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CLIMATE-SMART AGRICULTURE FOR SUSTAINABLE FOOD SECURITY

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Abstract: Climate-smart agriculture (**CSA**) is a sustainable approach that increases agricultural productivity and income while building resilience to climate change. By reducing greenhouse gas emissions, **CSA** contributes to climate mitigation. Key strategies include developing climate-resistant crop varieties, identifying vulnerable regions for strategic relocation, and utilizing early warning systems to minimize weather-related losses.

Computer models help predict climate impacts and inform the development of effective **CSA** practices. This research emphasizes the urgent need for policymakers to address climate change threats to agriculture.

By exploring risk management and insurance strategies, we aim to strengthen economic resilience. Our value chain approach focuses on interconnected climate adaptation strategies. For instance, in Northern Egypt, we address sea level rise through laser land leveling to reduce saline groundwater. In Upper Egypt, we optimize cropping patterns to adapt to rising temperatures. By leveraging the Strategic Global Climate Change Adaptation Preparedness Plan, our research seeks to combat drought. Implementing these optimized cropping patterns is projected to significantly increase farm profits, reduce water usage, lower CO_2 emissions, and decrease energy consumption in both existing and new agricultural lands across Egypt.

Implementing optimal cropping patterns is projected to significantly enhance agricultural sustainability in Egypt. Farm profits are expected to soar by 30.391% to 190.818%, while water usage, CO_2 emissions, and energy consumption will decrease by an average of 28.159%, 28.180%; 20.582%, 22.840% and 23.654%, 28.546% respectively, across both established and newly developed agricultural lands.

Keywords: Climate smart agriculture assessment (**CSAA**), environmental climate smart agriculture assessment (**ECSAA**) and environmentally extended input–output climate smart agriculture analysis (**EEI-OCSAA**) as a value chains.

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INTRODUCTION

Climate change and food and nutrition insecurity are two of the most pressing global challenges of our time. A sustainable food system offers a dual solution: healing our planet and ensuring food security for all. As the current agrifood system is a major contributor to climate change, accounting for one-third of global emissions. Feeding a projected global population of 9.7 billion people by 2050 **(FAO 2023)** will further strain our planet unless we transform how we produce and consume food. Historically, increased food production has relied on agricultural expansion and unsustainable resource use, creating a vicious cycle of growing emissions. Where food systems are the primary source of methane emissions and biodiversity loss, consuming around 70% of freshwater. Food waste alone is the world's third-largest emitter. This problem is particularly acute in developing countries, where agricultural emissions are on the rise **(FAO 2024)**.

The agri-food sector is a major contributor to climate change, primarily through deforestation and greenhouse gas emissions. Without significant mitigation efforts, achieving the Paris Agreement goals will be impossible. To address this crisis, the global food system must simultaneously increase production, adapt to climate impacts, and drastically reduce its carbon footprint. Climate-Smart Agriculture (**CSA**) offers a comprehensive approach to reconcile these challenges, ensuring food security, promoting sustainable development, and combating climate change **(World Bank 2024a).**

Climate-Smart Agriculture (**CSA**) is a comprehensive approach that integrates agricultural practices and technologies to simultaneously boost productivity, enhance resilience to climate change, and reduce greenhouse gas emissions. While building on existing agricultural knowledge and sustainability principles, **CSA** distinguishes itself in several key ways. First, it explicitly focuses on addressing the challenges posed by climate change within the agrifood system. Second, **CSA** systematically analyzes the interplay between increasing productivity, adapting to climate change, and mitigating its impacts. Third, it encompasses a diverse range of practices and technologies tailored to specific agro-ecological and socio-economic conditions. These include climate-resilient crop varieties, conservation agriculture, agroforestry, precision farming, efficient water management, and improved livestock management **(World Bank 2024b)**.

Climate-Smart Agriculture (**CSA**) offers a triple win solution: increased food production and quality without harming natural resources, improved livelihoods for rural poor, and greater resilience to climate change. By adopting **CSA** practices, farmers can boost incomes, reduce vulnerability to extreme weather events, and contribute to mitigating climate change. Despite its potential, **CSA** is currently underfunded. While the agrifood system accounts for one-third of global greenhouse gas emissions, it receives only 4% of climate finance. To achieve a sustainable food system, we must significantly increase financial support for smallholder farmers practicing **CSA (World Bank 2024b).**

METHODOLOGY

Climate change is a critical threat to global food security, with unsustainable agricultural practices as a primary driver. Conventional agriculture, reliant on methods that intensify greenhouse gas emissions, deplete natural resources, and harm ecosystems, is exacerbating this crisis.

As the world's population grows, the demand for food surges, necessitating a drastic shift towards sustainable agricultural practices. Current methods are major contributors to greenhouse gas emissions, deforestation, and water scarcity. Food waste further compounds the issue. Developing countries, experiencing rapid increases in agricultural emissions, are particularly vulnerable.

Addressing agriculture is imperative for achieving the Paris Agreement's climate goals. A transformative shift towards a productive, climate-resilient, and low-emission agri-food system is urgently needed.

Climate-Smart Agriculture (**CSA**) offers a comprehensive solution to the pressing challenges posed by climate change on agriculture. By simultaneously boosting productivity, enhancing resilience, and reducing greenhouse gas emissions, **CSA** provides a sustainable pathway for food production.

CSA is tailored to specific regional conditions, building upon existing knowledge and practices. This approach recognizes the interconnected nature of these goals and seeks to optimize outcomes for farmers and the environment. By increasing yields, improving food quality, and safeguarding against climate risks, **CSA** can significantly contribute to global food security.

Furthermore, **CSA** has the potential to mitigate climate change by reducing the agricultural sector's greenhouse gas footprint. However, scaling up **CSA** requires substantial investments, particularly to support smallholder farmers who are often most vulnerable to climate impacts.

Ultimately, embracing **CSA** is essential for building a resilient and sustainable food system. By prioritizing its implementation, we can create a future where agriculture thrives in harmony with the planet.

