322.07). However, both sole cotton and cotton intercropped with green gram and black gram were equally effective in maintaining the leaf area of cotton. Number of sympodial branches per plant was highest (20.40) under skip row planting of cotton + intercropping of black gram (2:1) and lowest (13.33) under skip row planting of cotton + intercropping of pearl millet (2:1). Flower initiation was earlier under sole skip row planting of cotton and 2-3 days late with the growing of intercrops in skip row planting.*

Keywords— deshi cotton, growth, intercropping, pearl millet.

I. INTRODUCTION

Cotton is a crucial fiber and cash crop in India, significantly influencing the nation's industrial and agricultural economy. It supplies the essential raw material, cotton fiber, to the cotton textile industry. In India, cotton directly supports the livelihoods of 6 million farmers and employs approximately 40-50 million people in its trade and processing. Cotton is known as the "King of Fibers" and is also referred to as "White Gold." Deshi cotton species produce high yields and need minimal chemical inputs, like fertilizers and pesticides, to achieve yields comparable to or better than American cotton.

Intercropping is a traditional and widespread practice in India and many other developing countries where farm sizes are generally small. Such cropping system is more relevant in rainfed farming as there is risk of crop failure either due to changes in seasonal climate or rainfall patterns. If two or more crops are simultaneously grown in same field, at least one may give something if the other fails. Consequently, intercropping offers a form of insurance against complete crop failure. In cotton a long duration widely spaced crop, the vacant interspaces between the rows during initial growth period can be utilized in better way by growing suitable short duration intercrops. It shows slow initial growth stage and takes 60-75 days to cover the interspaces by its canopy. This period offers excellent opportunity to exploit the conditions for raising an intercrop. Widely planted long duration crop like cotton along with its slow growth habit during initial stage allows enough time and space for growing short duration intercrops which can lead to increased production by proper utilization of resources and inputs. The main compulsion of intercropping is to make best and efficient use of natural resources for getting maximum return per unit area and time. In this system larger total yields are generally obtained than any of the pure crops. Productivity of the intercropping system can be substantially enhanced by proper selection of crops and their suitable varieties which may differ in duration, morphology and growth pattern from the principal crop so that peak requirements for moisture, nutrients, solar radiation etc. are met with steadily throughout the growing season.

II. MATERIAL AND METHODS

Field experiment was carried out during *kharif* season of 2018 at Agronomy section, College of Agriculture, Dhule. The experiment was laid out in randomized block design with seven treatments and three replications with gross and net plot size of 3.60 X 4.50 m^2 and 2.70 X 3.60 m^2, respectively. The seven treatments consisted of T_1: Sole cotton, T_2: Sole skip row planting of cotton, T_3: Skip row planting of cotton + intercropping of green gram (2:1), T_4: Skip row planting of cotton + intercropping of black gram (2:1), T_5: Skip row planting of cotton + intercropping of soybean (2:1), T_6: Skip row planting of cotton + intercropping of sesamum (2:1) and T_7: Skip row planting of cotton + intercropping of pearl millet (2:1). *Deshi* cotton variety JLA-505, green gram variety BM 2003-02, black gram variety TAU-1, soybean variety JS-335, sesamum variety JLT-408 and pearl millet hybrid Adishakti were used in experiment. Sole crop of cotton was sown at 45 x 22.5 cm, skip row planting of cotton was sown at 45 x 15 – 90 – 45 x 15 cm and all intercrops in the skip row pattern were sown at a distance of 10 cm from each other. The recommended fertilizer rate for *deshi* cotton (50:25:25 N: P_2O_5: K_2O kg/ha) was used for all treatments. Observations on growth parameters of *deshi* cotton were recorded. The data gathered from the experimental field were analyzed statistically. Standard statistical methods were used.

III. RESULTS AND DISCUSSION

3.1 Plant height:

Skip row planting of cotton + sesamum (2:1) recorded significantly the maximum plant height (150.20 cm) than skip row planting of cotton + pearl millet (2:1), however, it was on par with the rest of the treatments. This might be due to availability of optimum space to utilize the soil and environmental resources to the maximum extent due to less competition among crop plants. However, adverse effect of pearl millet may be due to its dominance and hybrid nature. Sharma *et al.* (2000) concluded that more plant height was from skip row spacing as compared to regular row spacing of the same plant population.

TABLE 1
PLANT HEIGHT OF COTTON AS INFLUENCED PERIODICALLY BY DIFFERENT TREATMENTS

Treatments	30 DAS	60 DAS	90 DAS	120 DAS	At Harvest
T_1:Sole cotton	29.72	104.93	134.00	136.87	142.93
T_2: Sole skip row planting of cotton	32.20	114.93	140.83	143.10	149.70
T_3:Skip row planting of cotton + green gram (2:1)	29.69	104.13	136.40	141.07	148.53
T_4:Skip row planting of cotton +black gram (2:1)	27.78	105.93	136.23	142.23	148.57
T_5:Skip row planting of cotton +soybean (2:1)	29.77	108.67	135.03	139.63	144.87
T_6:Skip row planting of cotton + sesamum (2:1)	29.79	113.33	141.80	146.13	150.20
T_7:Skip row planting of cotton + pearl millet (2:1)	27.69	76.40	94.67	98.13	106.73
SEm ±	1.40	4.12	4.19	3.90	3.44
CD (P=0.05)	NS	12.68	12.92	12.01	10.60

DAS- Days after sowing

3.2 Leaf area per plant:

Skip row planting of cotton + sesamum (2:1) recorded significantly the highest leaf area per plant than all the treatments. Minimum leaf area per plant was observed at treatment of skip row planting of cotton + pearl millet (2:1). Pearl millet grown alongside cotton significantly competed with it, resulting in a substantial reduction in the leaf area per plant. This may be due to the exhaustive nature of hybrid pearl millet. Singh *et al*. (2017) reported that the various treatments tried under study showed that the leaf area per plant was recorded higher in sole cotton than rest of the treatments.

TABLE 2
LEAF AREA PER PLANT OF COTTON AS INFLUENCED PERIODICALLY BY DIFFERENT TREATMENTS

Treatments	30 DAS	60 DAS	90 DAS	120 DAS	At Harvest
T_1:Sole cotton	20.27	151.64	272.17	281.58	284.14
T_2:Sole skip row planting of cotton	21.27	129.34	265.52	275.53	269.25
T_3:Skip row planting of cotton + green gram (2:1)	21.13	123.64	263.87	268.69	264.45
T_4:Skip row planting of cotton + black gram (2:1)	22.44	134.21	292.88	296.12	283.46
T_5:Skip row planting of cotton + soybean (2:1)	20.06	131.54	237.37	242.99	252.12
T_6:Skip row planting of cotton + sesamum (2:1)	23.56	139.5	287.33	311.83	322.07
T_7:Skip row planting of cotton + pearl millet (2:1)	22.8	91.34	164.35	181.83	183.05
SEm ±	2.05	7.46	19.71	16.82	9.15
CD (P=0.05)	NS	22.99	60.73	51.82	28.19

DAS- Days after sowing

3.3 Number of sympodial branches per plant:

Number of sympodial branches was significantly influenced due to different treatments. Skip row planting of cotton + black gram (2:1) recorded significantly the highest number of sympodial branches per plant than skip row planting of cotton + pearl millet (2:1) and skip row planting of cotton + soybean (2:1), however, it was on par with rest of the treatments. During this period soybean was in pod filling stage and more moisture extraction by soybean in this stage might have affected the growth of cotton The lowest number of sympodial branches per plant was observed in skip row planting of cotton + pearl millet (2:1), likely due to the competitive nature of the pearl millet intercrop. Deshmukh *et al.* (1987) reported the highest number of sympodial branches per plant under skip row method of planting than other planting patterns at Cotton Research Station, Khandawa, Madhya Pradesh.

TABLE 3
NUMBER OF SYMPODIAL BRANCHES PER PLANT OF COTTON AS INFLUENCED PERIODICALLY BY DIFFERENT TREATMENTS

Treatments	60 DAS	90 DAS	120 DAS	At Harvest
T_1: Sole cotton	12.93	17.93	18.53	19.07
T_2:Sole skip row planting of cotton	13.93	17.6	18.93	19.2
T_3:Skip row planting of Cotton + green gram (2:1)	12.8	17.8	19.2	19.53
T_4:Skip row planting of cotton + black gram (2:1)	13.13	19.13	19.93	20.4
T_5:Skip row planting of cotton + soybean (2:1)	12.27	16.47	18	18.53
T_6:Skip row planting of cotton + sesamum (2:1)	13.47	18	18.47	19.07
T_7:Skip row planting of cotton + pearl millet (2:1)	8.27	9.87	12.13	13.33
SEm ±	0.7	0.55	0.48	0.44
CD (P=0.05)	2.15	1.71	1.47	1.36

DAS- Days after sowing

3.4 Dry matter accumulation:

Dry matter accumulation was found to be non significant for all stages of crop growth due to different treatments. However, no pronounced effect of intercrops was observed on dry matter accumulation per plant. It may due to no excessive vegetative growth under rainfed condition. Similar results were also obtained by Kumar *et al.* (2017).

TABLE 4
DRY MATTER PER PLANT OF COTTON AS INFLUENCED PERIODICALLY BY DIFFERENT TREATMENTS

Treatments	30 DAS	60 DAS	90 DAS	120 DAS	At Harvest
T_1: Sole cotton	2.33	32.67	77.03	85.1	90.93
T_2:Sole skip row planting of cotton	2.87	25.2	78	89.93	97.53
T_3:Skip row planting of cotton + green gram (2:1)	2.27	21.27	73.97	90.03	118.27
T_4:Skip row planting of cotton + black gram (2:1)	2.73	22.93	71.77	81.87	101.27
T_5:Skip row planting of cotton + soybean (2:1)	2.2	22.13	74.27	83.47	110.07
T_6:Skip row planting of cotton + sesamum(2:1)	3.13	20.87	75.43	87.7	123.57
T_7: Skip row planting of cotton + pearl millet (2:1)	2.8	15.07	57.8	71.73	72.2
SEm ±	0.28	2.75	4.09	4.03	10.37
CD (P=0.05)	NS	8.47	NS	NS	NS

DAS- Days after sowing

3.5 Days to initiation of squares, flowering and first boll opening of cotton:

Days to initiation squares and first boll opening of cotton was found to be non-significant, however, days to initiation of flowering was found to be significant. Flowering began earlier in sole skip row planting of cotton compared to other treatments. There was a three-day delay in skip row planting for cotton + black gram (2:1), cotton + soybean (2:1), and cotton + sesamum (2:1), however, it was on par with the treatment of skip row planting of cotton + pearl millet (2:1) and skip row planting of cotton + green gram (2:1). Singh and Singh (2015) findings indicated that the Bt cotton and summer moong (1+1 and 1+2), Bt cotton and bajra fodder (1+1), and Bt cotton and cowpea fodder (1+2) combinations required more days to begin flowering in both years.

TABLE 5
DAYS TO INITIATION OF SQUARES, INITIATION OF FLOWERING AND FIRST BOLL OPENING OF COTTON AS INFLUENCED BY DIFFERENT TREATMENTS

Treatment	Days to initiation of squares	Days to initiation of flowering	Days to first boll opening
T_1: Sole cotton	45.67	61.67	100
T_2:Sole skip row planting of cotton	44.67	60.33	100.67
T_3:Skip row planting of cotton + green gram (2:1)	46.67	62.67	101.33
T_4:Skip row planting of cotton + black gram (2:1)	46.67	63	101
T_5:Skip row planting of cotton + soybean (2:1)	46	63	101.33
T_6:Skip row planting of cotton + sesamum (2:1)	46.67	63	100.67
T_7:Skip row planting of cotton + pearl millet (2:1)	45.67	62.33	100.67
SEm ±	0.47	0.43	0.47
CD (P=0.05)	NS	1.33	NS

FIGURE 1: Skip row planting of cotton + green gram (2:1)

FIGURE 2: Skip row planting of cotton + black gram (2:1)

FIGURE 3: Skip row planting of cotton + soybean (2:1)

FIGURE 4: Skip row planting of cotton + sesamum (2:1)

FIGURE 5: Skip row planting of cotton + pearl millet (2:1)

FIGURE 6: Sole skip row plating of cotton

IV. CONCLUSION

From the study, it can be concluded that plant height of cotton was influenced due to different intercrops at all the growth stages, except at 30 DAS. Intercrops viz., green gram, black gram, soybean and sesamum did not show any influence on plant height of cotton. However, pearl millet reduced plant height of cotton drastically and shown its dominance. Similar trend was observed in respect of leaf area per plant of cotton as regards to pearl millet as intercrop at all the growth stages, except at 30 DAS. Number of sympodial branches per plant was higher under skip row planting of cotton with black gam. There was no significance difference with the dry matter per plant, days to initiation of squares and first boll opening.

