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Efficient Methodology to Asses Impacts of Climate Change on Agricultural Productivity and Identifying Adaptive Strategies on a Global Perspective

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Abstract

This work inspects late exploration on various components that might influence rural efficiency on a worldwide scale because of environmental change. To feature huge areas of vulnerability, it projects changes in relevant hydrological, meteorological, and physiological amounts in plants utilizing a troupe of environment models. There haven't been numerous far-reaching assessments led on a worldwide scale, and the ones that have been done will more often than not miss specific significant subtleties like variances in irritation and sickness populaces and outrageous weather events, as well as the vulnerability inborn in environment conjectures. The most ideal way to evaluate the impacts of environmental change on dry spell from a rural standpoint is indistinct since various measures show essentially differed future gamble. Confounding issues is the way that a few kinds of local horticulture depend on icy masses, snowmelt, and far off downpours. The backhanded impacts of diseases, tempests, and ocean level ascent have not been estimated. Most fundamentally, it is muddled how much the immediate effects of rising CO2 on plant physiology will join with environmental change to adjust creation. Presently, it is difficult to precisely appraise the general impacts of environmental change on agrarian result worldwide.

Keywords: *Global Perspective, Agricultural Productivity, Adaptive Strategies, Climate Change.*

1. Introduction

In the next decades, Earth's climate is likely to be profoundly affected by the rising levels of greenhouse gases. Outrageous climate occasions will turn out to be more normal, ocean levels will rise, sea flows will converse, and precipitation examples will change, as indicated by the Intergovernmental Panel on Climate Change (IPCC), which projects that typical worldwide surface temperatures will climb by 2.8ºC this long time. These shifts may affect people's social and economic lives, which could have devastating effects on people's health.

Figure 1: Agriculture

Since climate and climate assume such a huge part in deciding rural efficiency, the farming area is especially in danger from the anticipated climate change. Predictions indicate that low-latitude and developing nations will be hit the hardest by the agricultural impacts of climate change.

1.1. Climate Change and Agriculture

Global agriculture is facing serious problems from climate change, which will affect agricultural yields, water availability, and food security in general. Traditional development conditions are disturbed by climbing temperatures, changed precipitation designs, and an expansion in the recurrence of outrageous climate occasions, which brings down horticultural production.

Figure 2: Climate Change on Agriculture

Shifts in climatic zones affect the suitability of certain crops in specific regions, necessitating adaptive measures such as crop diversification and the development of heat and drought-resistant varieties. changing pest and disease dynamics further threaten agricultural systems. Sustainable farming practices, precision agriculture, and the incorporation of resilient crop varieties are essential strategies to mitigate climate-related risks and ensure long-term food production.

1.2. Farm-Level Strategies on Climate Change and Agricultural Productivity

Farm-level strategies, including precision farming, efficient water management, drought-tolerant crop varieties, crop diversification, integrated pest management, conservation agriculture, weather forecasting technologies, and training programs, are crucial in addressing climate change's impacts on agricultural productivity and ensuring sustainable practices that can withstand climate change challenges. Here are some Farm-Level Strategies:

- ➢ Crop diversification and breeding
- ➢ Water management
- ➢ Sustainable land management
- ➢ Early warning systems and information access

1.3. Objectives of the Research

- To assess how climate change may affect worldwide agricultural productivity, including temperature, precipitation, extreme weather, and growing season shifts.
- To assess the climate change sensitivity of significant crops worldwide, taking regional climates and crop species' adaptability capacity into account.
- To study how climate change may affect soil structure, nutrient availability, and soil-borne illnesses worldwide to determine indirect effects on agricultural productivity.

2. Literature review

O'Brien, et al. (2004) Present the possibility of various openness by focusing on the associations between environmental change and globalization as well as the impacts they have on weakness. With an accentuation on rural weakness in India, the creators pinpointed the areas that were more powerless against market gambles welcomed on by globalization than to the risks related with environmental change.

Chaudhuri (2003) sees weakness as an ex-bet mark of the likelihood that the family would become devastated from here on out, though neediness is viewed as an ex-post proportion of family prosperity. As per the creator, neediness is a stochastic event, and to make successful strategies to lessen destitution considering future dangers and vulnerabilities, it is basic to grasp weakness as the probability that one might encounter neediness.

