International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Global Food Security: Challenges, Opportunities and Technological Solutions

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Abstract

Food security is a crucial component of national security, helpful to improve the well being of citizens, national culture and overall sustainability of society. Each country face different challenges on food security. India has transition effect on food security, other developing countries have completely different and comprehensive strategy of sustainable agriculture productivity and demonstrate major impact on reducing rural poverty. Countries are mainly focus on sustainable strategy for food security. This paper analyse how countries prioritise food quality and safety to improve overall health & nutrition, address systemic malnutrition issues. Initiative on climate resilient agriculture to increase resilience to pests and diseases while improving resilience to climate disasters. Subsequently, focus on emphasizing and recognising conflict and inequalities as core issues while reforming contemporary food system. The paper study issues, challenges of food security and find technological solutions to resolve the crisis of Global food security. Also, delve into transition combination of technological strategies, climate change, farmer Support Strategies, financial aid for agricultural development, Policy intervention for food security, Improving soil health & fertility & Enhancing crop Resilience to assessing the global food security.

Keywords: Food Security, Climate change, Sustainable agriculture, energy security and Reuse of resources

Introduction

Food security refers to availability of food & everyone can access it, According to World Bank, food security as having physical & economic access to safe and nutritious food that meets people's dietary needs & preferences. Developing countries have strategies to manage the challenges of food security. India integrate the pro nature, pro poor and pro women dimensions of sustainable agriculture and rural development. India showed the transition from Green Revolution to Evergreen Revolution. China & Brazil share completely different & comprehensive strategy of sustainable agricultural productivity and reducing rural poverty and food insecurity.

All these strategies concentrate on developing sustainable and secure method for food security in developing nation. Geographical factors significantly influence food security across various regions, impacting agricultural productivity, land use and socio economic dynamics.[1] Significantly need to understand crucial factors for developing effective food security strategies. Territorial factors play a vital role in shaping local food systems. The geographical distribution of resources and management practices

[1] *Mykhailivk, 0., (2023). The role of territorial factors in the transformation of local food supply. Actual Problems of Economics*

directly affects food supply, particularly in developing countries; Where economic crises often stem from inadequate food availability.

In Indonesia, Spatial analysis revealed that urban development reduces agricultural land, diminishing food carrying capacity in regions.[2] In Nigeria, Geospatial variability significantly affects food security. Factors such as gender, education , regional feature that compliance with food security. Bangladesh require comprehensive interventions including strategies for poverty reduction and education for all might be effective to reduce food security at rural households in Bangladesh. Bangladesh implement household food insecurity to evaluate the food insecurity status from the collected data by using questionnaire method. Multiple logistic regression model is associated with food insecurity.[3]Western australia region is quite isolated for cultivation of most food also quality of fresh produce was lower.

Improving affordability and quality of nutritious food in remote communities may positively impact food choices, improve food security and prevent chronic sensitive diet. Policymakers should consider influencing agriculture, trade, commerce, transport, freight and modifying local food economies. The level of food security based on food balance indicators – Division is based on geographical factors such as food supply, Consumer basket norms and qualitative indicators. Study identifies four main approaches to classifying regions. Factors that influence food security are a) Imbalanced food production b) Hunger c) Less demand in agricultural productivity d) Food gap supply in areas across Africa & Asia e) Less food demand for food production f) Climate change.

Require strategic research, Investment in affordable & suitable farm technologies, Agriculture for development, Ecosystem Services from agriculture, Gender mainstreaming, Include energy security, Resources reuse & recovery, Social protection program and Climate change are the features need to revive the agriculture sector for sustainable food security. Climate factors on food grains crops has a significant and negative impact on food security. Food grains crops integrate food security in different regions of India.[4]Agricultural productivity of food grain and commercial crops to assess the climatic change impact on agricultural productivity.