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Success Factors for Women Entrepreneurs in the Agro-Food Sector: The Moderating Role of Family Support

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***Abstract*—** *The goal of this research is to investigate the success factors (business competencies, marketing skills, government support, self-confidence, risk-taking and sociocultural factors) and their synergistic relationship and provide key recommendations on how to promote the success and growth of women agripreneurs going forward, to not only have a sustainable and desirably diversified agrifood industry. Moreover, the moderating role of family support has been studied in the framework. This study utilized a quantitative and causal research methodology to examine the relationship between antecedents of business success in women entrepreneurs. A web-based survey was conducted to gather data from 309 women engaged in different agro-food businesses in Northern India. The findings affirm that having practical business competencies, strong government backup, enhanced market proficiency, favourable social-cultural contexts, high self-esteem, and risk-taking are critical determinants of business success. Self-confidence also underlines the significance of family support in increasing the impact of some factors on business success. In this regard, family support enhances and amplifies the positive effects of sociocultural factors, self-confidence, and risk-taking abilities. This goes a long way to demonstrate the value of the familial setup when encouraging women in business.*

***Keywords*— business competencies, marketing skills, government support, self-confidence, risk-taking and sociocultural factors.**

I. INTRODUCTION

The economic growth of any country is strongly correlated with entrepreneurs (Sagar et al., 2023). These individuals possess problem-solving abilities, sufficient capital, and the capacity to produce innovative ideas in marketing to sell their products and services (Ordeñana et al., 2024). They also can make sound decisions to guarantee that these ideas are focused on generating profits. Entrepreneurs, particularly in small and medium firms, have the potential to significantly contribute to social and economic growth (Awan & Ahmad, 2017). The presence of women-owned small and medium enterprises is seeing significant growth and contributes to the economy of almost all regions in different countries like India (Rastogi et al., 2022). The untapped potentials of women entrepreneurs have been gradually changing due to the increasing awareness of their position and economic status in society (Agarwal et al., 2022). Although the number of women entrepreneurs in India is increasing, they still face several obstacles to achieving success, including a lack of support, insufficient funding, and family support.

The agrifood business is one of the critical sectors in world economies. It is a sector where women rise to seize opportunities while encountering challenges (Meliá-Martí et al., 2022). These women, often called 'agripreneurs,' are critical actors on the margins in promoting innovation, food security, and economic development in the 21st century (Singh et al., 2022). Women are inevitably influential within the core of the agro-food system and are more involved in more than forty per cent of the farming activity in the developing world (Estigoy et al., 2023). However, they face several obstacles, from dominant culture to prejudice and practices that limit their chances to receive resources, training, or access to legal protection. These barriers tend to keep them from attaining more technical jobs and present digital competencies of high career mobility and ownership (Khan et al., 2021). Also, challenges, including gender, considering that most affected by agriculture are women, and this worsens gender disparities. However, women in agriculture are driven to create solutions to hurdles they encounter, buoyed by the following factors (Savage et al., 2023). Substance social support and support structures are equally critical in supporting one to prepare to be constructive, providing a base for knowledge sharing, coaching, and reassurance. Modes of personality, tenacity, flexibility, and a visionary disposition are among the foundational characteristics on which many a woman erects her firm in the agro-food industry. When well tapped, these aspects allow women to challenge the odds in agriculture and food production systems for adversity (Ogujiuba, 2021). Another determinant is market training, whereby the females are trained to open their eyes and see what the market is compelling them to sell the products, among other factors (Agarwal et al., 2018; Khan et al., 2021). Therefore, the combination of the factors mentioned above defines a favourable landscape for women agripreneurs to thrive and usher in transformational change in the agro-food value chain. Former governmental policies that encourage women to manage agricultural food production, effective social networks to share experiences and learn from other women, additional personnel character, and trained women's market knowledge help cope with the challenges (Agarwal et al., 2018; Khan et al., 2021). The goal of this research is to discuss these success factors (business competencies, marketing skills, government support, self-confidence, risk-taking and sociocultural factors) and their synergistic relationship and provide key recommendations on how to promote the success and growth of women agripreneurs going forward, to not only have a sustainable and desirably diversified agrifood industry. Although these factors have been studied in separate frameworks (Agarwal et al., 2018; Khan et al., 2021), this work has used an integrated approach to study personal and other factors responsible for business success for women entrepreneurs in the food sector. Moreover, the moderating role of family support has been studied in the framework.

1.1 Research Gap:

Even though the research studies on women entrepreneurs in the agro-food sector have considerably increased in recent years, the documentation of the variables defining success and effectiveness in Northern Indian women entrepreneurs and the role of family support in those processes is scarce (Arafat et al., 2021). Previous and existing research primarily centres on the global general entrepreneurial context with little paradigmatic emphasis on the sociocultural and economic profile within Northern India (Garima et al., 2023). This region, with diverse cultural standards of both business and feminine, has its peculiar business climate that challenges and inspires women entrepreneurs. A study carried out in the recent past discussed the variables affecting the entrepreneurial capacity of women, explaining how government support, family social support, financial literacy and managerial skills impact the women involved in entrepreneurship. Nevertheless, it is necessary to indicate that this study has given insights into related general entrepreneurship environments instead of concentrating on the agro-food sector. Furthermore, the role of family support is a unique contribution to this work.

II. LITERATURE

Business success is the business owner's success in achieving their business objectives with positive performances evidenced in profitability, growth, market share, customer satisfaction, and sustainability, among others. Regarding business performance, profitability and productivity represent the critical financial elements of success, while business flexibility and its capacity for innovation are the many operational ones. Women entrepreneurship and risk are fundamental to entrepreneurial literature (Agarwal et al., 2018; Khan et al., 2021). For instance, women's involvement in entrepreneurship is primarily associated with their willingness to take risks, distinguishing them from employees and supervisors (Begley & Boyd, 1987). How a woman manages risk is likely to impact the firm's performance (Pattillo & Söderbom, 2000). Consequently, female entrepreneurs are motivated to seek investment in the volatile market (Johnell et al., 1995), as they can make decisions in such a chaotic market (Gedajlovic et al., 2004). Confidence, as defined in the entrepreneurship literature, refers to the ability of entrepreneurs to perceive opportunities and follow their goals with a strong belief in their abilities (Twibell et al., 2008). *Self-confidence* is considered to be of utmost importance in the field of entrepreneurship. It is widely regarded that having self-confidence assists entrepreneurs in their entrepreneurial endeavours (Oney & Oksuzoglu-Guven, 2015). Sociocultural elements encompass a combination of social and cultural influences that impact the success of women entrepreneurs. Women entrepreneurs in Asian nations have significant challenges related to *social and cultural conventions* and family difficulties (Poggesi et al., 2016). Therefore, Roomi et al. (2018) propose that a multifaceted interaction of sociocultural elements influences women's decisions to pursue entrepreneurial careers. Furthermore, the level of entrepreneurial activity at a particular time and location is determined by sociocultural factors (Veciana, 1999). *Business Competencies* are the knowledge, skills, and experience a person will apply when undertaking a business venture to achieve the set goals. Some areas include strategic management, financial control, analysis of current business operations, leadership and decision-making. Both intra- and ante-business competencies enable entrepreneurs to manage their organizations well by having adequate knowledge, skills, and ability to overcome any business obstacles. *Marketing skills* encompass the exertion of specific techniques aimed at advertising products or services. This includes market analysis, target groups, marketing communication, and ways of reaching the target using social networks, advertisement, and public relations. Marketing skills involve identifying and influencing customers through persuasion, requests, cultivation of favourable images, and appeals to purchase products. *Family support* can be the backup and support in terms of money, time or effort that an expatriate gets from family members while starting up a business. This could entail motivating the person to start a business, advising them to do so, providing capital or funds to start the business, and assisting them in carrying out administrative functions in connection with the business. These occur through encouragement, as the family's support can give the business person confidence, relieve pressure and provide a cushion, factors that improve the business person's ability to work (Agarwal et al., 2018; Khan et al., 2021). *Government support* refers to the overall endeavour put in place by the government in the form of programs, policies, and efforts meant for entrepreneurs. This may involve funds to reimburse costs, subventions, low-cost credit, pre- and post-graduate training, coaching, and advisory measures. Government support is critical in establishing a healthy environment for businesses, opening up opportunities, and supplying the means required for the commencement, development, as well as maintenance of enterprises (Agarwal et al., 2018; Khan et al., 2021). Government intervention plays an important role in supporting women entrepreneurs by identifying the key issues and providing appropriate solutions to change gender bias in their business environment.

III. METHODS

This study utilized a quantitative and causal research methodology to examine the relationship between antecedents of business success in women entrepreneurs. The investigation utilized a comprehensive questionnaire to include various variables related to business success, business competencies, sociocultural factors, self-confidence, risk-taking, government support and market skills. In addition, moderating variables in the form of family support were also added to the framework. A web-based survey was conducted to gather data from 309 women engaged in different agro-food businesses in Northern India.

3.1 Measures

Business competencies (5 items), government support (3 items) and market skills (3 items) were adapted from the work of Agarwal et al. (2018). Business success (5 items), sociocultural factors (3 items), self-confidence (3 items), and risk-taking (3 items) were adapted from the work of Khan et al. (2023). Family support (3 items) was adapted from the work of Powell and Eddleston (2013).

3.2 Objectives

- To study the influence of success factors on business success in women entrepreneurs.
- To study the moderating role of family support between success factors and business success in women entrepreneurs.

3.3 Factor Analysis

The questionnaire was modified to align with the local context. To analyze the factor structure, the "exploratory factor analysis" (EFA) feature of SPSS 26.0 was used, as suggested by Hair et al. (2006). To evaluate dependability, Cronbach's alpha was employed and found to be above the specified threshold of 0.60 (Hair et al., 2006). Regarding sample adequacy, the "Kaiser-Meyer-Olkin (KMO)" and "Bartlett's test of Sphericity" scores were both higher than the acceptable values (0.781 and 53789129, respectively). The eight components account for 85.1% of the variance. The dataset consisting of 28 items exhibited a loading above 0.50, as Hair et al. (2006) reported.

3.4 Data Analysis:

3.4.1 Respondent Profile:

The information gathered from 309 respondents (Table 1) offers a thorough picture of the several demographic and professional traits of Northern Indian agro-food business women entrepreneurs possess. The age distribution indicates a balanced representation across different age groups, with 14.56% of respondents aged 18–28, 39.81% aged 29–39, and 45.63% aged 40–50. This suggests a notable presence of younger and more seasoned businesspeople.

Regarding education, the bulk of respondents—60.52%—have a graduate degree, followed by postgraduates—30.74%; and a lesser fraction with a doctorate—8.74%. According to marital status figures, 45.95% of the respondents are single, and 54.05% are married. Experience as an entrepreneur range; 24.92% have 1–3 years, 46.28% have 4–6 years, and 28.80% have more than six years. According to work status, 34.95% of the respondents are part-time entrepreneurs, and the majority (65.05%) run their companies full-time. With 31.39% of respondents having a bachelor's degree, 26.21% a master's degree, 17.80% an MS/MPhil, and 13.91% a PhD, respondents' degree of education highlights the value of formal education even more. Higher education is a typical feature among successful women entrepreneurs in this area; just 10.68% have an intermediate or below education level. Data on company size shows that 35.92% of the respondents run companies with up to 20 people, 31.39% have 20–50 employees, and 32.69% supervise more than 100.

TABLE 1
RESPONDENT PROFILE

Variable	Category	Frequency	Percentage
Age	18–28 years	45	14.56
	29–39 years	123	39.81
	40–50 years	141	45.63
Education	Doctorate	27	8.74
	Postgraduate	95	30.74
	Graduate	187	60.52
Marital Status	Married	167	54.05
	Unmarried	142	45.95
Experience as Entrepreneur	1–3 years	77	24.92
	4–6 years	143	46.28
	More than six years	89	28.8
Work Status	Full-time	201	65.05
	Part-time	108	34.95
Education Level	Intermediate and less	33	10.68
	Bachelor	97	31.39
	Master	81	26.21
	MS/MPhil	55	17.8
	PhD	43	13.91
Business Size	Upto 20 employees	111	35.92
	20–50 employees	97	31.39
	More than 100 employees	101	32.69

Measurement Model

Figure 1 illustrates the construction of the measurement model through a confirmatory factor analysis (CFA) conducted using AMOS 26.0. The fit indices of the model indicate favourable results: CMIN/DF= 3.31; CFI = 0.931, GFI= 0.912, NFI =0.931, and RMSEA=0.054 (Hu & Bentler, 1999). The instrument's reliability was evaluated using C.R. (composite reliability) ratings, which surpassed the acceptable threshold of 0.60. To assess convergent validity, the study employed AVE (average variance extracted) scores to achieve a benchmark of at least 0.50 (Fornell & Larcker, 1981) and standard loadings that surpass 0.50. The analysis confirmed the discriminant validity by showing that the correlation coefficients were smaller than the square root of the AVE scores (Fornell & Larcker, 1981), thereby ensuring distinct separation between the components (Table 2).