Carter, Little, Mogues, & Negatu (2007) proposed the idea of the "neediness trap," which is characterized as the insignificant resource level beneath which families can't progress financially or finance the instruction of their youngsters. Families over the limit can completely recuperate from a climatic shock or serious event, however those beneath the edge will experience long haul adverse consequences.

Mutsvangwa-Sammie (2013) attempted to utilize the "normal neediness approach" to copy a similar thought. Rather than involving assets as a sign, they assessed weakness involving a structure for food security and oat creation. Destitution and food security are connected peculiarities. Destitution is a consequence of an absence of food security, therefore measures to end neediness likewise further develop food security. Weakness is a state and a variable of neediness for the devastated.

Hallegatte, et al. (2016) Showing how diminishing neediness and battling environmental change remain inseparable. The ruined are excessively impacted by environmental change, as per the creators, due to their expanded openness as well as on the grounds that they come up short on resources and defensive elements expected to moderate the impacts of the shift and adjust to it. Assuming the impacts of environmental change on the ruined are not thought about and coordinated into the structure of neediness strategy, destitution decrease won't be imaginable.

3. Research Methodology

The Indian agrarian area is altogether affected by outrageous weather occasions and environmental change. The drive will make benchmark information for key stream bowls' water, supplement, and horticultural creation. We will examine what the worldwide environment drivers mean for the environment at the stream bowl scale. Different adaption strategies will be created to build the water and supplement utilization effectiveness in view of the model discoveries.

3.1. Model Selection and Development

A powerful Computable General Equilibrium (CGE) model of the world economy was utilized in the review. The World Bank-created LINKAGE model filled in as the foundation for the model, which has its scholarly roots in deeply grounded multi-country applied general equilibrium models that have been utilized for a considerable length of time to look at worldwide exchange and environmental issues.

3.2. Production Structure Modeling

Under the assumption of constant re-visitations of scale, production in each economic area was displayed utilizing layered Constant Elasticity of Substitution (CES) functions. Different production structures were laid out for some exercises, including the animals and yield areas, to mirror the potential for substitution somewhere in the range of extraordinary and broad cultivating.

3.3. Factor Markets and Clearing Mechanism

It was expected that all factor and commodity markets would settle through prices. Agricultural land, capital, skilled and unskilled labour, and natural resources were the main factors of production.

3.4. Recursive Dynamic Model

The dynamic, recursive model was solved once a year through 2070, starting with 2004 as the base year. Exogenous factors such as labour and population expansion, technological advancements, and capital accumulation from savings were the main drivers of dynamic changes.

4. Simulations And Results

The baseline scenario for climate change impacts on economic activities from 2010-2070 assumed no impacts. It predicted a strong global economic growth per year from 2012-2050, declining from 2050-2070. Southeast Asia experienced 1.1 percentage points greater annual growth than the worldwide average.

4.1. Global Impacts

The study predicts a 1.5 % decline in global real GDP by 2070 due to climate change impacts on agricultural productivity. India, Sub-Sahara Africa, South Asia, and Central Asia are expected to suffer the largest GDP loss, with Southeast Asia experiencing a 1.5% drop. Agricultural adjustments around the world brought on by climate change have led to a real increase in New Zealand's gross domestic product.

Table 1: Effect on World Output and Welfare, 2070 (% change)

	GDP	Welfare (EV) as % of GDP	Terms of trade	crop	Sectoral Agriculture	output			Livestock	Processed food
					Paddy Rice	Wheat	Other Grains	Other crops		
World	-1.5	-1.4		-8.5	-6.3	-7.3	-6.5	-6.4	-6.5	-5.4
Australia	-1.4	-1.5	3.6	-65.4	-21.7	-55.8	-52.1	-32.1	5.4	-13
New Zealand	1.3	0.3	-1.3	164.2	21.4	42.5	15	215.6	-22	-6.5
Japan	1	-1.3	-1.3	2.5	-6.5	5.4	65.3	6.5	-1.4	3.3