MATHEMATICAL MODEL

This research expands and formalizes the conceptual underpinnings of Climate-Smart Agriculture (**CSA**) by integrating theories from agricultural development, institutional economics, and materials economics. A particular emphasis is placed on the adaptability and resilience dimensions of **CSA**, as these aspects remain under-explored in the economic literature.

Employing a mixed-methods approach, this research encompasses conceptual analysis, empirical investigation, policy evaluation, and case studies. It delves into four key areas: Proactive vulnerability reduction: Identifying and mitigating potential climate change impacts. Policy-driven adaptive capacity enhancement: Exploring how government policies can foster agricultural adaptation. System-level adaptive capability building: Analyzing the role of institutions, infrastructure, and research in supporting adaptation. Farm-level adaptive capacity increase: Investigating strategies for individual farmers to enhance resilience. The research culminates in a case study demonstrating the practical application of the developed framework. By examining a real-world context, the research highlights the diversity of agroecological and socioeconomic conditions confronting agricultural planners and policymakers and offers concrete examples to illustrate the conceptual and theoretical underpinnings.

This research investigates methods for measuring climate change vulnerability and its impacts, strategies to enhance adaptive capacity, and the post-implementation effects of various policy measures. It provides valuable insights for economists and policymakers by offering a novel interpretation and operationalization of resilience and adaptive capacity within the context of agricultural development and food security.

Combining rigorous methodological analyses of climate-smart agriculture (**CSA**) with an empirical case study from the Southeast Mediterranean Sea differentiates this research.

The research is structured as follows: Part 1: Conceptual Framework outlines the **CSA** concept, its methodologies, and core components. It connects **CSA's** core capabilities to fundamental economic principles and clarifies the interrelationships among resilience, adaptive capacity, innovation, technology adoption, and institutions within the **CSA** economic framework. Part 2: Case Study presents an empirical investigation by agricultural development economists in the Southeast Mediterranean Sea. It demonstrates the economic foundation of **CSA** in reducing vulnerability and enhancing adaptive capacity, distinguishing between policy, system, and farm-level responses. The case study addresses climate change policy challenges and offers a comprehensive overview of the CSA paradigm grounded in economic principles.

Sustainable food security via climate smart agriculture (SFSVCSA) as a value chain consists of

Climate smart agriculture assessment (CSAA) as a value chain

$$\text{Maxmize AGA}=\sum_{y1=1}^{Z1}(\text{Evy2-Evy1})+\sum_{y2=1}^{Z2}(\text{Evy4-Evy3}) \quad (1)$$

Z1: Total amount of productions cultivated in the scheme of old land

Evy_1: Economic value of production old land before adaptation to climate change

Evy_2: Economic value of production old land after adaptation to climate change

Z2: Total amount of productions cultivated in the scheme of new land

Evy_3: Economic value of production new land before adaptation to climate change Evy_4: Economic value of production new land after adaptation to climate change

V: Total annual volume of water used in the scheme

Subject to

$$EVy = Qy \, . \, Py - Cy \quad (2)$$

$$Qy = Ry \, . \, Ay \quad (3)$$

Q_y: Quantity of production y

R_y: Yield of production y

A_y: Area allocated to production y

P_y: Marketing price of production y

C_y: Production costs dedicated to production y

Environmental climate smart agriculture assessment (ECSAA) as a value chain

$$\text{Minimize EAGA}=\sum_{y1=1}^{Z1}(\text{Evy2-Evy1})+\sum_{y2=1}^{Z2}(\text{Evy4-Evy3}) \quad (4)$$

Z1: Total amount of crop emission in cultivated in the scheme of old land

Evy_1: Amount value of crop emission in old land before adaptation to competition

Evy_2: Amount value of crop emission in old land after adaptation to competition

Z2: Total amount of crop emission in cultivated in the scheme of new land

Evy_3: Amount value of crop emission in new land before adaptation to competition Evy_4: Amount value of crop emission in new land after adaptation to competition

Subject to

$$Qy = Ry \cdot Ay \tag{5}$$

Q_y: Quantity of crop emission in production y

R_y: Yield of crop emission in production y

A_y: Area allocated to production y

Environmentally extended input–output climate smart agriculture analysis (EEI-OCSAA) as a value chain

$$\text{Maxmize EEI-OAGA}=\sum_{y1=1}^{Z1}(\text{Evy2-Evy1})+\sum_{y2=1}^{Z2}(\text{Evy4-Evy3}) \tag{6}$$

Z1: Total amount of productions cultivated in the scheme of old land

Evy_1: Economic value of production old land before adaptation to competition

Evy_2: Economic value of production old land after adaptation to competition

Z2: Total amount of productions cultivated in the scheme of new land

Evy_3: Economic value of production new land before adaptation to competition

Evy_4: Economic value of production new land after adaptation to competition

V: Total annual volume of water used in the scheme

Subject to

$$EVy = Qy \cdot Py - Cy \tag{7}$$

$$Qy = Ry \cdot Ay \tag{8}$$

Q_y: Quantity of production y

R_y: Yield of production y

A_y: Area allocated to production y

P_y: Marketing price of production y

C_y: Production costs dedicated to production y

RESULTS AND DISCUSSION

This research introduces a novel analytical framework for assessing the effectiveness of Climate-Smart Agriculture (**CSA**) practices within Egypt's agricultural landscape. The framework comprises three complementary assessment approaches: Climate Smart Agriculture Assessment (**CSAA**): Evaluates the overall performance of **CSA** practices in achieving desired outcomes. Environmental Climate Smart Agriculture Assessment (**ECSAA**): Focuses on the environmental implications of **CSA** practices, including water use efficiency, greenhouse gas emissions, and soil health. Environmentally Extended Input-Output Climate Smart Agriculture Analysis (**EEI-OCSAA**): Provides a comprehensive assessment of the environmental and economic impacts of **CSA** practices across the entire agricultural value chain using input-output analysis.