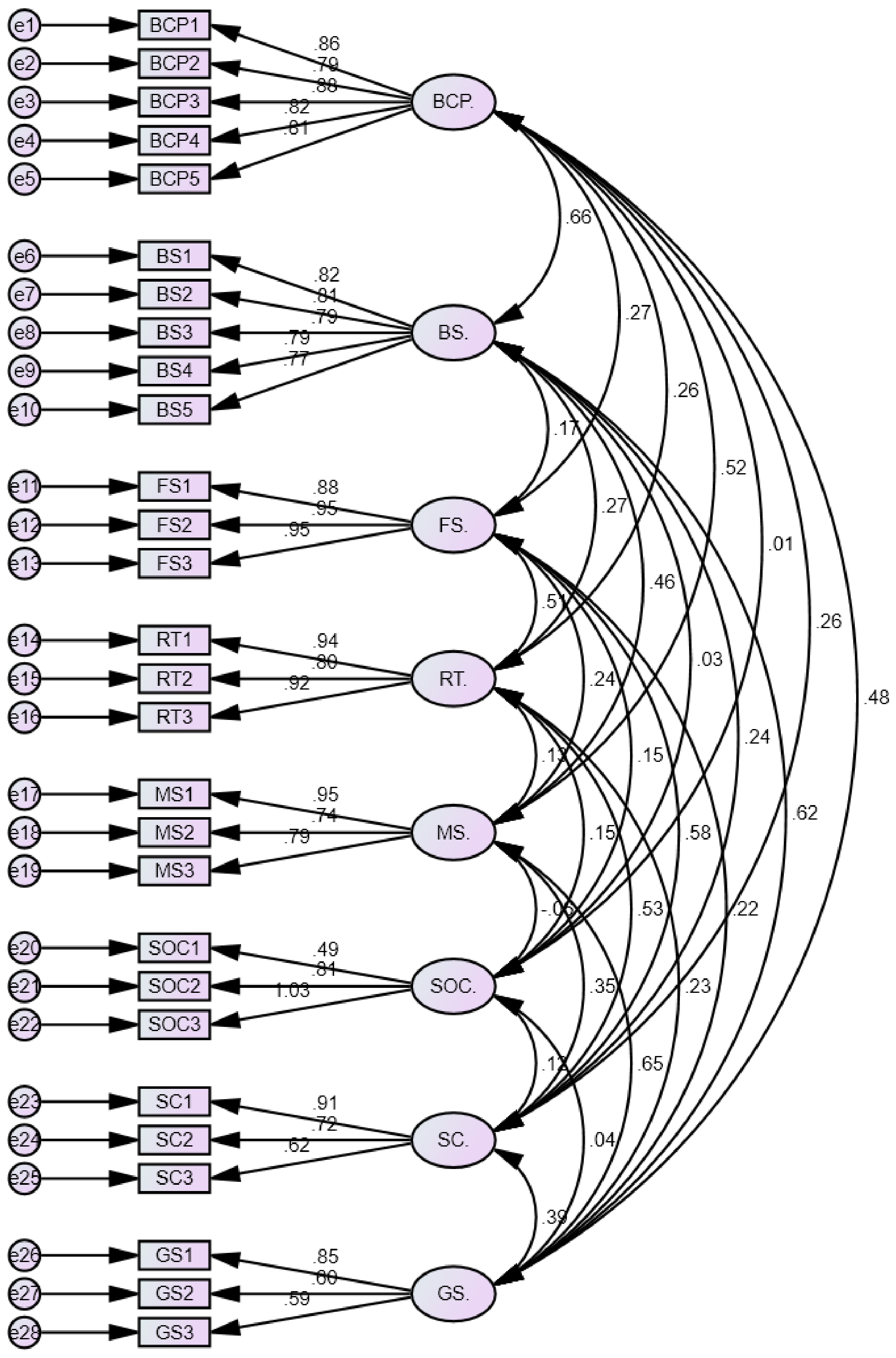

FIGURE 1: Measurement Model
Source: Author's Own

TABLE 2
VALIDITY AND RELIABILITY

	CR	AVE	SC.	BCP.	BS.	FS.	RT.	MS.	SOC.	GS.
SC.	0.8	0.58	**0.76**							
BCP.	0.92	0.69	0.256	**0.83**						
BS.	0.9	0.63	0.239	0.664	**0.8**					
FS.	0.95	0.86	0.58	0.269	0.167	**0.93**				
RT.	0.92	0.79	0.534	0.259	0.267	0.514	**0.89**			
MS.	0.87	0.7	0.346	0.519	0.458	0.239	0.13	**0.83**		
SOC.	0.8	0.59	0.122	0.014	0.029	0.154	0.15	-0.06	**0.77**	
GS.	0.73	0.51	0.386	0.482	0.625	0.217	0.23	0.655	0.035	**0.69**

Source: Author's of this Paper

Note: SC-Self-confidence; BCP-Business competencies; BS-Business success; FS-Family support; RT-Risk taking; MS-Marketing skills; SOC-S

3.5 Structural Model

Using the structural model, one examined the relationship between dependent and independent variables. The next figures show the model's fit well:

CMIN/df=4.40, GFI=0.904, CFI=0.919, RMSEA=.068, NFI=0.940.

Examining the hypotheses reveals critical new directions for understanding the elements affecting business success for agro-food sector women entrepreneurs.

Supported by the statistics ($\beta = 0.35$, $p = 0.01$), H1 suggests that corporate abilities (business competencies) significantly affect business success. This implies that the success of the entrepreneur's company is much influenced by their knowledge and ability set. With findings showing a positive and noteworthy link ($\beta = 0.23$, $p = 0.05$), H2 investigates how government backing affects business success. This emphasizes how government policies, subsidies, and support programmes help to promote entrepreneurial success. With a noteworthy positive effect ($\beta = 0.32$, $p = 0.02$), H3 looks at how market skills affect company success. Success seems driven mainly by good marketing plans and knowledge of market dynamics. H4 investigates the influence of sociocultural elements on corporate performance, therefore displaying a notable positive correlation ($\beta = 0.22$, $p = 0.04$). This emphasizes how much cultural and social support networks shape entrepreneurial results. With a high positive association ($\beta = 0.37$, $p = 0.01$), H5 centres on self-confidence as a determinant of business success. One of the main things that enables women business owners to follow and reach their objectives is confidence in their capacity. Based on the data ($\beta = 0.34$, $p = 0.03$), H6 evaluates how risk-taking affects business success and is instead supported by it. Navigating the uncertainty of the corporate world and succeeding in business depends on being ready to take measured risks. The results imply that the success of women entrepreneurs in the agro-food sector mostly depends on a mix of personal abilities, external assistance, market savvy, sociocultural backing, self-confidence, and risk-taking.

TABLE 3
STRUCTURAL MODEL ESTIMATES

Hypotheses	Independent Factor	Dependent Factor	Standard (β)	P	Result
H1	Business Competencies	Business Success	0.35	0	Supported
H2	Government Support	Business Success	0.23	0.1	Supported
H3	Market Skills	Business Success	0.32	0	Supported
H4	Sociocultural Factors	Business Success	0.22	0	Supported
H5	Self-Confidence	Business Success	0.37	0	Supported
H6	Risk-Taking	Business Success	0.34	0	Supported

Note: Source: Author's Own

P=.001

IV. MODERATION

The moderation analysis investigates the effect of family support on the interaction among several independent variables and corporate success. The following (Table 4) summarises the outcomes:

H7 examines how family support and business competencies interact to affect company performance. The moderation effect is insignificant with β = 0.15 and p = 0.12. This implies that family support does not change the effect of business competencies on company success. H8 looks at how family and government assistance interact to affect business success. Furthermore, displaying a non-significant moderating influence is the outcome (β = 0.18, p = 0.08). This suggests that the effect of government support on business success is not much changed by family support. H9 investigates how family support and market skills combine to determine business success. The outcome (β = 0.20, p = 0.06) shows that the moderating effect is insignificant, implying that family support does not considerably change the influence of market abilities on company success. H10 investigates the relationship between family support and sociocultural elements of corporate success. With β = 0.28, p = 0.02, the critical outcome shows that family support dramatically increases the favourable impact of sociocultural elements on corporate success. Therefore, a supportive family environment can magnify the advantages of good sociocultural settings, increasing business success. H11 looks at how family support and self-confidence interact to affect company performance. The critical outcome (β = 0.33, p = 0.01) reveals that family support dramatically increases the favourable influence of self-confidence on company performance. This emphasizes the need for a loving family to increase company owners' confidence, which improves their companies' results. H12 looks at how risk-taking and family support interact to affect company performance. The primary outcome (β = 0.31, p = 0.03) shows that family support dramatically increases the favourable influence of risk-taking on corporate performance. This implies that a supportive family might inspire business owners to take measured risks, enhancing their chances of success.

TABLE 4
MODERATION EFFECT OF FAMILY SUPPORT

Hypotheses	Interaction	Outcome	P-value	P-value	Results
H7	Business Competencies x Family Support	Business Success	0.15	0.12	Not Supported
H8	Government Support x Family Support	Business Success	0.18	0.08	Not Supported
H9	Market Skills x Family Support	Business Success	0.2	0.06	Not Supported
H10	Sociocultural Factors x Family Support	Business Success	0.28	0.02	Supported
H11	Self-Confidence x Family Support	Business Success	0.33	0.01	Supported
H12	Risk-Taking x Family Support	Business Success	0.31	0.03	Supported

V. CONCLUSION & DISCUSSIONS

The analysis suggests several critical success factors for women entrepreneurs in the agro-food sector in Northern India: business competencies, government support, market skills, sociocultural factors, self-confidence and risk-taking. The findings affirm that having practical business competencies, strong government backup, enhanced market proficiency, favourable social-cultural contexts, high self-esteem, and risk-taking are critical determinants of business success. Self-confidence also underlines the significance of family support in increasing the impact of some factors on business success. In this regard, family support enhances and amplifies the positive effects of sociocultural factors, self-confidence, and risk-taking abilities. This goes a long way to demonstrate the value of the familial setup when encouraging women in business. In light of the research discoveries, former theoretical propositions of multifaceted initiatives are necessary for entrepreneurial success. Various actors, including policymakers, educational institutions, communities, and families, uniquely contribute to a favourable environment for women entrepreneurs. Based on the assessment of the factors highlighted in this paper and given the acknowledgement of the role of the family in supporting women in business, it is possible to work towards the improvement of the entrepreneurial environment and the successful development of female-led enterprises in the agro-food industry. As a result, this investigation offers an understanding and comprehension of factors that are important to business success among women entrepreneurs in the agro-food industry in Northern India. They agreed that business competencies, government support, market skills, sociocultural, self-confidence and risk-taking are essential factors, which confirms that the factors for entrepreneurial success are compound.

The obtained findings show that the critical area of focus for future entrepreneurs is building strong business competencies and a high level of market skills that will enable them to conduct business effectively in competitive environments. Also, it encourages the significance of the more extensive supportive governmental policies about establishing proper political initiatives to encourage various entrepreneurial actions. Another area of concern is the sociocultural factors that give shape and meaning to entrepreneurial activities. Overall, the cause analysis significantly showed that family support moderated the relationship between sociocultural factors, self-confidence, risk-taking, and business success, implying the importance of a supportive family environment. This means that family support multiplies the possibilities of the various factors that are positive for business, hence improving performance. These observations hold relevant and significant implications for the following stakeholders. The authorities must increase awareness and provide women interested in entrepreneurship with resources, such as financial support, training for women business people, or other resources. If institutions of learning are to equip women with the requisite skills and knowledge in entrepreneurship, they need to offer a rounded curriculum in entrepreneurial education. Extended support from the community and families must be encouraged to enhance the sustainability and support for entrepreneurship. Still, it is possible for future studies to look at other variables connected with business performance and scrutinize these antecedent–outcome linkages across various periods. Future empirical research that includes longitudinal research designs could offer further understanding of this analysis regarding the flow of entrepreneurship development and the absorptive effects of different factors in business continuity. In conclusion, this study calls for, instead stresses, the need to develop multi-faceted intervention strategies in promoting women entrepreneurs in the agro-food chain, with particular reference to the interplay of self-attribute, external resources and family encouragement on business performance.

IMPLICATIONS

Therefore, these findings have some of the broad implications of this study that will affect different players involved in helping women entrepreneurs scale their ventures in the agro-food sector in Northern India. In particular, the results supporting an increase in government support as being positively associated with the business success of female entrepreneurs means that current and future support programs should be strengthened and developed specifically for women. These involve financial support in cash, donations, and the provision of cheap credit and loans. Also, there is a need for policies that should recommend training and development that will increase business competencies and market skills through policies such as workshops, mentorship and online classes. Schools are also very relevant since they supplement the practice of entrepreneurship by providing the totality of courses and programs that support and foster institutional learning through practical sessions, case studies, and experiences. Such affiliations with industry giants can expose students to entrepreneurial environments and provide more adequate networking opportunities to prepare them. Based on the results of the analysis, the supportive community and family are emphasized as the most critical aspects because family support shows the most substantial moderation influence on sociocultural factors, self-confidence, and risk-taking. As such, efforts should be made to ensure that families and society at large appreciate the essentiality of their support for the development of an entrepreneur. Additional efforts that comprise community-based programs with options for group support, meetings, and organization of successful female business owners would also improve the sociocultural layer. Women entrepreneurs themselves should ensure they enhance their business-related knowledge and expertise through learning and training experiences, attending business-related workshops and seminars, and seeking mentors. Another implication of fear of failure is that by acknowledging the importance of family support, as well as ensuring that family members are engaged in the business, clients can be assured of a home that supports them as they scale up their businesses, step out of their comfort zones, and be ready to take more risks.

FUTURE RESEARCH

Longitudinal studies should be emphasized to examine how these factors and their connections with business success change over time. Thus, much more light would be shed on the sustainability of entrepreneurial success. Furthermore, to give a more precise picture of the workings of businesses, researchers should analyze and highlight other factors that may affect business success and growth, such as concepts peripheral to entrepreneurship, such as technology, innovation, and markets. Lastly, the paper shows the need for a more comprehensive approach when promoting women entrepreneurs, paying attention to the given factors and appreciating the significance of the results in the form of family and community support to contribute to the need to improve the environmental conditions for effective development and success in agro-food entrepreneurship.