PRC	-0.2	-2.2	-1.6	-1.2	-1.6	3.1	-1.3	-1.3	-2.3	-2.5
Korea	-1.3	-1.3	-1.5	-6.2	-6.1	1.2	-12.5	-6.4	-1.5	-1.3
Southeast Asia*	-1.5	-2.8	-2.6	-24.6	-26.1	-21.6	-24.5	-21.6	-1.5	-5.6
India	-5.1	-6.4	-5.2	-36	-22.3	-31.5	-62.4	-35.6	-41.5	-32.6
Rest of South Asia	0.4	-3.5	2.1	-21.6	-32	-16	-65.4	-25.1	-3.3	-65.4
Central Asia	-2.5	-1.6	-1.3	56.2	24-4	33.5	4.2	65.2	11.2	-1.4
Rest of Asia	-1.5	-1.8	1.9	-21.3	-23.4	-25.3	-34.5	-13.5	2	-6.2
Canada	-1.3	1.3	1.5	33.2	1.6	28.6	6.5	24.6	-26.3	-0.4
US	-1.0	1	1.6	4.3	12.3	21.3	1.4	6.9	-4	-1.6
EU	-1.6	1	-1.9	12.3	21.5	65	24	12.4	23.4	4.6
Latin America	-0.9	-3.4	-0.4	-32.5	-21.3	-32.6	-32.6	-24.6	-3.4	-6.4
Sub-Sahara Africa	-1.1	-2.3	-1.6	-34.5	-14.5	-54.3	-11.1	-26.4	-1.7	-3.6
Rest of the world	-0	-2.4	-1.6	-01.4	-4	-04.3	-32.6	-6.6	-5.6	-6.4

Global welfare losses are affected by international price adjustment, while aggregate welfare impacts often track changes in real GDP, according to the study. Gains for nations with a net agricultural export will offset losses for countries with a net agricultural import as a result of higher international pricing for crop products compared to manufactured exports from high-income nations.

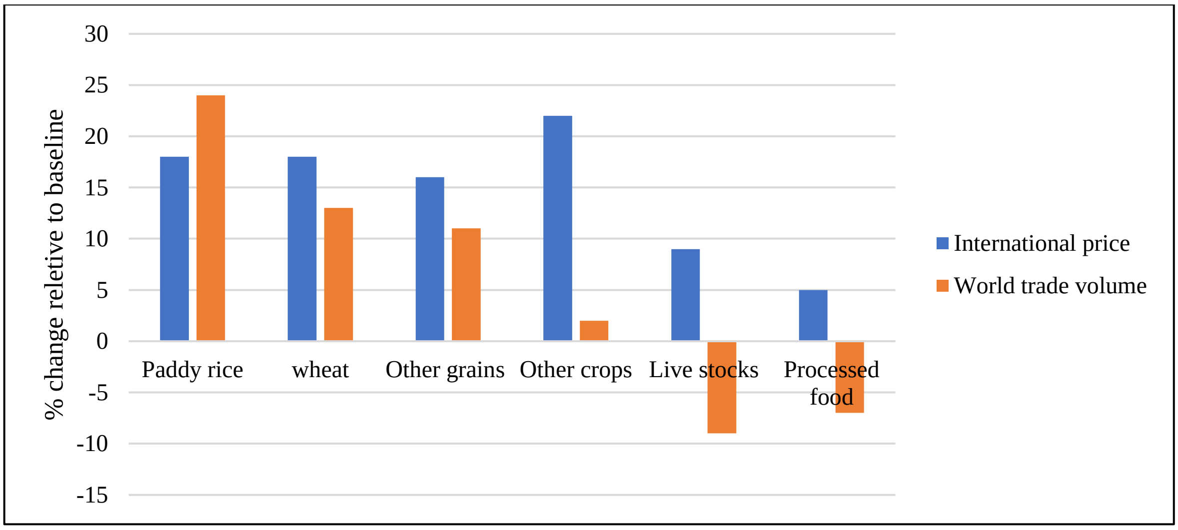

Figure 3: Graph Showing the Effects of Climate Change on Global Trade and International Prices for Agricultural Products, 2070

According to the results of the global agricultural output simulation, crop production would decrease by 2070, which is less than half of what Cline predicted. Non-industrial countries, which would experience the ill effects of the impacts of climate change than industrialized ones, are losing ground, which contributes to this pattern. Reduced agricultural productivity is mitigated to some extent by cross-sectoral reallocation of resources. Crop productivity would increase in areas where the effects were minor or beneficial.