Developing countries face serious challenges in food security field. Food security is not a function of food grains crops only and some other socio – economic and government policy factors also may affect the food security. FSI is an integrated index that includes a wide range of factors significantly associated with food security. Food security concerns have multiple dimensions ever evolving with time, space and the complexity of human needs. Integrate approach that reduce hunger and ensure no longer a barrier to economic and social development. This is a global issue affecting billions of people worldwide. Poverty, conflict, natural disasters, Climate change and gender inequality are major drivers of hunger. Address underlying causes of hunger through policies that promote economic growth, sustainable growth, access to education and healthcare, social protection programs and conflict resolution can create a world where all access to education and healthcare, social protection programs and conflict resolution and nutritious food. Strategic approach can change the socio economic development.[5]

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[2] *Rahman, K., Rohsulina, Pranichayudha., & Agung, H., (2024). Assessing regional food security: A Spatial analysis of food carrying capacity in Baki District, Sukoharjo Regency. Indonesia*

[3] *Pollard., M. (2014). Geographic factors as determinants of food security: A western Australian food pricing and quality study. Asia Pacific Journal of Clinical Nutrition, Vol. 23 Issue 4 pp703*

[4] *Singh. K A., & Sharma. Pritee., (2018). Climatic variables on food security in developing economies: a conceptual review. MoJ food Processing & Technology. Vol. 6 Issue 1 no*

[5] *Upasana. S., (2023). The impacts of poverty on hunger: An examination of the relationship between socio economic status and food insecurity. International Journal of agricultural science and food technology. Vol. 9 Issue 2 pp 041 - 043*

Multiple leveled socio economic intervention with the purpose of Improving food security in rural, high poverty communities and evidence based practices and tools. Rural communities face unique problems to food accessibility as compare to urban areas, urban areas are more accessible food security is a public health issue in rural & high poverty communities. Food security & poverty are interlinked with each other as cause & effect for agrarian economy of India. Climate condition affects food grains and non food grain productivity, socio economic and government policy variables affect food security.[6] Social exclusion explain how unequal access to rights can disturb the cycle for economy. Paucity of resources and capabilities reflect the impact on political, economic, social and cultural vulnerability leads to health disparities.[7]

Climate change significantly impact food security in all countries depends on agriculture production. Climate change has four major kind of stances such as food availability, food accessibility, food utilisation and food system stability. By 2080, Climate change affect agricultural production and food security due to increasing global population size; Also, impact on human health, livelihood assets and food production and distribution channels (FAO, 2008). In India, Gross domestic product (GDP) may decrease up to 6.2 % and agriculture production may decrease up to 24% by 2080 due to climate change.[8] Food security is directly related to climate change through its impact on agricultural production.[9] The link between Climate change, biodiversity and food security are evidently impact climate change & affect food security particularly in communities and locations that depend on rain fed agriculture, it require strong policies, releasing high yield stress resistant varieties, developing climate resilient irrigation structure and agriculture.[10]

Strategic research priorities are outlined for a range of sectors that underpin global food security including: agriculture, ecosystem services from agriculture, climate change, international trade , water management solutions, the water energy food security nexus, service delivery to smallholders and women farmers, better governance models and regional priority setting. Food security require agricultural intervention, reorienting the existing agricultural research institutions, policy framework, policies for tackling food security which involves issues such as agriculture for development, ecosystem services from agriculture and gender mainstreaming concentrate on food security within agriculture sector by incorporating cross cutting issues such as energy security, resources reuse and recovery, social protection programs and involving civil society in food policy making Processes by promoting food sovereignty.[11]

Many policies introduce to aim consumer demand for food including employment and incomes, food preferences and consumer knowledge, health services and food safety. Effective public policies to influence the areas of demand and access through markets and supply. There are few facets which

[6] *Kumar, Ajay & Sharma. Pritee., (2013). Impact of Climate Variation on Agricultural Productivity and food security in Rural India. Economics E - Journal*

[7] *Brady. PJ., (2021). The Relationship between Political, Economic, Social and Cultural Vulnerability and food insecurity among adults aged 50 years and older. Multidisciplinary digital publishing Institute*

[8] *Zhai. F., & J . Zhuang (2009). "Agriculture impact of Climate Change: A general equilibrium analysis with special references to Southeast Asia, ADBI working Paper. Series 131*