The framework is applied to Egypt's "old and new lands," a region encompassing approximately 1.39 million hectares within the Nile Valley and Delta **(MALR, 2024).** This area, comprising 13 governorates (Alexandria, Menoufia, Gharbia, Kafr El Sheikh, Ismailia, Dakahlia, Qaliubiya, Sharqia, Port Said, Suez, Damietta, El-Behaira, and Cairo) within the Nile River Delta **(Figure 1)**, is characterized by a complex, multi-seasonal cropping system heavily reliant on the Nile River for irrigation. The research further incorporates economic and financial analysis, including the calculation of internal rate of return for crop production.

This study adopted a multi-phased approach to evaluate climate-smart agriculture (**CSA**) practices. The assessment encompassed climate-smart agriculture assessment (**CSAA**), environmental climate-smart agriculture assessment (**ECSAA**), and an environmentally extended input-output climate-smart agriculture analysis (**EEI-OCSAA**) to comprehensively examine the entire value chain (**Figure 2**). To identify the optimal cropping pattern, the study initially focused on winter cultivation in Egypt's old and new lands. A subsequent simulation determined the optimal pattern for the entire season. This pattern was then refined to align with the region's existing cropping practices (2021/2022 - 2023/2024), considering production goals and hazard mitigation. Farmer-reported field data, collected through surveys and specialized inputs, served as the core of the model. Additional data on agricultural landscape, socioeconomic conditions, crop area, yield, costs, water consumption, and production systems were sourced from the Egyptian Ministry of Agriculture and Land Reclamation (**MALR 2024**), the Egyptian Ministry of Water Resources and Irrigation (**MWRI 2024**), and primary sources. Greenhouse gas emissions were calculated based on power input. All data used in this research represents average values from 2021/2022 to 2023/2024.

Table 1 presents a baseline assessment of current cultivation practices and their associated economic values in the study area during the winter season for both old and new lands. Data is sourced from the Egyptian Country Agricultural Production Model System (**ECAPMS 2024**), detailing crop types, cultivated areas, and economic valuations. This research investigates the potential of Climate-Smart Agriculture Assessments (**CSAA**) to enhance agricultural sustainability in Egypt's Nile Valley by optimizing water use efficiency and land-use allocation to maximize farm income. Key Findings: Water scarcity necessitates efficient management: The research explores strategies to reduce water consumption while preserving crop yields. Land-use optimization boosts profitability: Reallocating land based on soil and water conditions, as demonstrated by laser land leveling, can increase farm income. Comparative analysis of CSAA approaches: The research evaluates three approaches: **CSAA** for overall sustainability, Environmental CSAA (**ECSAA**) for greenhouse gas reduction, and Environmentally Extended Input-Output CSAA (**EEI-OCSAA**) for comprehensive environmental impact assessment.

Results from **Tables 2-4** and **Figures 3-10** demonstrate the substantial benefits of Climate-Smart Agriculture Approaches (**CSAA**) in Egypt. **CSAA** significantly enhanced economic performance, increasing farm income through optimized water and land management. Environmentally, it reduced greenhouse gas emissions and air pollution compared to traditional methods. This research conclusively establishes **CSAA** as a cornerstone for sustainable agriculture in Egypt. Water-use efficiency emerges as a critical factor in sustainable agriculture. Our proposed model, which incorporates laser land leveling, decreased overall water consumption by 28% in both existing and new agricultural areas. This achievement enabled expanded crop cultivation while maintaining or improving farm profitability. Laser land leveling, proven to be cost-effective, is recommended for widespread implementation across Egypt due to its ability to enhance water distribution, boost crop yields, and increase farmers' incomes. Comparative analyses of three CSAA approaches (**CSAA)**, Environmental CSAA (**ECSAA**), and Environmentally Extended Input-Output CSAA (**EEI-OCSAA**) - revealed substantial environmental improvements over conventional practices. Notably, ECSAA excelled in minimizing greenhouse gas emissions, fostering a healthier ecosystem and public health.

Financial analysis demonstrates that the proposed model surpasses the current system in terms of net income, especially within newly cultivated agricultural areas. By reducing overall production costs and expanding the cultivated land, the model offers a compelling financial advantage.

Investment Potential and Recommendations: The model's enhanced internal rate of return (**IRR**) and reduced risk profile underscore its strong investment potential. To optimize the Egyptian agricultural sector, the research advocates for the implementation of Sustainable Food Security via Climate-Smart Agriculture (**SFSVCSA**). As a key component of this strategy, laser land leveling is highlighted for its ability to significantly improve water efficiency and farm profitability.

Conclusion: This research provides a robust case for adopting climate-smart agricultural practices in Egypt. These practices not only deliver substantial economic benefits but also contribute to environmental sustainability, ensuring a secure food supply for the future.

CONCLUSION

Climate Smart Agriculture (CSA) emerged in 2009 to address the gap in climate change policies related to agriculture and food security. Its goal is to provide global guidelines for sustainable agriculture under a changing climate, focusing on increasing agricultural productivity and incomes, enhancing resilience to climate impacts, and reducing greenhouse gas emissions. Developing countries face challenges in reducing emissions and adopting sustainable technologies, contributing to inconsistencies in **CSA** implementation. While research on **CSA** practices, tools, and programs grows, its effectiveness is becoming clearer. Success depends on integrating climate change considerations into broader agricultural development strategies.

A comparative analysis of three assessment methods (**CSAA, ECSAA, and EEI-OCSAA**) in Egypt evaluated the potential of **CSA** to achieve sustainable food security. Results indicate significant benefits: reduced water consumption, increased cultivated land, higher net financial benefits, improved internal rate of return, and lower cultivation risk. These findings suggest that **CSA** can enhance food security and economic gains in Egypt.

A deeper analysis of **CSA** practices in Egypt using the three assessment methods revealed substantial improvements. Water use decreased by 28-28.2%, cultivated land increased significantly, and net financial gains reached billions of Egyptian Pounds. The internal rate of return also saw a substantial increase, reducing cultivation risk.

Based on these results, the research proposes a Growth Complementarity Between Agriculture and Industry (**GCBAAI**) value chain to further boost Egypt's agricultural sector. This framework emphasizes the importance of understanding **CSA's** adaptability and resilience through a mixed-methods approach. By focusing on vulnerability reduction, policy development, institutional building, and farmer-level strategies, the framework aims to provide insights for economists and policymakers to build resilience through **CSA**. Ultimately, it offers a broader theoretical foundation for effective **CSA** implementation.