4.2. Impacts on Southeast Asian Countries

While six Southeast Asian countries are expected to see substantial macroeconomic repercussions from the anticipated decline in agriculture productivity, Singapore is expected to feel more moderate real GDP implications. Lesions to welfare will outweigh cuts to GDP.

Table 2: Climate Change's Macroeconomic Effects on Southeast Asian Countries, 2070 (% change)

	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
Real GDP	-1.5	-1.8	-0.8	-1.4	-1.3	-0.8
Welfare (EV) as % of GDP	0.8	-0.4	-2.8	-1.9	-3.4	2.3
Terms of Trade	-1.4	-1.9	-1.8	-1.3	-1.4	1.0
Consumption	-0.8	-0.9	-1.6	-1.7	-5	-0.8
Investment	-1.8	-1.1	-1.5	-1.6	-1.4	-1.7
Exports	-1.8	-3.4	-1.9	1	-1.6	-4.2
Imports	-5.6	-2.3	-2.4	-2.1	-1.4	-0.4
Factor prices						
Capital	-1	1.4	1.6	-1.6	-1.8	-1.4

Unskilled labor	-1.4	-1.4	-3	-2	-3	-2.4
Skilled labor	-1.9	-0.7	-1.6	-2.4	-2.2	-3.2
Land	6.9	2.4	1.8	-4.5	-2.3	2.4

This research looks at how welfare losses in Southeast Asia are affected by agricultural productivity shocks caused by climate change. With a little help from worldwide production contractions, it discovered that local productivity decline is the main culprit behind these losses in Indonesia, the Philippines, Thailand, and Vietnam.

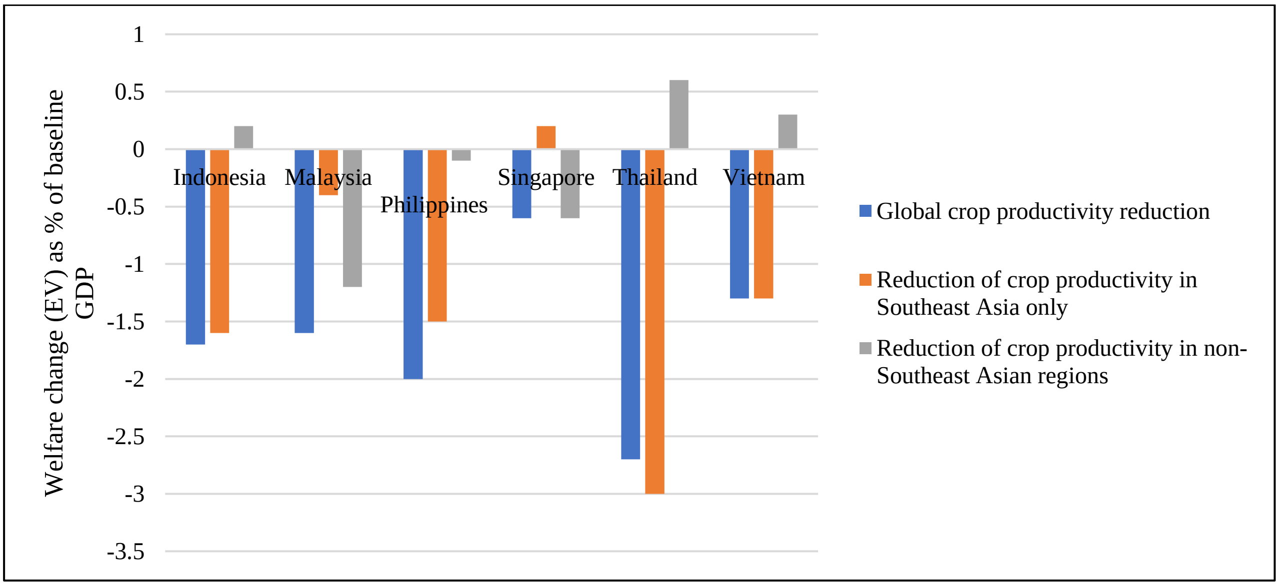

Figure 4: Welfare Effects Decomposition Visual Presentation, 2070

Table 3: Breakdown of Welfare Effects, 2070

	Global crop productivity reduction	Reduction of crop productivity in Southeast Asia only	Reduction of crop productivity in non-Southeast Asian regions
Indonesia	-1.7	-1.6	0.2
Malaysia	-1.6	-0.4	-1.2
Philippines	-2	-1.5	-0.1
Singapore	-0.6	0.2	-0.6
Thailand	-2.7	-3	0.6
Vietnam	-1.3	-1.3	0.3