[9] *Ahmad. J ., Dastgir and S. Haseen (2011). Impact of Climate Change on agriculture and food security in India', International Journal of Agricultural Environment and Biotechnology 4 (2): 129 - 137*

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influence producer supply by enhancing food production through rural infrastructure development, agricultural research and development research management, farm inputs and produce pricing.[12]
Collective stakeholder engagement will prove as essential in bringing about the policy changes and investment reforms that required to achieve a solution. Food security is both a complex and challenging issue to resolve as it cannot be characterized or limited by geography not defined by a single grouping i.e., demography, education, geographic location or income. Achieving sustainable global food security will require a holistic systems based approach, built on a combination of policy and technological reform, utilise existing systems combined with state of the art technologies & techniques. Digital transformation has a promoting effect on the level of food security and there is regional heterogeneity in this promoting effect; digital transformation in regional food security improve the level of food security by promoting technological innovation, agricultural scale management and marketization levels.
Farming & agricultural activities severely affected by climatic change. Some regions severely affected by floods & droughts, Severely affected areas are livestock, forestry, fisheries and aquaculture. Food distribution has been varied in urban and rural areas. The growth of the biofuels market has reduced the land used for growing food crops. Storage capacity is another issue for food security. Inadequate and improper storage facilities for grains, often stores outside under tarps that provide little protection from humanity and pests. Lack of education and training on new techniques, technologies and agricultural products. Traditional farming methods are slightly more time consuming and delay the production of food grains etc. Better techniques must be implemented in farming, increased irrigation, providing high quality of fertilizers, invest more in conducting research on grain storage technologies, collaborate with nations that have high farm output but low food wastage due to superior grain storage facilities.

Global food Challenges

Food security could be in jeopardy due to climate change and natural resources which is responsible to threaten the sustainability of food system at large. Food security challenges to implement an ability to deal with increasing food shortages, which caused due to combination of waste and an ever expanding world population. Increase food production by 70% finite infrastructure. Evolution of food system has responded to and driven perpetual charging dietary habits; and pattern of consumption. To overcome the challenge, trade will have an important role to play in ensuring that resources are used efficiently and sustainably, Multilateral reforms are needed to ensure that the world trading system should work properly. Multifaceted and linked global strategy is needed to ensure sustainable and equitable food security. Require to reduce the impact of the food system on the environment. Global food system strategy require processing, producing and distributing food security in various countries to make the equitable food security system.

Technological strategies for food security

Certain kind of crop production methods started from the Green Revolution such as increased mechanisation, expansion of irrigation infrastructure, chemical fertilizers and synthetic organic crop production chemicals arranged the entire process for agricultural production. It is mentioned, these initiatives doubled crop productivity per hectare. Policymakers and regulators who needs to develop and

[12] *Qureshi. M Ejaz., Dixon, John & Wood. Mallisa., (2015). Public Policies for improving food and nutrition security at different scales. Springer link, Vol 7 pages 393 – 403*

provide tailor made support evidence based research.[13]Ensuring adequate food availability to an increasing world population constitutes one of the biggest challenges faced by humankind. Scientific and technological advances in food production during the last century enabled agriculture to cope with concomitant increase in food demand.[14]

Fundamental problems of food security are addressed with several mechanism such as SI of agriculture and the United Nations Sustainable Development Goal to end hunger. Need arable soil, soil remediation or reclamation which make this goal easier to achieve. Mapping of research trends and existing knowledge trajectories are important in order to hypothesize and reach conclusive solution.[15] Sufficient investment in modern agriculture are needed to alleviate the food crisis in developing countries. Require Multilateral agreement and actions for an effective solution. Technological innovations are accepted and implement at all levels. Food security has a challenge to implement technology in food production which still needs to be improved; resulting in low productivity, high food losses and reduced efficiency. Encourage innovative Strategy as sustainable increases in diet quality on total factor productivity, Growth in yielding crop and social protection programs.