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Table 1: Changes area in winter cultivation of old and new land of Egypt flow values from the mean (2010/2011-2012/2013) -(2020/2021-2022/2023) to CSAA (Bold is values that have increased, normal are values that have decreased)

Winter cultivation in old land of Egypt				
	Mean	***EESU***	*Change*	*%*
Wheat	1073116.38	671994.540	-401122	-37.38
Broad Beans	12494.160	20153.700	7660	61.30
Barley	4390.260	4258.380	-131.9	-3.00
Lentil	98.280	179.760	81.5	82.91
Fenugreek	987.420	23.940	-963.5	-97.58
Chick Peas	766.920	0.000	-766.9	-766.92
Lupine	42.420	337.680	295.3	696.04
Flax	9582.300	4054.680	-5527.6	-57.69
Onion	75331.620	24141.600	-51190.0	-67.95
clover	575932.560	353264.940	-222668	-38.66
Clover Tahreesh	4412.520	98081.760	93669.2	2122.81
Garlic	16398.900	1351.140	-15047.8	-91.76
Sugar Beet	163800.840	90047.160	-73753.7	-45.03
Tomato	23106.720	17569.020	-5537.7	-23.97
Vegetables	106255.800	75637.380	-30618.4	-28.82

Winter cultivation in new land of Egypt				
	Mean	***EESU***	*Change*	*%*
Wheat	236527.20	**236527.20**	**0.00**	**0.00**
Broad Beans	20608.980	**20608.98**	**0.00**	**0.00**
Barley	84106.680	**84106.68**	**0.00**	**0.00**
Lentil	0.000	**0.00**	**0.00**	**0.00**
Fenugreek	282.660	**282.66**	**0.00**	**0.00**
Chick Peas	117.600	**117.60**	**0.00**	**0.00**
Lupine	0.000	**0.00**	**0.00**	**0.00**
Flax	128.940	**128.94**	**0.00**	**0.00**
Onion	19201.560	**19201.56**	**0.00**	**0.00**
clover	184799.580	**184799.58**	**0.00**	**0.00**
Clover Tahreesh	3517.920	**3517.92**	**0.00**	0.00
Garlic	3155.040	**3155.04**	**0.00**	**0.00**
Sugar Beet	60201.960	**60201.96**	**0.00**	**0.00**
Tomato	42407.400	**42407.40**	**0.00**	**0.00**
Vegetables	101933.580	**1499142.49**	**1397208.91**	**1370.71**

Data source: (1) MALR (2024) (2) **CSAA** model (2024) (3) ECAPMS, (2024)

Table 2: Changes area and energy consumption in winter cultivation of old and new land in Egypt flow values from the mean (2010/2011-2012/2013) -(2020/2021-2022/2023) to CSAA (Bold is values that have increased, normal are values that have decreased)

Winter cultivation in old land of Egypt				
	Mean	***EESU***	*Change*	*%*
Irrigated area of crop in old land	2174017.02	2158911.30	-15106	-0.695
Crop revenue	121087.4	**394599.0**	**273511.6**	**225.9**
Crop profit	108505.9	**249981.3**	**141475.4**	**130.4**
Crop production cost	29188.1	**47936.9**	**18748.8**	**64.2**
Labor Wages	2718.9	**8257.1**	**5538.2**	**0.0**
Other Expenses (Labor Wages)	674.0	**2116.0**	**1442.0**	**213.9**
Crop water consumption	14183.7	**9564.9**	**-4618.8**	**-32.6**
Kerosene fuel million tons	10506.4	3131.4	-7375.0	-70.2
Energy consumption in cultivation TJ	286.7	**64.6**	**-222.1**	**-77.5**
Main crop yield	65.9	**105.4**	**39.4**	**59.8**
Secondary crop yield	21.8	**34.8**	**13.0**	**59.8**
Main crop price	5883.9	**20912.3**	**15028.3**	**255.4**
Secondary crop price	290.3	**617.5**	**327.2**	**112.7**
Manure	459.9	1487.6	1027.7	223.4
Fertilizers	2050.7	3508.6	1458.0	71.1
Winter cultivation in new land of Egypt				
	Mean	***EESU***	*Change*	*%*
Irrigated area of crop in new land	761702.3	**2158911.25**	**1397208.91**	**183.432**
Crop revenue	59398.0	**163853.4**	**104455.5**	**175.9**
Crop profit	53601.4	**108345.4**	**54744.0**	**102.1**
Crop production cost	20183.0	**37738.6**	**17555.5**	**87.0**
Labor Wages	1274.8	**6713.7**	**5438.9**	**426.7**
Other Expenses (Labor Wages)	310.0	**1408.0**	**1098.0**	**354.2**
Crop water consumption	10498.6	7812.4	-2686.2	-25.6
Kerosene fuel million tons	3419.9	5449.0	2029.1	59.3
Energy consumption in cultivation TJ	60.0	101.4	41.3	68.9
Main crop yield	43.1	**74.4**	**31.3**	**72.6**
Secondary crop yield	9.1	**12.0**	**2.9**	**32.3**
Main crop price	2379.7	**11620.3**	**9240.7**	**388.3**
Secondary crop price	110.1	139.9	29.8	27.1
Manure	178.5	**1043.7**	**865.1**	**484.6**
Fertilizers	706.2	**2386.2**	**1680.0**	237.9

Data source: (1) MALR (2024) (2) **CSAA** model (2024) (3) ECAPMS, (2024)

Table 3: Changes in the economic and financial values for the winter season in the old and new land in Egypt flow values from the mean (2010/2011-2012/2013) -(2020/2021-2022/2023) to CSAA (Bold is values that have increased, normal are values that have decreased).