Gains and losses in production factors follow different patterns in different countries. The average return to agricultural components typically increases after negative shocks to agricultural productivity because the demand for agricultural products is inelastic. But since they employ so many intermediate agricultural inputs, Singapore and Thailand's return to land rates are falling.

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Table 4: Effects on Southeast Asian Trade and Agricultural Production, 2070 (% change)

	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
Output						
Crop agriculture	-24.5	-24.5	-33.6	-58.7	-38.5	-22.2
Rice	-26	2.7	-22.8	-47.5	-24.7	
Other grain	-8.8	-63.7	-24	-37.6	-1.0	
Other crops	-24.5	-42.2	-36.7	-58.7	-38.5	-8.3
Livestock	-5.5	-3.7	-1.4	204.2	23.7	-6
Processed food	-7.5	6.6	-5.3	23.8	-1.8	-25.3
Exports						
Crop agriculture	-36.4	-58.1	-67.8	-58.3	-68.5	29.4
Rice	-28.2	-62.3	-84.3	-52.6	57.9	
Other grain	-48.8	-85.7	-59.9	-69.3	-22.3	
Other crops	-36.2	-58.2	-67.8	-58.3	-71.4	8.9
Livestock	2.8	32.8	68.6	228.7	93.2	31.7
Processed food	-8.4	5.9	-8.5	24.9	-2	-32.7
Imports						
Crop agriculture	9.8	5.8	35.4	-1.5	22.8	-8.4
Rice	26	61.7	45.2	2.6	24.8	43.9
Wheat	-3.8	26.7	28.8	4.4	6	-26.4
Other grain	41.9	4.4	53.9	8.5	78	-38.7
Other crops	24.7	4.3	45.2	-1.7	23.2	-7.9
Livestock	-8.8	-27.5	-36.3	-5.3	-35.4	-23.3
Processed food	-24.7	-25	-23.5	-2.8	-27.2	-27.8

Exports of crops from Southeast Asia will decline as a whole due to rising producer prices, with the exception of rice, which will see an increase in exports from Vietnam. By 2070, Southeast Asia's agriculture sector will be even more reliant on imports due to rising import dependency.