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Assessing the Impact of Climate Variability on Maize Production in Rwanda: A case of Gakenke District

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Abstract— *The changes in climatic variables is a challenge for the humanity as they affect different ecosystems important for life. This study assessed the impact of climate variability on maize production from 2012 to 2021. Specifically, this study 1) assessed the pattern of precipitation and temperature variability, 2) analysed the production of maize, and 3) investigated the relation between climate variability and maize production in Gakenke district. This study was conducted in three sectors, with a sample of 322 maize farmers. Climatic data were obtained from the Rwanda Meteorological Agency. Both descriptive statistic and regression and correlation analysis were performed in RStudio. The results show a remarkable variability in the annual mean temperature and annual rainfall. The mean temperature and amount of rain have increased by +1.34°C and 1.74 mm in Cyabingo, by +1.47°C and 1.997 mm in Gakenke, and by +1.52°C and 3.389 mm in Gashenyi. An overall increase in maize yields was highlighted and much dependent on temperature variation than precipitation variability. A strong correlation was between the temperature and yields, with r values of 0.98 for Cyabingo, 0.90 for Gakenke, and 0.94 for Gashenyi. The regression analysis indicates that maize yields were significantly influenced by temperature variability, with R-squared values of 0.960 (p-value = 0.000), 0.815 (p-value = 0.000), and 0.885 (p-value = 0.000) respectively in Cyabingo, Gakenke, and Gashenyi. On the other side, a mild positive correlation (r = 0. 43), a moderate negative correlation (r = -0.59), and a weak negative correlation (r = -0.1) were between precipitation and maize yields in Cyabingo, Gakenke, and Gashenyi, respectively. The regression analysis also indicates that maize yield of was not significantly influenced by precipitation variability. Although this study shows the temperature as an important factor for maize production, its continuing rise could bring to heavy rains and unexpected strong weather events, with ultimate negative impacts. Thus, adaptation strategies on climatic variability should be enhanced in order to minimize its disastrous effects on maize production.*

Keywords- Climate variability, Climate change, Maize production, Gakenke district, Rwanda.

I. INTRODUCTION

The global development has encountered a significant challenge in the form of climate. This is primarily resulting from the effect of worldwide climate change, variation in rainfall patterns, and the rising average temperatures, which have introduced new hurdles and risks to all human and world wide. Changes in the climate are the result of both natural and human-induced factors occurring across continents and oceans [1]. These changes extend beyond typical atmospheric conditions and can be attributed to natural influences like the Earth's orbital variations, volcanic activities, and crustal movements, as well as human activities such as the accumulation of greenhouse gases and aerosols, deforestation, intensive farming, waste disposal, transportation, industrial operations, and overconsumption [2]. Global warming, indicated by the overall increase in the planet's temperature, has emerged as a predominant trend that will usher in significant global transformations in the future. Recent studies highlight important information on the expected problems of food insecurity as consequence of climate change [3], [4], with particular effect on local communities that depend on rain-fed agriculture [5].

Agriculture makes up roughly 39% of Rwanda's total gross domestic product (GDP) and provides livelihoods for about 88% of the whole population, particularly in rural parts of the country, where the majority of Rwandans reside [6]. More than 65% of Rwandan population depend on agriculture, forestry and tourism resources for income generation and food security [7]. Among the four key sectors, agriculture stands out as a major factor accelerating the economic development and significantly improving the livelihoods in Rwanda. However, the sector is much prone to the weather and climate-related hazards, including unusual rainfall patterns, hail, floods, landslides, and extended periods of drought, all of which are consequences of climate variability, particularly in terms of temperature and rainfall patterns [8]. Recent incidents have shown the severe consequences of extreme weather events on agricultural output accross different parts of the country.

Therefore, it is critical to understand the extent of the effects of climate variability as an option for sustaining crop production and meet the countrywide food demand. In the light of this concern, this study assessed the impacts of climate variability on maize production in Gakenke district, northern part of Rwanda. Specifically, it provides important data of climate variability (especially on precipitation and temperature pattern) during the past 10 years (from 2012 to 2021), provides data on maize production and its trends in the study area during this study period, and also analyses and predicts the impact of climate variability on maize production in the study area. This provides information that is required to facilitate farmers for their adaptation to climate change thereby reducing their vulnerability to climatic crisis.

II. MATERIALS AND METHODS

2.1 Study site description:

This study was conducted in Gakenke district, one of the five districts of the Northern Province of Rwanda. The climate in Gakenke district is generally humid climate, with the average annual temperature varying between 16ºCand 29ºC and annual rainfalls ranging from 1100 mm to 1500 mm [9]. As it is the case for the entire country, Gakenke district experiences four different seasons: The small dry season: January-February, the high rain season: March- end May, the high dry season: June-end August, and the small rain season: September- December. This climate makes Gakenke district to be a favourable region of agricultural activities. Gakenke district is characterized in general by high inclined hills separated by rivers and marshlands. These marshlands are generally exploited during the dry season [9] . The map showing the sectors selected for this study is presented below:

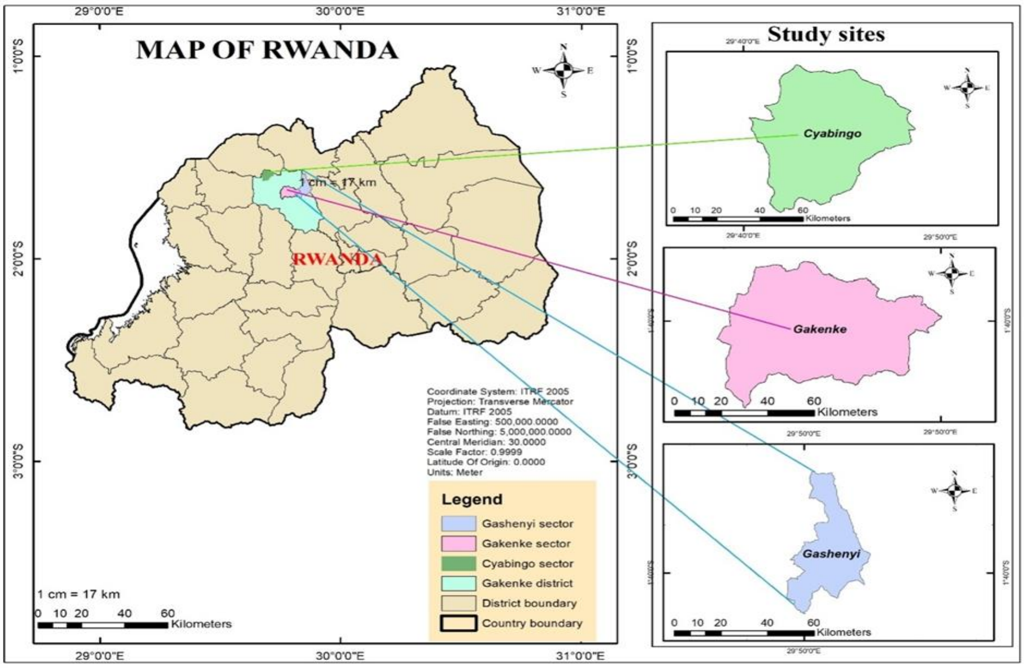

FIGURE 1: District map showing the selected sectors for sampling

2.2 Study population and sample size:

This study focused on farmers living in three sectors of Gakenke district, namely: Gakenke, Gashenyi, and Cyabingo sectors. These sectors were selected due to their accessibility and because they are under the some agro-climatic conditions, rendering Gakenke district a prime location for agricultural activities. The target population consisted of farmers who are organized into land consolidation cooperatives. Among these farmers, only those who have been growing maize for, at least, the past ten years were considered as respondents. Their total number is 1648 with 689 located in Gakenke ,539 in Gashenyi and 420 in Cyabingo sector. A sample of n is the numbers of maize's farmers that were interviewed, and was determined using this formula: $\boldsymbol{n} =$

$\frac{N}{1+N(e)^2}$ Where n = Sample size, N= study population which is the total number of farmers in Gakenke, Gahenyi, and Cyabingo sectors and e = margin of error that was 5% meaning that the confidence level was 95%. Hence, $n = \frac{1648}{1+1648\,(0.05)^2}$= 321.8~322.

Proportionate sampling method was used to determine the number of maize farmers who were interviewed in each of the three sectors. The following formula was used: $= \frac{Ni \times n}{N}$, where ni = the sample size proportion to be determined, Ni = the population proportion in the stratum, n = the sample size, and N = the total population

TABLE 1
PROPORTION OF POPULATION IN EACH SECTOR

Farmers in land consolidation groups/ cooperatives Sector	Number of households	The proportion of population to be interviewed per sector	The proportional percentage (%)
Gakenke	689	135	42
Gashenyi	539	105	33
Cyabingo	420	82	25
Total	1648	*n*= 322	100

2.3 Data collection:

This study applied a non- probability sampling technique. Purposive sampling method was used to select three sectors. The proportionate sampling method was also applied as a non- probability sampling to determine the number of maize farmers to be interviewed in each of the three sectors. Primary data of maize production were gathered through semi-structured interviews, face to face, with maize farmers (n = 322) as respondents. These interviews explored a range of perspectives concerning the implications of climate variability and its impact on maize production in Gakenke district. The data were collected in a face to face interview and were recorded using a detailed schedule with open and closed questions. For the secondary data, the literature review encompassed pertinent climate-related scientific publications, reports, and policy documents collected from various locations. In order to obtain rainfall and temperature datasets, meteorological data recorded at the nearest Cyabingo, Paroisse Nemba, and Minazi meteorological stations were accessed from the RMA. The ArcGIS 10.8 software was used to draw a study area location map, and required (administrative boundary) shapefiles were accessed form Gakenke district.

2.4 Data Analysis:

Data were analysed to assess the impact of climate variability on maize production in Rwanda: a case of Gakenke district. For the first and second objectives, descriptive statistic was performed to assess the pattern of precipitation and temperature variability and to analyse the production of maize over the past 10 years in Gakenke district. For the third objective, regression and correlation analysis were performed to relate climatic data with maize yields in order to find out the relationship between climate variability and maize production in the study area. This was also to provide information for future prediction regarding the impact of climate variability on maize production. Both descriptive statistic and regression and correlation analysis were performed in RStudio.

III. RESULTS AND DISCUSSION

This study has investigated the impacts of climate variability on maize production in Gakenke district. These impacts were analysed in three dimensions, specifically by: 1) assessing the pattern of precipitation and temperature change over the past 10 years in Gakenke district, 2) analysing the production of maize over the past 10 years in Gakenke district, and 3) finding out the relation between climate variability and maize production in Gakenke district. All respondents answered all questions. The majority of respondents (72%) were females while 28% were male 72% of respondents attended primary school. Among them, 90% did only agriculture and 10% added small business during the study period. The analysis results showed that agricultural sector encompasses mainly the persons with lower level of formal education.

3.1 Status of climate variability (rainfall and temperature pattern) over the past 10 years in Gakenke, Gashenyi and Cyabingo sector:

3.1.1 Trend of Temperature Patterns:

Temperature variations in the study areas (Fig. 2, Fig. 3, and Fig. 4). Temperature trend lines in wetland of Gakenke, Gashenyi and Cyabingo sector indicate the similar since 2012 to 2021 there is increase in mean temperature. In Gakenke the average maximum temperature was 18.86ºC whereas the minimum was 17.39ºC since 2012 to 2021 making increase of 1.47ºC, In Gashenyi the average maximum temperature was 20.52ºC whereas the minimum was 19.00ºC since 2012 to 2021 making an increase of 1.52ºC. In Cyabingo the average maximum temperature was 20.24ºC whereas the minimum was 18.90ºC since 2012 to 2021 making an increase of 1.34ºC.

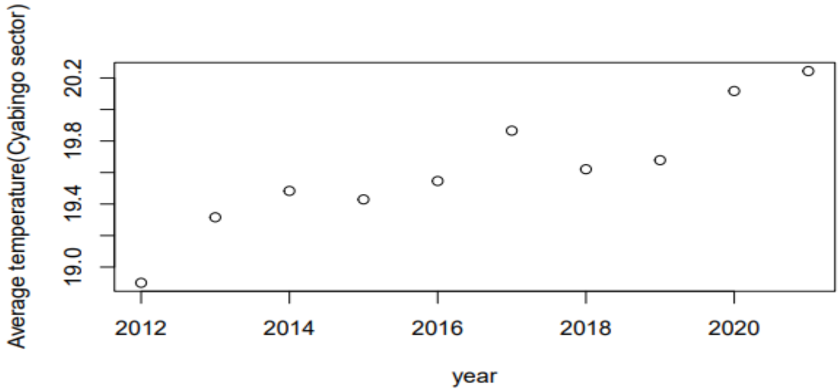

FIGURE 2: Trend of temperature for Cyabingo wetland between 2012 and 2021 (Source: RMA, 2024).

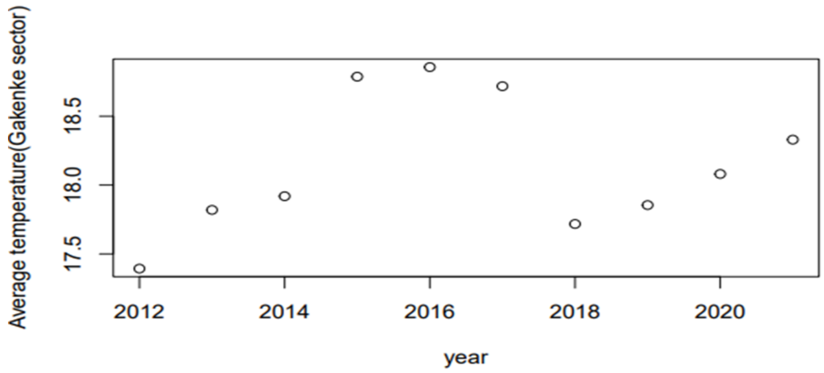

FIGURE 3: Trend of temperature for Gakenke wetland between 2012 and 2021 (Source: RMA, 2024).