Winter cultivation in old land of Egypt				
	Mean	**EESU**	Change	%
Irrigated area of crop in old land	2174017.02	**2158911.30**	**-15106**	**-0.695**
Main crop yield	65.9	**105.4**	**39.4**	**59.8**
Secondary crop yield	21.8	**34.8**	**13.0**	**59.8**
Main crop price	5883.9	**20912.3**	**15028.3**	**255.4**
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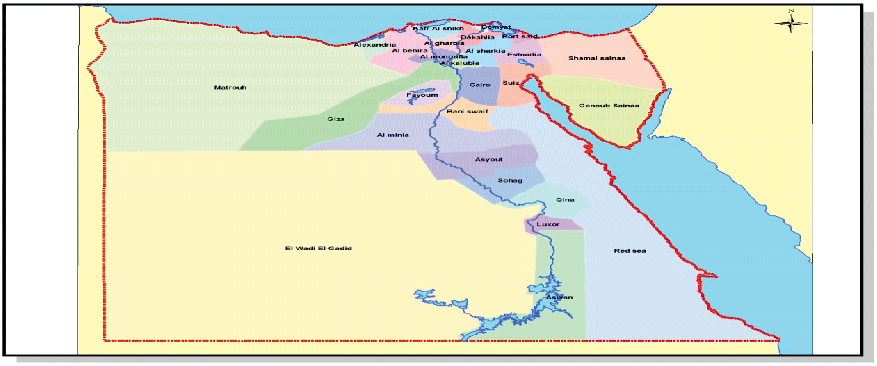
Crop revenue	121087.4	**394599.0**	**273511.6**	**225.9**
Crop profit	108505.9	**249981.3**	**141475.4**	**130.4**
Crop production cost	29188.1	**47936.9**	**18748.8**	**64.2**
Labor Wages	2718.9	**8257.1**	**5538.2**	**0.0**
Other Expenses (Labor Wages)	674.0	**2116.0**	**1442.0**	**213.9**
Rate of return (IRR)	3.15	**7.23**	**4.08**	**129.68**
Absolute Risk	159.72%	**49.01%**	**-110.71%**	**-69.31**
Winter cultivation in new land of Egypt				
	Mean	**EESU**	Change	%
Irrigated area of crop in new land	761702.3	**2158911.25**	**1397208.91**	**183.432**
Main crop yield	43.1	**74.4**	**31.3**	**72.6**
Secondary crop yield	9.1	**12.0**	**2.9**	**32.3**
Main crop price	2379.7	**11620.3**	**9240.7**	**388.3**
Secondary crop price	110.1	139.9	29.8	27.1
Crop revenue	59398.0	**163853.4**	**104455.5**	**175.9**
Crop profit	53601.4	**108345.4**	**54744.0**	**102.1**
Crop production cost	20183.0	**37738.6**	**17555.5**	**87.0**
Labor Wages	1274.8	**6713.7**	**5438.9**	**426.7**
Other Expenses (Labor Wages)	310.0	**1408.0**	**1098.0**	**354.2**
Rate of return (IRR)	**1.94**	**3.34**	**1.40**	**72.00**
Absolute Risk	**124.35%**	**45.08%**	**-79.27%**	-63.75

Data source: (1) MALR (2024) (2) CSAA model (2024) (3) ECAPMS, (2024)

Table 4: Changes in crop emissions of the winter season in the old and new land in Egypt flow values from the mean (2010/2011-2012/2013) -(2020/2021-2022/2023) to ECSAA (Bold is values that have increased, normal are values that have decreased)

Winter cultivation in old land of Egypt				
	Mean	**EESU**	Change	%
NO_x	**25.24688464**	**7.52465592**	**-17.722**	**-70.196**
SO_2	**25379.4124**	**7564.15488**	**-17815.3**	**-70.196**
CO_2	**nugatory**	**nugatory**		**nugatory**
SO_3	**8.064714377**	**2.40363125**	**-5.661**	**-70.196**
CO	nugatory	nugatory		**nugatory**
CH	**nugatory**	**nugatory**		**nugatory**
SPM	**25.24688464**	**7.52465592**	**-17.722**	**-70.196**
Winter cultivation in new land of Egypt				
	Mean	**EESU**	Change	%
NO_x	**1.7031253**	**2.7136028**	**1.010**	**59.331**
SO_2	**8.2180926**	**13.093951**	**4.876**	**59.331**
CO_2	**8261.2316**	**13162.684**	**4901.45**	**59.331**
SO_3	**nugatory**	**nugatory**		**nugatory**
CO	**2.6251385**	**4.1826536**	**1.558**	**59.331**
CH	**nugatory**	**nugatory**		**nugatory**
SPM	**nugatory**	**nugatory**		nugatory

Data source: (1) MALR (2024) (2) **ECSAA** model (2024) (3) ECAPMS, (2024)



Lower Egypt		Middle Egypt	Upper Egypt	Outside the Valley
Alexandria	Port Said	Giza	Assuit	New Valley
Gharbia	Sharkia	Beni Suef	Sohag	Matruh
Menoufia	Damietta	Fayum	Qena	South Sinai
Ismailia	Suez	Mania	Luxor	North Sinai
Kafr-El Sheikh	Behera		Aswan	Noubaria
Qalyoubia	Cairo			
Dakahlia				

Figure 1: Nile River valley

Source: (Hamada 2024)

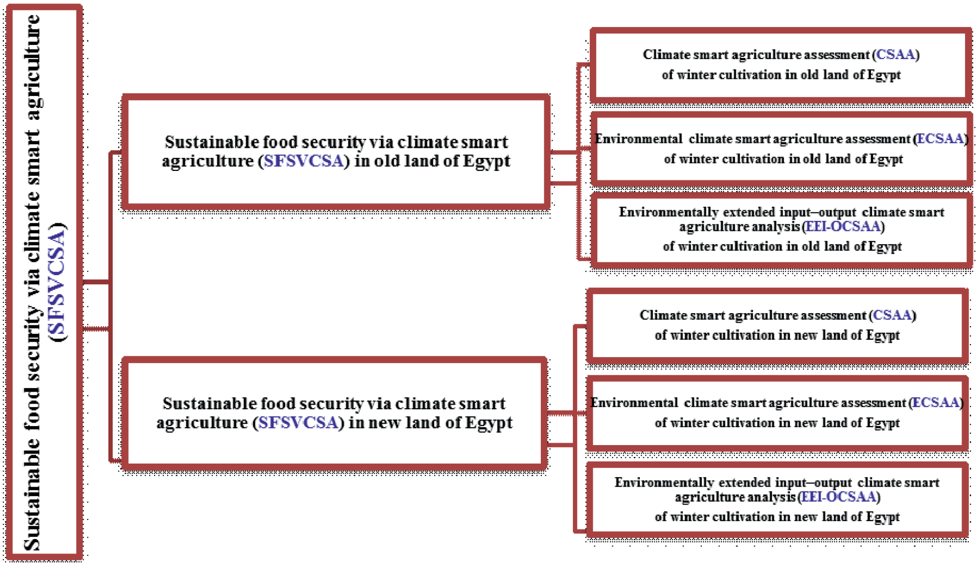


Figure 2: Structure model of Climate smart agriculture assessments (CSAA) as a value chain in Egypt