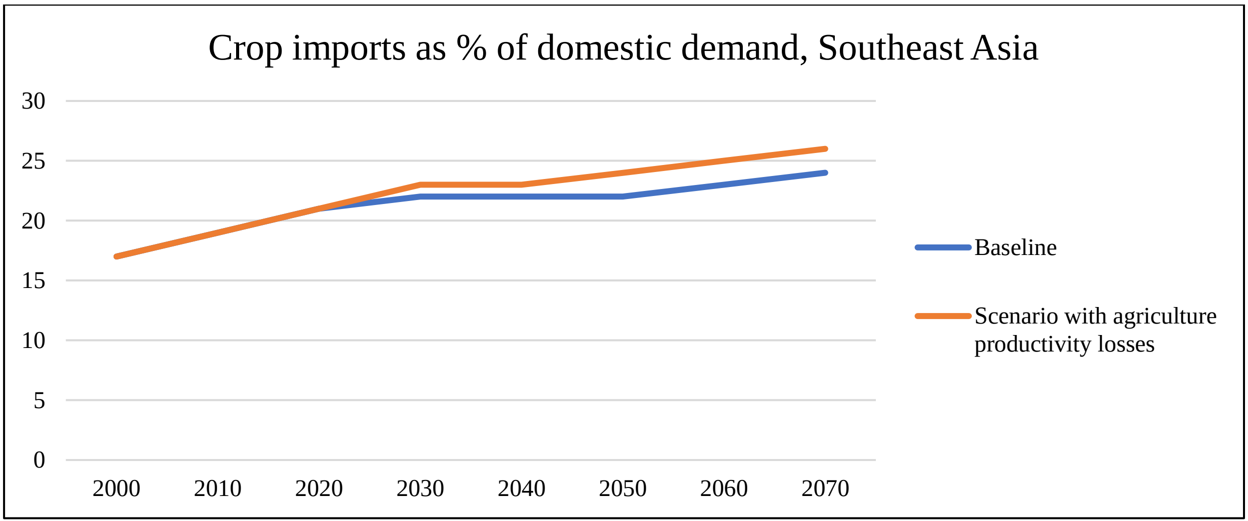

Figure 5: The Agricultural Sector's Reliance on Imports

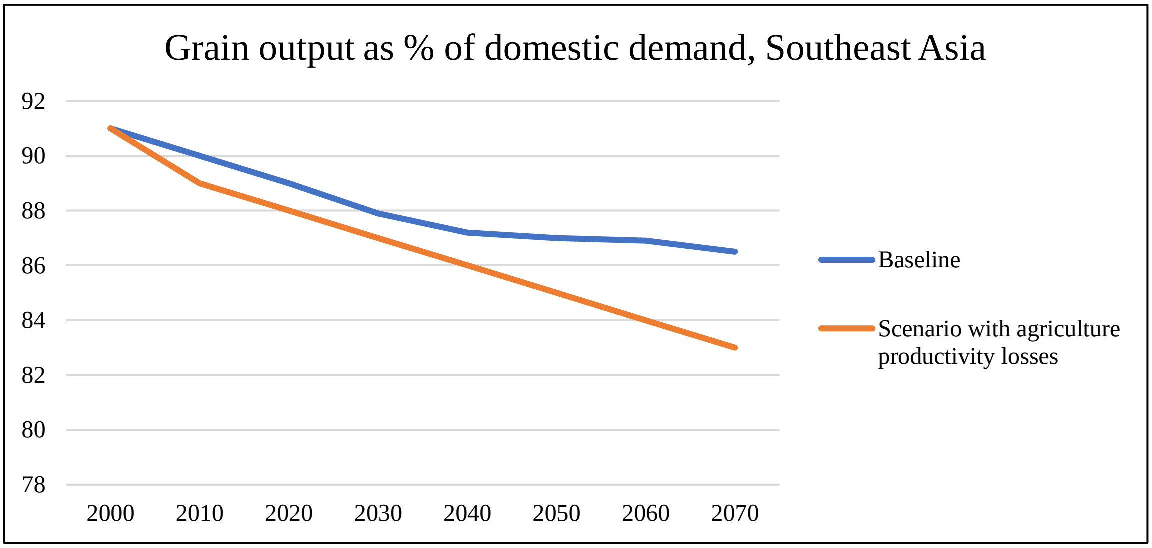

Figure 6: Ability to Meet One's Own Grain Needs

Table 5: Grain Self-sufficiency Ratio

	2000	2010	2020	2030	2040	2050	2060	2070
Baseline	91	90	89	87.9	87.2	87	86.9	86.5
Scenario with agriculture productivity losses	91	89	88	87	86	85	84	83

4.3. Sensitivity to the Baseline Agricultural Productivity Growth Assumption

Agrarian efficiency was expected to create at similar rate as assembling and services in the pattern situation. While specialized headway has stopped, worldwide grain yields have dropped from 2.7% during the '60s and '70s to 1.6% in the last quarter of a long period. In particular, complete variable efficiency development rates in Southeast Asia tumbled from 0.99% during the 1970s to - 0.67% during the 1980s and - 0.48% during the 1990s. With so little money going into R&D, we can expect this pattern of negative productivity growth to persist for at least another 20 years.

Table 6: Alternative baseline agricultural productivity growth assumptions, 2070: climate change consequences (% change).

	Real GDP	Welfare (EV as % of GDP)
Southeast Asia	-2.4	-3
Indonesia	2.6	-3.5
Malaysia	-2	-2.9
Philippines	-2.8	-3.5
Singapore	-1.4	-1.8
Thailand	-3	-3.9
Viet Nam	-1.8	-2.5

Because of more slow efficiency development, Southeast Asia's agrarian portion of Gross domestic product in 2070 was marked down, leaving it more vulnerable to expansions in worldwide ware prices. The necessity for technology advancements in agriculture to address possible climate change concerns is supported by the fact that long-term reliance on imports increases trade losses and welfare.