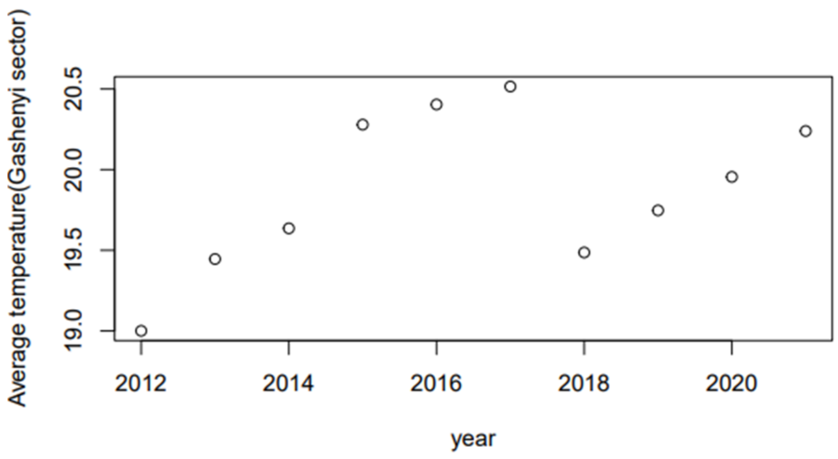

FIGURE 4: Trend of temperature for Gashenyi wetland between 2012 and 2021 (Source: RMA, 2024).

The results of this study show that the mean temperature has increased by +1.34ºC in Cyabingo, +1.47ºC in Gakenke, and by +1.52ºC in Gashenyi, These mean temperature increases are much greater compared to 1.09 ºC reported as the increase in global temperature in 2011-2020 above the reference period (1850-1900) [10]. Recent prediction shows that global temperature increase will be at 1.8 to 4.0ºC in the next few decades given that the earth's temperature is likely to rise about 0.1 to 0.2ºC per decade [2], [11]. However, Global warming reaching 1.5ºC is expected to cause unavoidable increases in multiple climate hazards and risks to ecosystems and humans [10].

3.1.2 Trend of Rainfall Patterns:

The of this study show that there is variation in rainfall patterns since 2012 to 2021 (Fig.5, Fig. 6, and Fig.7) with abnormal rainfall fluctuations, where a little increase is observed in Cyabingo and Gakenke wetlands while a high increase was noted in Gashenyi wetland. In Cyabingo the maximum precipitation was3.915mm whereas the minimum was 2.175mm. In Gakenke, the maximum precipitation was 4.556 mm whereas the minimum was 2.559 mm. In Gashenyi, the maximum precipitation was 5.019 mm whereas the minimum was 1.630 mm since 2012 to 2021.

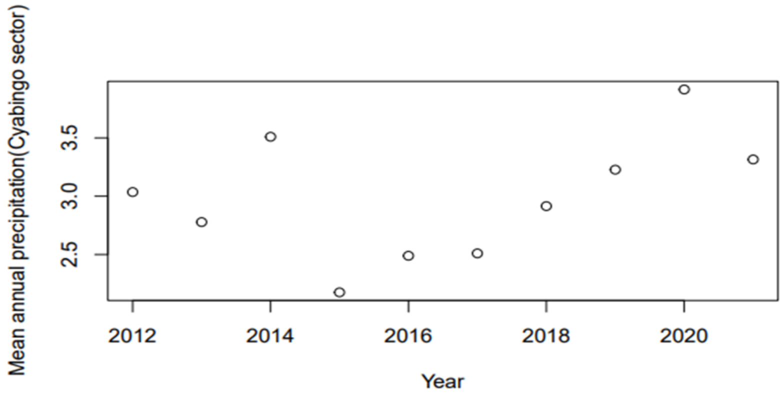

FIGURE 5: Trend of rainfall for Cyabingo wetland between 2012 and 2021 (Source: RMA, 2024).

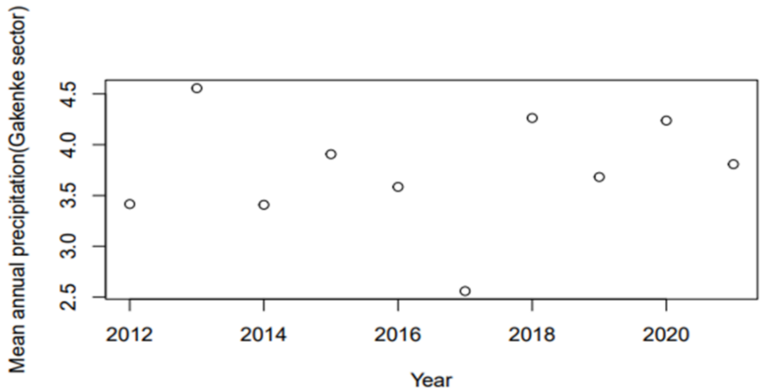

FIGURE 6: Trend of rainfall for Gakenke wetland between 2012 and 2021 (Source: RMA, 2024).

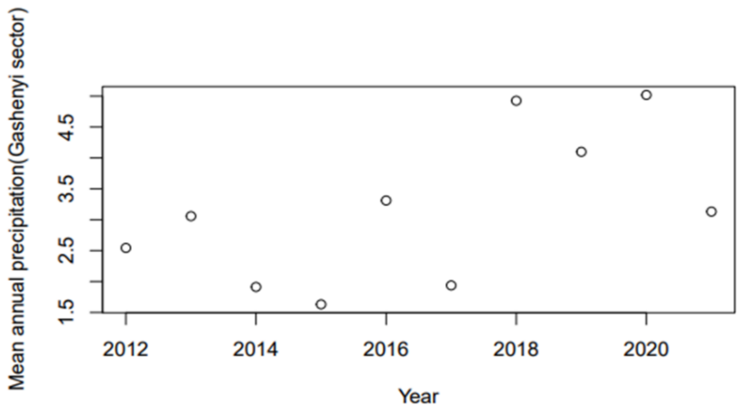

FIGURE 7: Trend of rainfall for Gashenyi wetland between 2012 and 2021 (Source: RMA, 2024).

The analysis of rainfall and temperature data recorded from weather stations indicated significant increase in temperature over the past 10 years and show the variability in rainfall. This is in accordance with the recent findings of rainfall and temperature in all regions of the country including the study areas (Uwiragiye A. , 2016).

3.2 Status of variation of maize yields over the past 10 years in Gakenke, Gashenyi and Cyabingo sector:

The results for the analysis of collected data (Fig.8, Fig.9, and Fig.10) indicate the variation of maize yield during the study period. In Cyabingo the maximum yield was 1.477 tons/ha whereas the minimum was 1.364 tons/ha since 2012 to 2021 with mean 1.421tons/ha. In Gakenke the maximum maize yield was 1.505 tons/ha whereas the minimum was 1.452 tons/ha since 2012 to 2021 with mean 1.472 tons/ha. In Gashenyi the maximum yield was 1.473 tons/ha whereas the minimum was 1.344 tons/ha since 2012 to 2021 with mean 1.414 tons/ha.

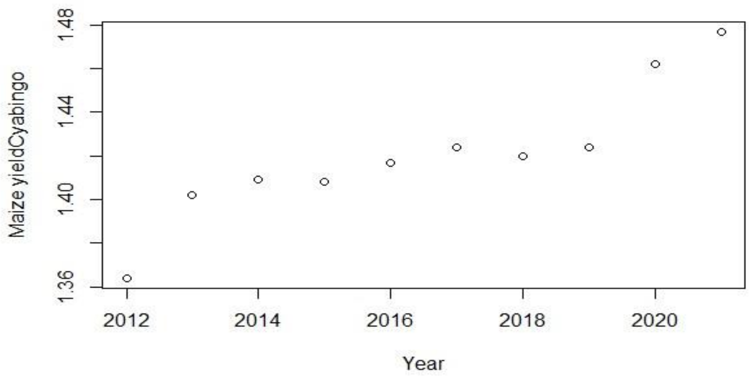

FIGURE 8: Variation of maize yields over the past 10 years in Cyabingo

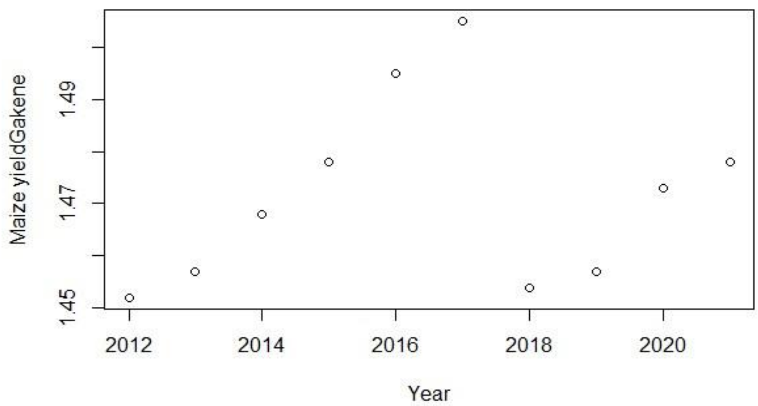

FIGURE 9: Variation of maize yields over the past 10 years in Gakenke

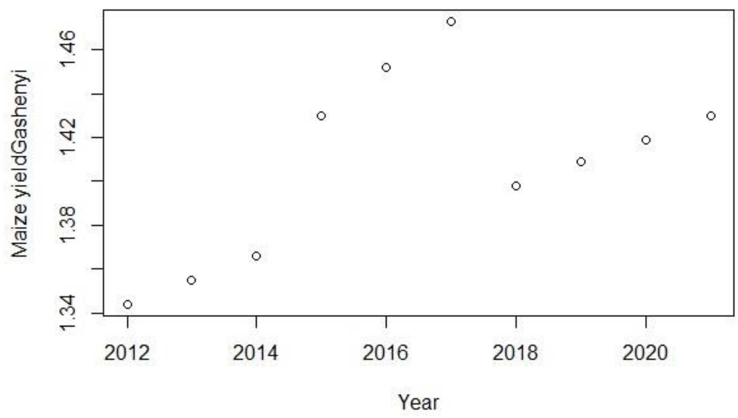

FIGURE 10: Variation of maize yields in the past 10 years in Gashenyi

3.3 Correlation between climate variability and maize yield:

3.3.1 Correlation between temperature, precipitation and maize yield in Cyabingo Sector:

TABLE 2
CORRELATION MATRIX OF TEMPERATURE, PRECIPITATION AND MAIZE YIELD IN CYABINGO SECTOR

Variable	*M*	*SD*	1	2
1. Temperature	19.62	0.39		
2. Precipitation	2.99	0.53	0.39 [-.32, .82]	
3. Maize_Yield	1.42	0.03	.98** [.91, 1.00]	0.43 [-.28, .83]

Note: M and SD are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation. * indicates p< .05. ** indicates p< .01.

The table 2 above shows the means, standard deviations, and correlations with confidence intervals. It highlights a strong correlation (r value =0.98) between temperature and maize yield during the past ten years. A mild correlation is also noticed between precipitation and maize yield and between temperature and precipitation with correlation coefficients (r) of 0.43 and 0.39, respectively.

3.3.2 Correlation between temperature, precipitation and maize yield Gakenke sector:

TABLE 3
CORRELATION MATRIX OF TEMPERATURE, PRECIPITATION AND MAIZE YIELD IN GAKENKE SECTOR

Variable	*M*	*SD*	1	2
1. Temperature	18.15	0.5		
2. Precipitation	3.74	0.56	-0.39 [-.80, .37]	
3. Maize_Yield	1.47	0.02	.90** [.63, .98]	-0.59 [-.89, .06]

Note.M and SD are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation. * indicates p< .05. ** indicates p< .01.

The table 3 above presents the means, standard deviations, and correlations with confidence intervals. The results of this study, in Gakenke sector, show a strong correlation (r value = 0.90) between temperature and maize yields during the past 10 years. On the other side, the results also show moderate negative correlation (r value = -0.59) between precipitation and maize yield in Gakenke sector and a mild negative correlation (r value = -0.33) between temperature and precipitation.

3.3.3 Correlation between temperature, precipitation and maize yield Gashenyi sector:

TABLE 4
CORRELATION MATRIX OF TEMPERATURE, PRECIPITATION AND MAIZE YIELD IN GASHENYI SECTOR

Variable	*M*	*SD*	1	2
1. Temperature	19.87	0.49		
2. Precipitation	3.16	1.21	-0.21 [-.74, .49]	
3. Maize_Yield	1.41	0.04	.94** [.76, .99]	-0.01 [-.64, .62]

Note. M and SD are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation. * indicates p< .05. ** indicates p< .01.

The table 4 above presents the means, standard deviations, and correlations with confidence intervals. It highlights a strong positive correlation (r value = 0.94) temperature and maize yield and a mild negative correlation between (r value = -0.21) between precipitation and temperature in Gashenyi sector. However, in this sector, the results obtained present a weak negative correlation (r value = -0.01) between precipitation and maize yield.