Source: (CSAA model 2024)

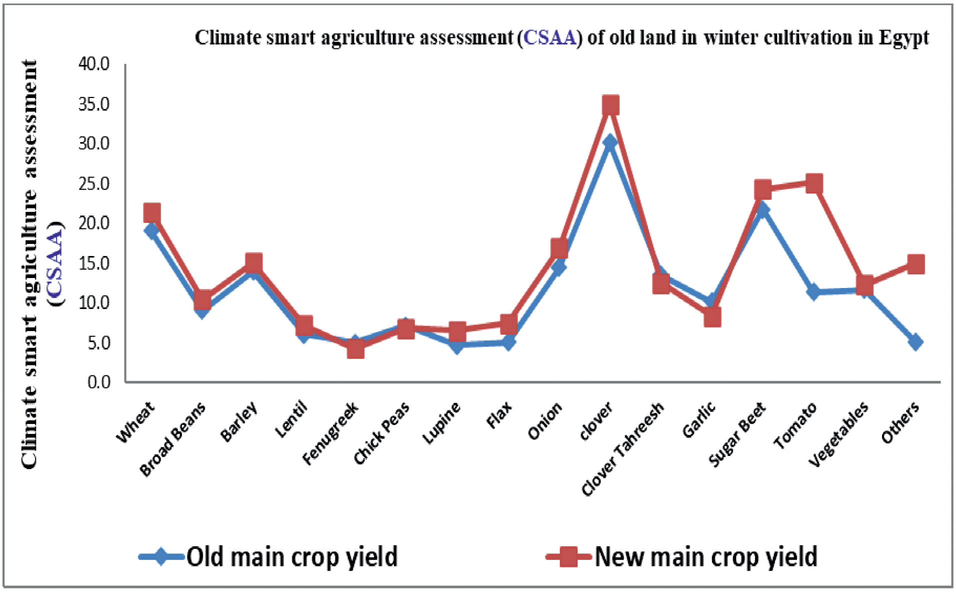


Figure 3 Changes climate smart agriculture assessment from {(2010/2011-2012/2013) -(2020/2021-2022/2023)} to CSAA

Data source: (1) MALR (2024) (2) CSAA model (2024) (3) ECAPMS, (2024) (4) CSAA, (2024)

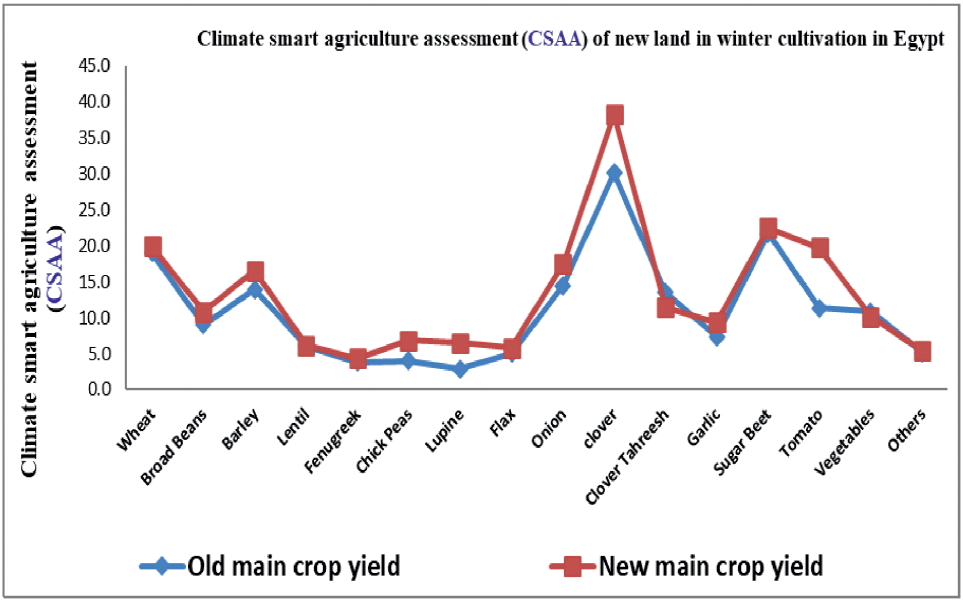


Figure 4 Changes climate smart agriculture assessment from {(2010/2011-2012/2013) -(2020/2021-2022/2023)} to CSAA

Data source: (1) MALR (2024) (2) CSAA model (2024) (3) ECAPMS, (2024) (4) CSAA, (2024)