5. Conclusions

As a major international problem, climate change is already having a harmful effect on some parts of the world. The agricultural sector may suffer moderate, though unequally distributed, economic losses according to a worldwide CGE model. The burden of the losses would fall disproportionately on developing nations. Reduced agricultural productivity due to climate change is anticipated to cause modest output losses in Southeast Asia, a region that is both a major producer and consumer of agricultural goods. Economic welfare in Southeast Asia may suffer more as a result of the region's growing reliance on imported agricultural goods. The future of agricultural technology is clouded by doubt, as the Green Revolution's production boosts appear to be running dry. Climate change might have serious consequences, especially in Southeast Asia, if rising incomes and populations outpace technical advancements. In order for Southeast Asia to effectively deal with climate change, it is essential to reverse the region's diminishing production.

References

[1] Carter, M. R., Little, P. D., Mogues, T., & Negatu, W. (2007). Poverty traps and natural disasters in Ethiopia and Honduras. World development, 35(5), 835-856.

[2] Chaudhuri, S. (2003). Assessing vulnerability to poverty: concepts, empirical methods and illustrative examples. Department of Economics, Columbia University, New York, 56.

[3] FAO. (2020). The state of food and agriculture 2020. Overcoming food insecurity during COVID-19.

[4] Hallegatte, S., Vogt-Schilb, A., (2016). Unbreakable: building the resilience of the poor in the face of natural disasters. World Bank Publications.

[5] Hijmans, R.J., et al. (2020). Global gridded crop area maps based on observations, remote sensing, and geospatial information system techniques. Agricultural Systems, 179, 102852.

[6] Jones, J.W., et al. (2019). Global food security and climate change. Nature Research, 4(9), 1030.

[7] Nelson, G.C., et al. (2019). Adaptation and resilience: Responding to hazardous events, weather and climate extremes, and sea-level rise. In: H.-O. Pörtner et al. (Eds.), IPCC Special Report on the Ocean and Cryosphere in a Changing Climate.

[8] Nyamwanza, O., Manzungu, E., Mutsvangwa-Sammie,. (2013). Institutional proliferation in natural resource management and agricultural innovation in South-West Zimbabwe. Journal of Humanities, 38, 1-21.

[9] o'Brien, K., Leichenko, R., Kelkar, U., Venema, H.,. (2004). Mapping vulnerability to multiple stressors: climate change and globalization in India. Global environmental change, 14(4), 303-313.

[10] Ripplinger, D., et al. (2020). Climate change impacts on global crop yields: A review of recent studies. Global Change Biology, 26(1), 1-21.

[11] Serdeczny, O., et al. (2019). Climate change impacts on wheat and barley yields in sub-Saharan Africa: An RCP/ESM ensemble multi-model analysis. Environmental Research Letters, 14(9), 094008.

[12] van der Velden, Y., et al. (2019). Bridging the climate-agriculture gap: A typology of climate-smart agricultural interventions. Environmental Science & Policy, 99, 196-202.

[13] Vermeulen, W., et al. (2019). Climate change, food security, and the poor: A comprehensive review. Global Food Security, 19, 1-12.

[14] Wollenberg, E., et al. (2018). The role of forest and landscape restoration in achieving the SDGs. Landscape Ecology, 33(6), 1537-1555.

[15] Zougna, T., et al. (2019). A global assessment of vulnerability of agricultural systems to climate change. Global Change Biology, 25(10), 3205-3222.

[16] Performance Rubrics for Robustness Evaluation of Web Mutation Operators

[17] Suguna Mallika, S., Rajya Lakshmi, D., Esther Rani, T.

---

[18] International Journal on Recent and Innovation Trends in Computing and Communication, 2023, 11(9s), pp. 665–674

[19] Mehraj, H., Jayadevappa, D., Haleem, S. L. A., Parveen, R., Madduri, A., Ayyagari, M. R., & Dhabliya, D. (2021). Protection motivation theory using multi-factor authentication for providing security over social networking sites. Pattern Recognition Letters, 152, 218-224.