3.4 Effect of temperature and precipitation on maize production in Gakenke district:

3.4.1 The regression analysis of temperature and maize yields in Cyabingo sector:

The estimated model for maize yield highlights a linear relationship between the temperature and maize yields in this sector, and the regression analysis indicates that the yield of maize obtained by farmers was significantly influenced (at 96.0%) by temperature change during the past 10 years (R-squared = 0.960, with p-value = 0.000). Therefore, based on this study, the temperature can be considered as an important factor for maize production in Cyabingo sector and its change could potentially affect maize yields as highlighted by the regression model (expression/equation) presented in the Fig. 11 below.

TABLE 5
REGRESSION MODEL SUMMARY

Model	R	R-Square	P-value	Confidence interval
1	0.98	0.96	0	95%

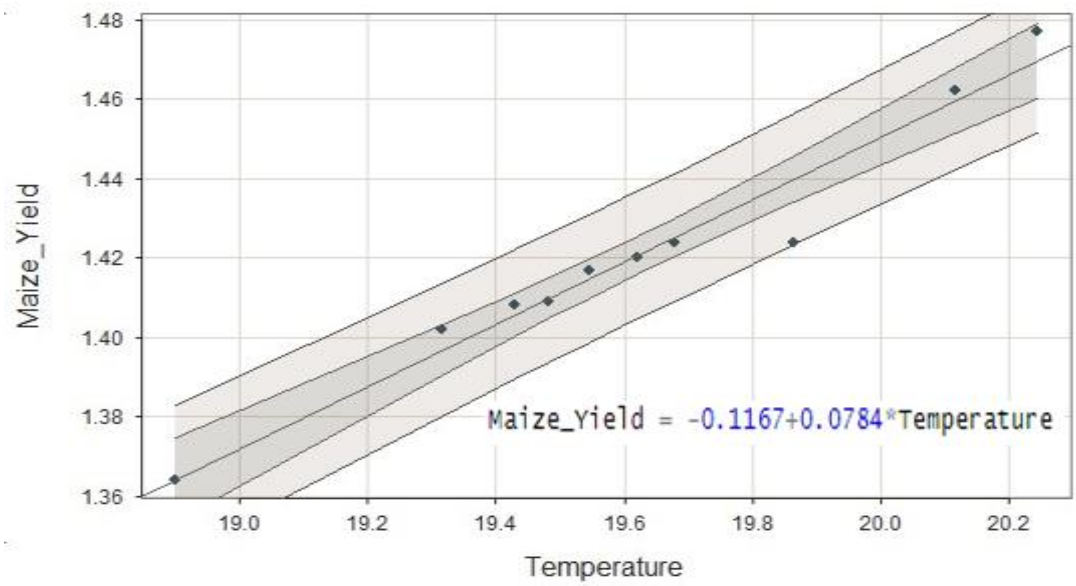

FIGURE 11: Simple linear regression model for maize yield in Cyabingo sector

3.4.2 The regression analysis of precipitation and maize yields in Cyabingo sector:

Although the estimated model for maize yield highlights a linear relationship between the precipitation and maize yields in this sector, the regression analysis (Fig. 12) indicates that the yield of maize obtained by farmers was not significantly influenced by precipitation change during the past 10 years (R-squared = 0.184, with p-value = 0.217). The change in maize yield observed can only be explained at 18.4% by precipitation change. As highlighted by the regression model presented in the Fig.12, the change in precipitation could not significantly affect the expected yields of maize in Cyabingo sector.

TABLE 6
REGRESSION MODEL SUMMARY

Model	R	R-Square	P-value	Confidence interval
1	0.428	0.183	0.217	95%

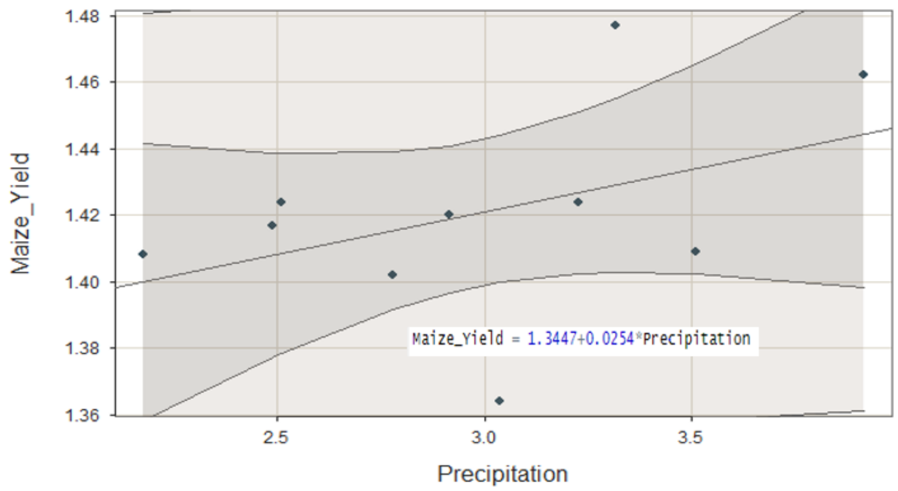

FIGURE 12: Simple linear regression model for maize yield in Cyabingo sector

3.4.3 The regression analysis of temperature and maize yields in Gakenke sector:

The estimated model for maize yield highlights a linear relationship between the temperature and maize yields in this sector, and the regression analysis (Fig.13) indicates that the yield of maize obtained by farmers was significantly influenced (at 81.5%) by temperature change during the past 10 years (R-squared = 0.815, with p-value = 0.000). Therefore, based on this study, the temperature can be considered as an important factor for maize production in Gakenke sector and its change could potentially affect maize yields as highlighted by the regression model presented in the Fig. 13 below.

TABLE 7
REGRESSION MODEL SUMMARY

Model	R	R-Square	P-value	Confidence interval
1	0.903	0.815	0	95%

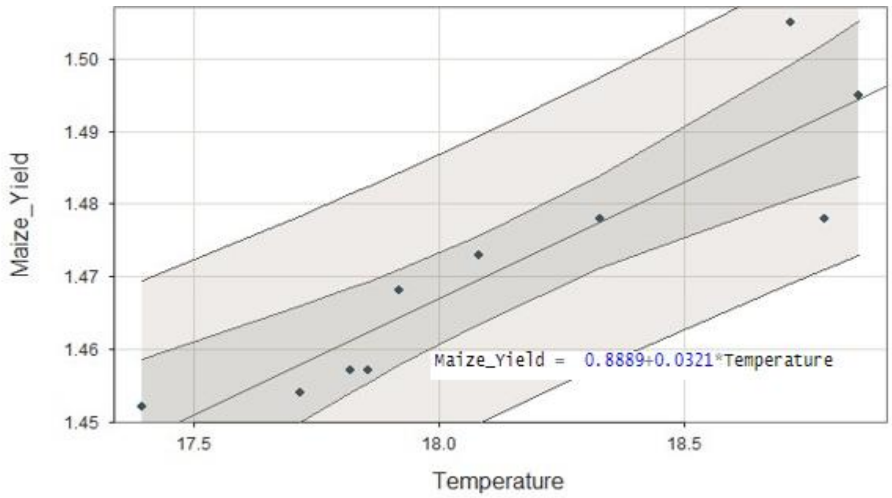

FIGURE 13: Simple linear regression model for maize yield in Gakenke sector

3.4.4 The regression analysis of precipitation and maize yields in Gakenke sector:

Although the estimated model for maize yield highlights a linear relationship between the precipitation and maize yields in this sector, the regression analysis (Fig. 14) indicates that the yield of maize obtained by farmers was not significantly influenced by precipitation change during the past 10 years (R-squared = 0.349, with p-value = 0.072). The change in maize yield observed can only be explained at 34.9% by precipitation change. As highlighted by the regression model presented in the Fig. 14, the change in precipitation could not significantly affect the expected yields of maize in Gakenke sector.

TABLE 8
REGRESSION MODEL SUMMARY

Model	R	R-Square	P-value	Confidence interval
1	-0.59	.349	.072	95%

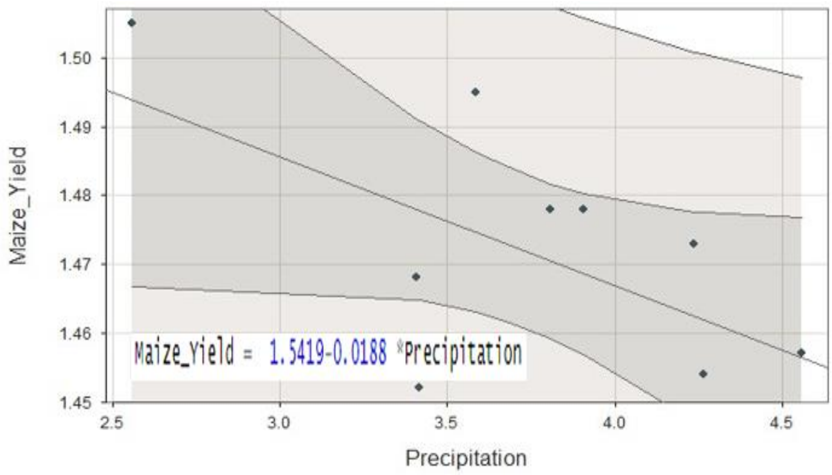

FIGURE 14: Simple linear regression model for maize yield in Gakenke sector

3.4.5 The regression analysis of temperature and maize yields in Gashenyi sector:

The estimated model for maize yield in Gashenyi sector highlights a linear relationship between the temperature and maize yields in this sector, and the regression analysis (Fig.15) indicates that the yield of maize obtained by farmers was significantly influenced (at 88.5%) by temperature change during the past 10 years (R-squared = 0.885, with p-value = 0.000). Therefore, based on this study, the temperature can be considered as an important factor for maize production in Gashenyi sector and its change could potentially affect maize yields as highlighted by the regression model presented in the Fig. 15 below.

TABLE 9
REGRESSION MODEL SUMMARY

Model	R	R-Square	P-value	Confidence interval
1	.941	.885	.000	95%

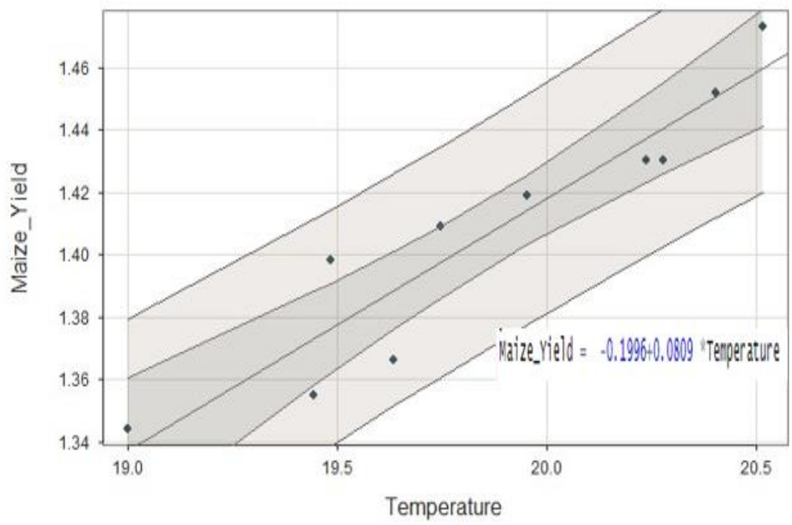

FIGURE 15: Simple linear regression model for maize yield in Gashenyi sector

3.4.6 The regression analysis of precipitation and maize yields in Gashenyi sector:

Although the estimated model for maize yield highlights a linear relationship between the precipitation and maize yields in this sector, the regression analysis (Fig. 16) indicates that the yield of maize obtained by farmers was not significantly influenced by precipitation change during the past 10 years (R-squared = 0.00016, with p-value = 0.971). The change in maize yield observed can only be explained at 0.016% by precipitation change. As highlighted by the regression model presented in the Fig.16 the change in precipitation could not significantly affect the expected yields of maize in Gashenyi sector.

TABLE 10
REGRESSION MODEL SUMMARY

Model	R	R-Square	P-value	Confidence interval
1	-0.013	.00016	.971	95%

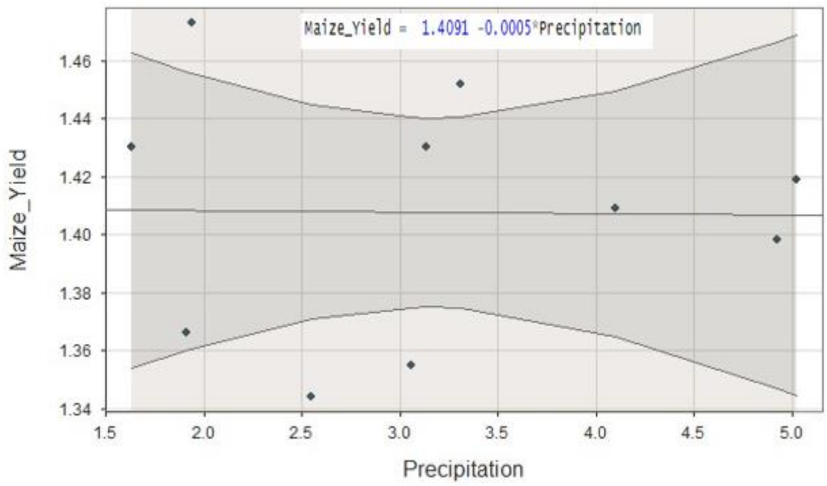

FIGURE 16: Simple linear regression model for maize yield in Gashenyi sector

IV. CONCLUSION

In conclusion, the results of this study reveals that, during the period dating from 2012 to 2021, there has been a remarkable variability in annual rainfall and annual mean temperature in the areas of study. This study provides evidence on the impacts of climate variability on maize production in Gakenke district, particularly through the variation of temperature. Thus, based on this study, the temperature can be considered as an important factor for maize production in Gakenke district, strongly positively correlated with maize yield, and its change has potentially affected maize yields as highlighted by the regression models presented above. The study does not show strong correlation between precipitation and maize yield, and the influence of precipitation was not statistically significant. However, the continuing rise in temperature observed in the study area could result in heavy rains and unexpected strong weather events, with ultimate disastrous effects on maize yields in the future. Yet, as the global temperature is continuingly increasing, climate change is expected to potentially affect the regions much depending on rain-fed agriculture [5], such as Rwanda. In this concern, regression models of maize yields were drawn for selected sectors, and could be a useful tool for future prediction.