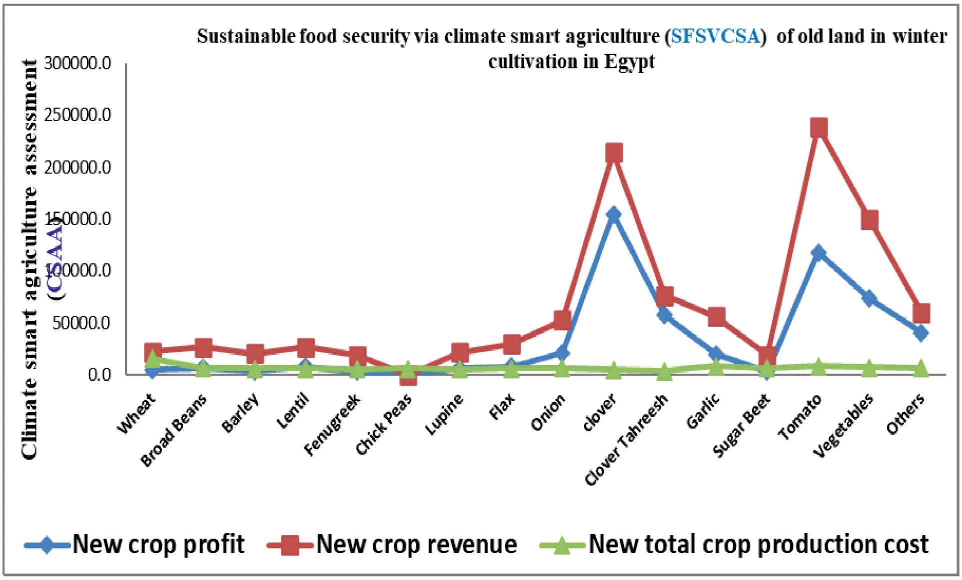


Figure 5 Changes environmental climate smart agriculture assessment (ECSAA) from {(2010/2011-2012/2013) -(2020/2021-2022/2023)} to ECSAA

Data source: (1) MALR (2024) (2) CSAA model (2024) (3) ECAPMS, (2024) (4) CSAA, (2024)

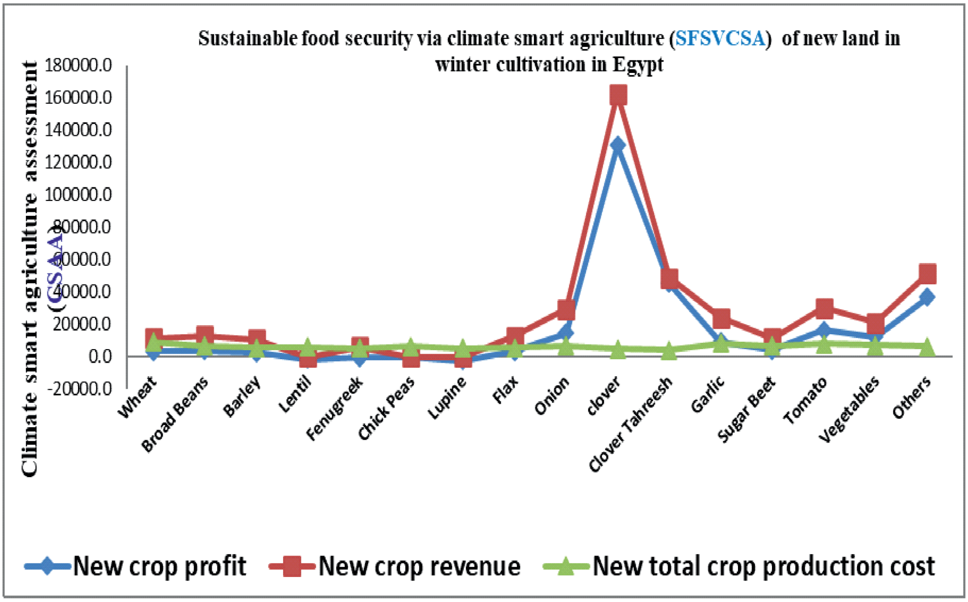


Figure 6 Changes environmental climate smart agriculture assessment (ECSAA) from {(2010/2011-2012/2013) -(2020/2021-2022/2023)} to ECSAA

Data source: (1) MALR (2024) (2) CSAA model (2024) (3) ECAPMS, (2024) (4) CSAA, (2024)

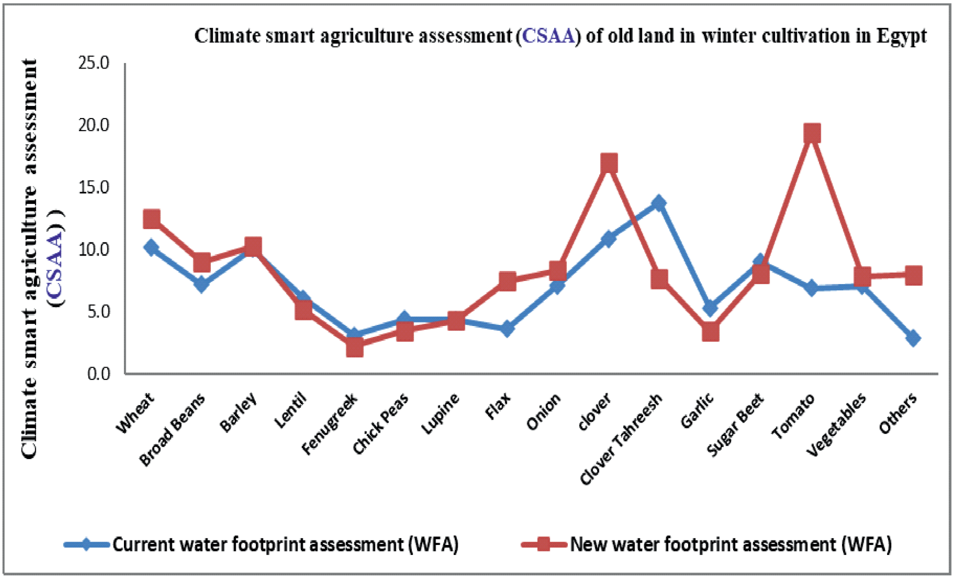


Figure 7 Changes climate smart agriculture assessments (CSAA) from {(2010/2011-2012/2013) -(2020/2021-2022/2023)} to CSAA

Data source: (1) MALR (2024) (2) CSAA model (2024) (3) ECAPMS, (2024) (4) CSAA, (2024)