[20] Soni, M., Khan, I. R., Babu, K. S., Nasrullah, S., Madduri, A., & Rahin, S. A. (2022). Light weighted healthcare CNN model to detect prostate cancer on multiparametric MRI. Computational Intelligence and Neuroscience, 2022.

[21] Sreenivasu, S. V. N., Gomathi, S., Kumar, M. J., Prathap, L., Madduri, A., Almutairi, K., ... & Jayadhas, S. A. (2022). Dense convolutional neural network for detection of cancer from CT images. BioMed Research International, 2022.

[22] Sharma, D. K., Chakravarthi, D. S., Boddu, R. S. K., Madduri, A., Ayyagari, M. R., & Khaja Mohiddin, M. (2022, June). Effectiveness of machine learning technology in detecting patterns of certain diseases within patient electronic healthcare records. In Proceedings of Second International Conference in Mechanical and Energy Technology: ICMET 2021, India (pp. 73-81). Singapore: Springer Nature Singapore.

[23] Mannepalli, K., Vinoth, K., Mohapatra, S. K., Rahul, R., Gangodkar, D. P., Madduri, A., ... & Mohanavel, V. (2022). Allocation of optimal energy from storage systems using solar energy. Energy Reports, 8, 836-846.

[24] Rubavathy, S. J., Kannan, N., Dhanya, D., Shinde, S. K., Soni, N. B., Madduri, A., ... & Sathyamurthy, R. (2022). Machine Learning Strategy for Solar Energy optimisation in Distributed systems. Energy Reports, 8, 872-881.

[25] Bansal, P., Ansari, M. J., Ayyagari, M. R., Kalidoss, R., Madduri, A., & Kanaoujiya, R. (2023, April). Carbon quantum dots based nanozyme as bio-sensor for enhanced detection of glutathione (U) from cancer cells. In AIP Conference Proceedings (Vol. 2603, No. 1). AIP Publishing.

[26] Kadam, P. S., Rajagopal, N. K., Yadav, A. K., Madduri, A., Ansari, M. J., & Patil, P. Y. (2023, April). Biomedical waste management during pandemics. In AIP Conference Proceedings (Vol. 2603, No. 1). AIP Publishing.

[27] Torres-Cruz, F., Nerkar Charushila, K., Chobe Santosh, S., Subasree, N., Madduri, A., & Pant, B. (2023, April). A review on future prospects on magnetic levitation for disease diagnosis. In AIP Conference Proceedings (Vol. 2603, No. 1). AIP Publishing.

[28] Sugumar, D., Dixit, C. K., Saavedra-Lopez, M. A., Hernandez, R. M., Madduri, A., & Pant, B. (2023, April). White matter microstructural integrity in recovering alcoholic population. In AIP Conference Proceedings (Vol. 2603, No. 1). AIP publishing.

[29] Krishna, B., & Janarthanan, M. (2023). Realization of fractional order lowpass filter using different approximation techniques. Bulletin of Electrical Engineering and Informatics, 12(6), 3552–3561. doi:https://doi.org/10.11591/eei.v12i6.5750

[30] Krishna, B., & Gowtham, M. (2023). Design and Applications of Digital Differentiators Using Model Order Reduction Techniques. Tuijin Jishu/Journal of Propulsion Technology, 44(4), 2949-2956

[31] Krishna, B. T. (2023). Various Methods of Realization for Fractional-Order Elements. ECTI Transactions on Electrical Engineering, Electronics, and Communications, 21(1), 248544. https://doi.org/10.37936/ecti-eec.2023211.248544

[32] Krishna, B., & Janarthanan, M. (2023). Design of a Fractional Order Low-pass Filter Using a Differential Voltage Current Conveyor. Journal of Telecommunications and Information Technology, 2023, 17-21

[33] Krishna, B. (2021). Realization of Fractance Device using Continued Fraction Expansion Method. ADBU Journal of Electrical and Electronics Engineering (AJEEE), 4(2), 1-9.

[34] Battula, Krishna. (2019). QRS Detection Using Fractional Order Digital Differentiators. American Journal of Biomedical Engineering. 9(1), 1-4.