V. RECOMMENDATIONS

This study shows an evidence regarding the variability in climatic parameters (precipitation and temperature) observed during the past 10 years and their potential impacts as highlighted by the regression models elaborated for maize yields in Gakenke district. Therefore, in this study area, adaptation strategies on climatic variability should be adopted and enhanced at farm level in order to minimize the disastrous effects of climate change on maize production. The perceptions of local farmers on the impacts of temperature and precipitation changes on maize production in Gakenke district could serve as a key asset for future research in order to investigate, in details, the way each climatic parameter is influencing the production of maize. Similar research should be conducted in other different agro-ecological zones in order to obtain sufficient data and a meaningful understanding on the effects of climate change on maize production, thereby contributing to the resilience and sustainability of agriculture in Rwanda.

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Business Growth and Development for Women Entrepreneurs in the Organic Food Sector – A Structural Equation Modelling Approach

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***Abstract*—** *Women in contemporary times have excelled in many ventures, including the growing organic food sector. The cross-sectional quantitative survey seeks to understand how work and life balance, access to resources, business challenges and support, and market opportunities impact the participation and development of women in organic commerce. This study investigated the association between the determinants (market opportunities, support, challenges, work-life balance and resources) of business growth among organic women entrepreneurs using a quantitative and causal research methodology. A survey was used to collect information from 317 women in Northern India who were involved in various organic food enterprises. The analysis was carried out using SPSS 26.0 and AMOS 25.0 using regression analysis. The regression analysis used in the work is SEM (structural equation modelling). Results show that market opportunities, support systems, and access to resources are vital to the success and growth of Women Entrepreneurs in this sector. On the other hand, business challenges show that challenges affecting women's entrepreneurship are likely to hinder business development. These findings support the need for support systems to address these hurdles and improve women's promotion in the organic foods sector. The general implications of the results from research on the global organic food sector and women's contributions are potentially far-reaching for all categories of stakeholders, from governmental and policymaker levels to community leaders and financial institutions. The findings show the overall net positive effects of market opportunities on business growth, indicating that when women entrepreneurs enjoy better access to these markets and resources, their businesses grow.*

***Keywords*— business growth; business development; women entrepreneurs; organic food sector; growth factors.**

I. INTRODUCTION

Women in contemporary times have excelled in many ventures, including the growing organic food sector (Nagpal, 2024). Such a change is not solely related to enhancing the customer interest in purchasing organic products, and the interest has been escalating because of the rising consumer consciousness about health and environmental issues (Milojevic et al., 2021; (Nagpal, 2024). It is also about the new generation of businessmen and businesswomen, a new generation of entrepreneurs who are totally different and completely gender-neutral, a new generation of entrepreneurs who are bringing new ideas and concepts and, above all, are very keen on the ethical business outlook and on the ideals which are at the base of the concept of organic farming (D'Silva & Bhat, 2022). The organic market, which is rapidly emerging, therefore, offers an exciting research focus point for understanding the intersection between gender relations, entrepreneurialism, and sustainability. This research was deemed necessary because of the acknowledgement that women entrepreneurs play a significant, yet not without controversy, role in the growth of the organic sector. Yet, the growth of this market is far from suggesting greater freedom or creativity; on the contrary, it opens a network of specifications that women have to face (D'Silva & Bhat, 2022; Ghosh & Cheruvalath, 2007; Nagpal, 2024). Some of these barriers include concerns that persist as longstanding obstacles such as the acquisition of finances and networks; other challenges can be described as the density of operational complexities, the challenges of managing an organic business while managing family needs and other commitments within an organizational structure. The requirement for studying such experiences must be balanced, as it can help realize the gender-specific challenges and strengths and enhance women's entrepreneurship development to strengthen the organic segment (D'Silva & Bhat, 2022; Ghosh & Cheruvalath, 2007; Nagpal, 2024).

However, the literature reveals that different variables influence business growth in this sector. Market opportunities and the perception of prospects displayed by women entrepreneurs demonstrate their confidence and strategic vision of the sector. It is also about their ability to secure the financial, physical, and educational resources, that can be the driving force to their business initiatives (D'Silva & Bhat, 2022; Ghouse et al., 2021). Maintaining a proper work-life balance is also crucial and affects not only these business owners and their lives but also the well-being of their companies (Kajtazi, 2021). Additionally, the details of women in the sector, particularly business constraints like extremely involved organic certification procedures and stiff market competition, warrant examination to uncover the tenacity and flexibility needed to prosper in this segment (Ghouse et al., 2021; Mamun et al., 2021). Support systems are a powerful influence behind these triggers and are defined to range from bureaucratic governmental support structures to acquaintances' support systems. These support structures could be influential and easily reachable in determining the direction of entrepreneurship for women in the organic sector (Petridou & Glaveli, 2008). Lastly, the unambiguous performance indicators for these ventures are the growth and sustainability – factors that not only signify the financial profitability of the ventures but also speak of their contribution to realizing the cardinal objective of sustainable development and social justice (Abdullah et al., 2014; Fallah & Soori, 2023). The cross-sectional quantitative survey seeks to understand how work and life balance, access to resources, business challenges and support, and market perceptions impact the participation and development of women in organic commerce and how they can determine the industry's future.

1.1 Research Gap:

As the organic sector evolves, more women are at the helm of this growing sector, and with them, it is bringing in the positive changes necessary for the ongoing evolution of the world's diets and the health consciousness behind them (Muthulingam & Madhuwanthi, 2020). Their advancement within this sphere is evidence of a growing change in the societal attitude towards engendering the entrepreneurship sphere, largely noticed in India and now exhibited in organic food sector. These women embody a balance of creativity, dedication, and management, coupled with imposed principles of sustainability, which are revolutionizing the market (Dsouza & Panakaje, 2023). However, it is equally important to note that some barriers exist to women's access to organic products. It faces a range of issues, such as uncertainty in financing, which is a complex process, lack of adequate support from the government and low consumer and stakeholder awareness of the matter. These challenges are further challenged by culture and economic baseline, where women will likely have limited chances of accessing the much-needed raw materials and connections that help businesses thrive (Ndlovu, 2022). However, there is a correlation between the challenges described and women entrepreneurs currently operating in the organic sector. They are positioning themselves to provide the market, which is becoming more sensitive to the issue of ethical consumption, with products from their unique perspectives and vantage viewpoints (Maity & Sahu, 2020). This often entails a strategic-thinking process that is macros, planning and executing processes that make financial and socio-ecological sense in the long term for their organizations and the markets, societies and ecosystems that host them. The above resilience is also strengthened by the networks developed – these are groups of like-minded people who can foster mentorship, encourage, and offer other support as well as business links (D'Silva & Bhat, 2022; Ghosh & Cheruvalath, 2007; Kothari, 2017). Such networks are beneficial, providing a source of group wisdom and support which assists women in overcoming the issues and barriers within the natural organic economy. Still, there is a requirement for specific consideration of the issues that women entrepreneurs in the organic industry experience. They also itemized a definite reduction in gender-specific research and concomitant policies that could offer a more penetrating distinction between genders that may aid in understanding their distinctive trials and tribulations (D'Silva & Bhat, 2022; Ghosh & Cheruvalath, 2007; Nagpal, 2024; Ndlovu, 2022). Therefore, bridging these gaps is a significant step in the right direction to foster an environment that will nurture and acknowledge the efforts of these women and enable positive progression for them. Therefore, it could be said that women entrepreneurs face various barriers when doing business in the organic sector but are still very strong and creative. Amid their success in the expansion of the organic food sector, their progress exposes the need to prepare the conditions for these women, as well as the general organic initiative, to grow and thrive to the extent that the ideals of equity and sustainability, which the women represent, will promote as well.

II. LITERATURE

The research on female entrepreneurs in the organic sector is diverse and combines several essential factors. This literature review also compiles findings in a way that builds from prior studies to give a solid foundation to these variables and uses.

2.1 Perceived Marketing opportunities:

While there may be some form of likeness in how women generally view opportunities in the organic sector, it is essential to consider the particular position or perspective of women business owners. This perception can, therefore, profoundly impact their operations, business models and investment strategies (Anthopoulou, 2010; Farnworth & Hutchings, 2009). Investigate shows that women entrepreneurs would display positive or negative mannerisms while approaching the market: positive perception being optimism and vice-versa.

2.2 Resource Access:

The mechanism of this perception stems from a number of factors like market forces, consumer attitude and the nature of competition. For example, a favourable view of the target market will likely prompt higher growth rates and exploitative strategies, whereas mistrust may lead to conservative decision-making. One of the significant challenges affecting women in business is limited access to these resources, which hinders them from excessively developing their businesses (Hobe, 2021: Nagpal, 2024). Financial-related limitations are strongly felt, where female entrepreneurs experience enormous challenges when engaging lenders as most of the lending institutions still have ingrained bias, and most times, these women lack any form of collateral to offer to the lending institutions (Otoo et al., 2012). Also, the availability of educational materials and training in business management and organization can improve their knowledge of the business and increase efficiency, yet such a chance is only sometimes given.

2.3 Work-Life Balance:

This is one of the most critical issues that women entrepreneurs must consider, especially since they must consider work and home responsibilities. This balance can confer potential benefits on their well-being and the stability of their businesses. Women can also be encumbered with household chores in most cases, which significantly shortens the time they can spend running their ventures (Pareek & Bagrecha, 2017). It is crucial to recognize best practices in work-life balance to sustain the bosses' well-being and guarantee the future stability of their businesses (Finlay, 2008).

2.4 Business Challenges:

Real-life business issues affecting female players in the organic industry Women who participate in the organic market experience several issues that affect their growth. These are the accuracy or rigorous certification criteria that must be met, market conditions, and people’s demands (Ghouse et al., 2021; Mamun et al., 2021).

2.5 Support system:

Compliance with organic product certifications can be lengthy and expensive, which may be a big problem, especially for women with small businesses. Furthermore, market forces by influential and better-established players stifle women-owned businesses from finding suitable niches (Anthopoulou, 2010). The government and non-governmental organizations and the availability and quality of social networks constitute an essential factor in the sustainability and success of women-owned businesses (Petridou & Glaveli, 2008). The suitable support structures will enable women entrepreneurs to gain the required inputs and connections to succeed (Anthopoulou, 2010; Nagpal, 2024).

2.6 Business growth:

Women entrepreneurs in the organic food value chain sector achieved their goals and objectives in sustaining and expanding their business ventures. This variable is the endurance of their operations and the economic effect they will have on their businesses. It has revealed that sustainable business activities are vital in the organic products industry due to the significant focus on environmental and social factors. The enduring attribute for success is the capacity to attain business growth besides retaining an organic perspective (Abdullah et al., 2014; Kothari, 2017).

III. METHODS

This study investigated the association between the determinants (opportunities, support, challenges, work-life balance and resources) of business growth among women entrepreneurs in organic food sector using a quantitative and causal research methodology. A survey was used to collect information from 317 women in Northern India who were involved in various organic food enterprises.

3.1 Measures:

Market opportunities, support systems, business challenges, work-life balance resource access and business growth, were measured using three items each on a 5-point Likert scale.

3.2 Objectives:

- To study the influence of market opportunities on business growth concerning women entrepreneurs in the organic food sector.
- To study the influence of support systems on business growth concerning women entrepreneurs in the organic food sector.
- To study the influence of business challenges on business growth concerning women entrepreneurs in the organic food sector.
- To study the influence of resource access on business growth concerning women entrepreneurs in the organic food sector.
- To study the influence of work-life balance on business growth in the organic food sector concerning women entrepreneurs.

IV. ANALYSIS & INTERPRETATION

The analysis was carried out using SPSS 26.0 and AMOS 25.0 using regression analysis. The regression analysis used in the work is SEM (structural equation modelling).

4.1 Participants' Profile:

Concerning 317 respondents (Table 1), 53.63% of the respondents, or the majority of women entrepreneurs in the organic industry, are older than 35. Just 10.41% of people are younger than 25, compared to 35.96% who are between the ages of 25 and 35. 48.26% are married, 38.17% are single, and 13.56% are in the "other" group. 49.84 per cent of female entrepreneurs have been in business for over five years. 29.02% of those with two to five years' experience and 21.14% with one to two years' experience come next. A sizable fraction of female entrepreneurs—65.93%—work full-time in their companies, compared to 34.07% who work part-time. According to the educational distribution, 42.90% of female entrepreneurs have a bachelor's degree, followed by a master's degree (27.34%), an intermediate degree (16.09%), and a category labelled "Others" (13.56%). Of women entrepreneurs, 36.28% have more than thirty employees, 35.65% have up to fifteen employees, and 28.08% have between fifteen and thirty employees.