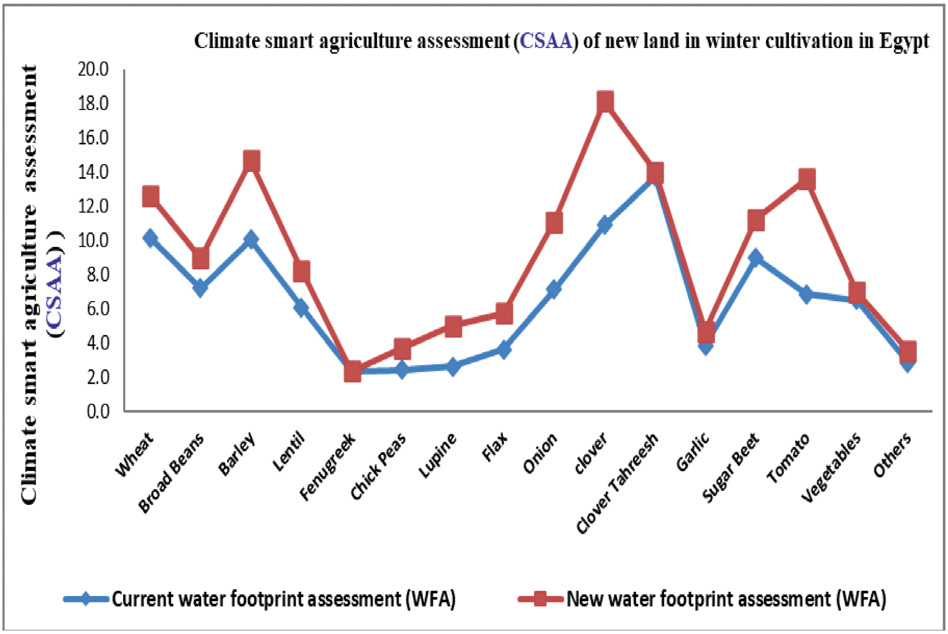


Figure 8 Changes climate smart agriculture assessments (CSAA) from {(2010/2011-2012/2013) -(2020/2021-2022/2023)} to CSAA

Data source: (1) MALR (2024) (2) CSAA model (2024) (3) ECAPMS, (2024) (4) CSAA, (2024)

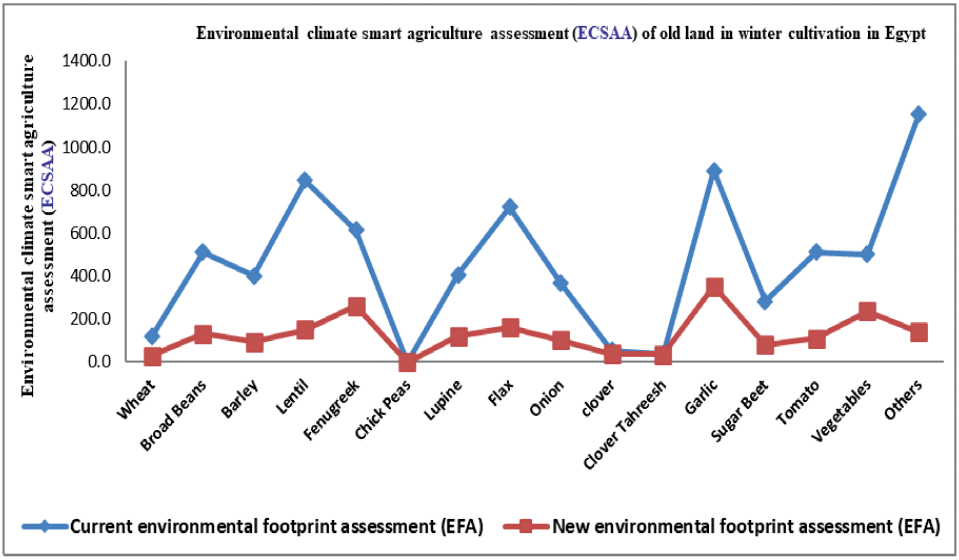


Figure 9 Changes environmental climate smart agriculture assessment (ECSAA) from {(2010/2011-2012/2013) -(2020/2021-2022/2023)} to ECSAA

Data source: (1) MALR (2024) (2) CSAA model (2024) (3) ECAPMS, (2024) (4) CSAA, (2024)

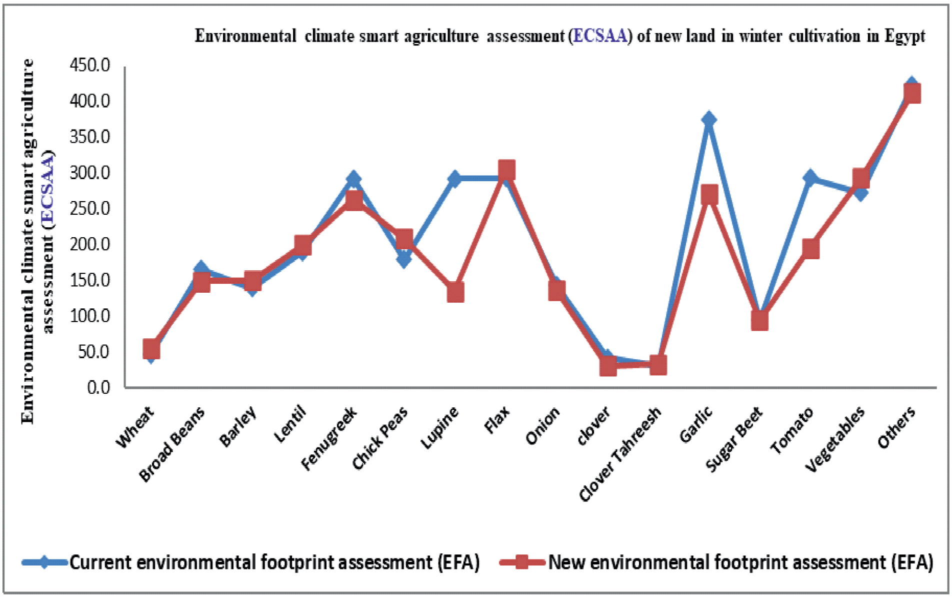


Figure 10 Changes environmental climate smart agriculture assessment (ECSAA) from {(2010/2011-2012/2013) -(2020/2021-2022/2023)} to ECSAA

Data source: (1) MALR (2024) (2) CSAA model (2024) (3) ECAPMS, (2024) (4) CSAA, (2024)