TABLE 1
PARTICIPANT'S PROFILE

Variable	Category	Frequency	Percentage
Age	Below 25 years	33	10.41%
	25–35 years	114	35.96%
	Above 35 years	170	53.63%
Marital Status	Married	153	48.26%
	Unmarried	121	38.17%
	Other	43	13.56%
Involvement in Business	1–2 years	67	21.14%
	2–5 years	92	29.02%
	More than five years	158	49.84%
Work Status	Full-time	209	65.93%
	Part-time	108	34.07%
Education	Intermediate and less	51	16.09%
	Bachelor	136	42.90%
	Master	87	27.44%
	Others	43	13.56%
Business Size	Up to 15 employees	113	35.65%
	15–30 employees	89	28.08%
	More than 30 employees	115	36.28%

4.2 Measurement Model:

The measurement model was constructed using a confirmatory factor analysis (CFA) in AMOS 25.0, as illustrated in Figure 1. The model's fit indices suggest that the results are favourable: CMIN/DF= 3.22; CFI = 0.927; GFI= 0.904; NFI = 0.928; and RMSEA=0.061 (Hu & Bentler, 1999). C.R. (composite reliability) ratings were employed to assess the instrument's reliability, and they exceeded the acceptable threshold of 0.60. To evaluate convergent validity, the study implemented AVE (average variance extracted) scores to establish a criterion of at least 0.50 (Fornell & Larcker, 1981) and standard loadings that exceed

0.40. The analysis corroborated the discriminant validity, which demonstrated that the correlation coefficients were less than the square root of the AVE scores (Fornell & Larcker, 1981). Consequently, the components were clearly distinguished (Table 2).

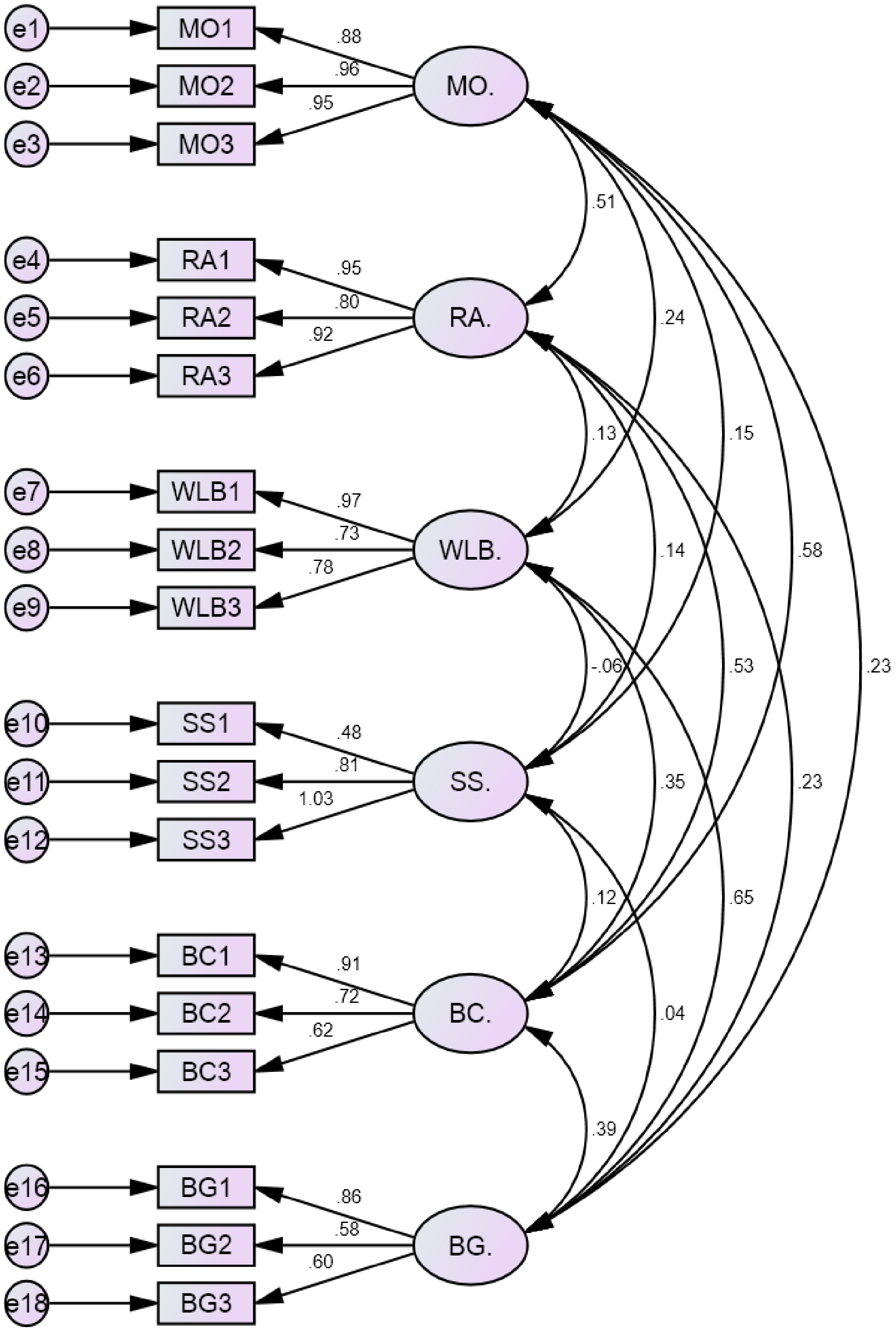

FIGURE 1: Measurement Model

Source: Author's Own

TABLE 2
VALIDITY AND RELIABILITY

Factors	CR	AVE	BC.	MO.	RA.	WLB.	SS.	BG.
BC.	0.799	0.576	**0.759**					
MO.	0.949	0.862	0.581	**0.929**				
RA.	0.92	0.794	0.534	0.514	**0.891**			
WLB.	0.871	0.695	0.346	0.242	0.13	**0.834**		
SS.	0.838	0.651	0.119	0.147	0.142	-0.055	**0.807**	
BG.	0.725	0.516	0.392	0.226	0.235	0.652	0.043	**0.69**

Source: Author's Own

Note: BC-business challenges; marketing opportunities; WLB-Work work-life balance; resource systems; resource access; BG-business growth.

4.3 Structural Model

Using the structural model, this work examined the relationship between predictor and outcome variables.

CMIN/df=4.25, GFI=0.908, CFI=0.921, RMSEA=.062, NFI=0.934.

4.4 Market opportunities and the growth of businesses

The results drawn from the regression analysis showed that market opportunities have a strong positive relationship with the growth of businesses in the organic food sector for women entrepreneurs, evidenced by a beta coefficient of (0. 38, p < 0. 05). This is an indication that there is consistency in the growth of business opportunities amongst women in this kind of business as the market expands.

4.5 Support systems and the growth of businesses

Functioning support systems have a net positive influence on the growth of women business entrepreneurs in the organic food industry, and the beta coefficient of the research shows a moderate association between the two (β = 0. 28, p < 0. 05). This, therefore, suggests that there is a strong potential for supportive policies and programs to a contribute to the success of women-owned business ventures.

4.6 Business challenges and the growth of businesses

Indeed, business challenges can be statistically identified as having a negative association with business growth by calculating the beta coefficient whereby businesses with high challenges have a negative beta coefficient of β=- 0. 24, t = 2. 62, p < 0. 05). From the above relationship, it is inferred that the higher the level of threats that come with being a woman entrepreneur, the slower rate of business evolution in the organic food industry.

4.7 Resource Access and the growth of businesses

Resource access also has a positive relationship with business growth, and more specifically, there is a significant positive beta coefficient of resource access, which is equal to 0. 37, and this is a very significant value (< 0. 01). This means it is possible to bring change in the fortunes of women entrepreneurs in the organic segment by making available better access of resources including funding, land, technologies, and many more.

4.8 Work-life balance and the growth of businesses

There is evidence of the significance of the predictor, work-life balance, with the beta coefficient (β = 0. 29, p < 0. 05) demonstrating a positive impact on business growth. This implies that women business people can develop a balance between home and office demands as a strategy for enhancing the growth of the business in the organic food sector.

V. CONCLUSION

A statistical perspective suggests that many factors at work affect business growth in one way or another. Market opportunities, support systems, and access to resources are vital to the success and growth of Women Entrepreneurs in this sector. On the other hand, business challenges show that challenges affecting women's entrepreneurship are likely to hinder business development. These findings support the need for support systems to address these hurdles and improve women's promotion in the organic foods sector.

VI. DISCUSSION

The findings state that where there are more excellent market opportunities, there is enhanced business growth, which underlines the need for market access among women entrepreneurs. This implies that when women have optimum access to customers, they will be able to serve the customers in their target markets, hence promoting their businesses' success. Increasing market orientation entails marketing human capital development, market information, and marketing events, particularly for convergence with the targeted buyers and suppliers by women entrepreneurs. The moderate positive results reported in support systems about business growth are essential to stress the contribution of extra organizational support in evolving entrepreneurial success. Education, sponsorship, support and encouragement from the government and the community in terms of resources and from the experienced successful women entrepreneurs, respectively, can enable the women emblem to create their businesses. Measures that were taken and are still being taken to eliminate or even discrimination against women can also enhance the available wall for women. The highly positive and significant relationship between resource availability and business expansion supports the notion that the requisite financial, human, and physical resources are sine qua non for business growth and longevity. Proposed solutions that might become catalysts for developing women's businesses include providing increased autonomy over capital, including microfinancing, grants for female-owned businesses, and targeted training in financial management. The evidence confirming a positive link between work-life balance and business development means that an effective balance of work and personal responsibilities may improve business performance. This reveals the necessity of official and organizational measures that would allow women entrepreneurs to have a flexible schedule, childcare, and societal expectations that accept them working both for their companies and in their households. This correlation shows that the level of challenges faced in business, such as gender bias, network limitations, and regulation, all reduce the level of growth. Mitigating these challenges through unique initiatives and training, for instance, gender-sensitivity training and diversity in business networking events and receptions for business, and the simplification of business laws to be more friendly to women will go a long way to ensuring that women entrepreneurs get equal chances of survival as their male counterparts. Lastly, it is crucial to highlight that some environmental conditions determine the probability of success among women entrepreneurs in the organic food sector; those conditions involve increasing market opportunities for the targeted business segment, improving support structures and resources available for this segment, addressing the risks and obstacles of doing business, and providing women business owners with a work-life balance. This requires cooperation among stakeholders, including policymakers, financial institutions, and community heads, to ensure that women girls experience an enabling environment in their operation of organic food value chain ventures for sustainable income generation.

6.1 Implications

The general implications of the results from research on the global organic food sector and women's contributions are potentially far-reaching for all categories of stakeholders, from governmental and policymaker levels to community leaders and financial institutions. The findings show the overall net positive effects of market opportunities on business growth, indicating that when women entrepreneurs enjoy better access to these critical markets, their businesses grow. This suggests the need for activities to boost the marketing of women entrepreneurs' products. This can be in the form of training and mentoring, especially in the area of marketing and promotions and linking them to more significant markets. The role of support systems in business is critical when it comes to the growth of a business. According to these factors, it would be seen that the majority received some external help for mentorship, subsidies, and supportive policies. The need, therefore, arises to sustain and expand funding for governmental and non-governmental organizations and agencies, as well as to assist and offer various forms of support to women within the organic food sector. The availability of resources became a fundamental concern, and financial, human, and physical resources were vital for expanding and continuing businesses. These findings indicated that financial institutions and investors must develop specific services for women business owners and that training initiatives should tackle how these firms can manage their resources and run their operations effectively. Work-life balance with overall well-being correlates to new business performance and shows that employee satisfaction is essential to corporate success. According to this, there is a necessity to develop more work-life balance policies and business schedules for appropriate working hours and flexible leaves, including parental and child care services. Measures of that nature would not only help promote the continuance of women in business but also promote the productivity of business women and the growth of businesses.

On the other hand, the 'negative' correlation between challenges faced by business and growth emphasizes that women continue to face limitations and discrimination as entrepreneurs. This requires continued revamped efforts to alter these barriers through education, gender sensitivity training, policies that will embrace women, and push for women's networks that embrace all these women. These findings together signify a need for a policy framework that holistically addresses all the requirements of women entrepreneurs. This entails improving market access, strengthening support structures empowering women, improving resources, and attending to the particularities of women and their ability to balance work and family. Doing so would not only benefit women entrepreneurs but also help the overall growth and sustenance of the organic foods industry and hence have a domino effect on communities as well as those key to economic empowerment.

6.2 Future Research

It is essential to prioritize longitudinal research to investigate how these variables and their relationships to company success evolve. As a result, the sustainability of entrepreneurial success becomes more straightforward. Additionally, to provide a more accurate understanding of how businesses operate, scholars should examine and draw attention to additional elements that could have an impact on the prosperity and expansion of firms, such as ideas unrelated to entrepreneurship, like markets, innovation, and technology. Finally, the study highlights the need for a more all-encompassing strategy when supporting female entrepreneurs, taking into account the variables at play and realizing the importance of the outcomes in the form of community and family support to help address the need to enhance the environmental conditions for successful growth and development in organic-food entrepreneurship.

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