Climate change

Emerging technologies such as genetic modification, methods for improving soil fertility and irrigation technologies can increase food availability.[16] Post harvest and agro processing technologies address food accessibility bio fortification technologies make food nutritious and most significantly Climate smart solutions anchored in Science, technology and innovation (STI) which includes use of precision agriculture and early warning systems which mitigate food instability. Reliable technological approaches require to deliver food security in a resource constrained environment. Unlocking pathways to reduce the food production, food waste and capturing more food produced for human consumption which directly satisfy the needs of human consumption and provide opportunity to enhance food security without impacting the environment. Nitrogen fertilizers and water resources for irrigation started using since 1961, due to lack of investment in research and infrastructure reflected the negative impact on crop yielding process which includes challenge of water scarcity.[17]

Food security is directly dependent on the food chain and associated food system process. Climate change is increasing concern across the border. Countries have developed their national strategies and adaptation plans to alleviate the negative impact of climate change. Climate change impact on crop productivity that could have repercussions on food security and the stability of the whole food systems. Adapting food systems both to increase food security and to prevent future negative impact from climate change will require attention to agricultural production. Combination of crop modelling and climate scenarios estimate the effects of extreme climate events that impact food insecurity, Under extreme climate event, 20 – 36%

[13] *McCarthy, Ultan, Uysal Ismail., Melis Ricardo Badia., Mercier, Samuel., O'Donnell, Colm & Ktenioudaki, Anastasia (2018). Global food security: Issues, Challenges and technological Solutions. Trends in food Sciences & Technology. Vol 77 pg 11 – 20*

[14] *Hubert, Bernard., Rosegrant, Mark., Boekel, Martinus & Ortiz, Rodomiro (2010). The future of food: Scenario for 2050. ASA Journal*

[15] *Godfray, H., Beddington, J., Crute, Ian., Haddad. L., Lawrence. David., Muir. J., Pretty. J., Robinson. S , Thomas. S., & Toulmin. C., (2010). Food Security: The Challenge of feeding 9 billion people. Science*

[16] *Rosulia, Amelia & Multaningsih. (2023). Climate change impact on food security: A review. Journal of environment and Sustainability. Vol 6, Issue 3, pp 227 - 238*

[17] *Rani, Pretty & Reddy R G. (2023). Climate change and it's impact on food security. International Journal of Environment and Climate Change Vol. 13, Issue: 3, pp 104 - 108*

and 11 – 33% population face hunger by 2050. This scenario estimate the effects of extreme climate events on future food insecurity.[18]

Farmer Support Strategies

Agriculture output require about 40% in 2012, manage 90% of the world's farms, produce 80% of the world's food; boosting agriculture to produce more food, contemporary focus is on the root causes of hunger & malnutrition through transformation changes to our food system. Increasing productivity and economic returns to smallholders consider as decent strategy to support farmer. According to FOA, farming in a sustainability manner is a central challenge to achieve global poverty reduction and environmental management objectives.

Food security challenge to implement an ability to deal with increasing food shortages, caused by a combination of waste and an ever expanding world population. To improve the decision making & food Productivity, climate change strategies positively impact food security. Gender, education, land size, family size, agricultural extension are some factors that influence farmers' decisions to adopt climate change strategies, these strategies help to mitigate the adverse effects of climate change in livelihoods.

Financial aid for Agricultural Development

To improving the agriculture sector's image by increasing productivity and returns on investment and providing new and different employment opportunities. Fostering private sector commitment and collaboration with different countries have showed a effective and offer a development based solutions includes knowledge, experience, good practices, innovative policies, technologies and resources that have proven cost effective and have huge potential to be up scaled for the benefit of others. Development of Industry and Service industry, various policies plays vital role in promoting agricultural development and increasing farmer's income. Improvement of people's living standards and the improvement of environmental awareness, focus of agricultural development has begun to change, focusing on adjustment of agriculture structure, ecological recycling agriculture and agricultural tourism.[19]

Policy Intervention for Food security

No Single policy for food security resolve the issues & challenges of food security. Policies are required to advance the aggregate and household food security, this system needs re – establishing economic balance and economic growth to provide the basic structure for sustainable economic growth to food security. If one policy is not helpful to make positive effect then specific programme is to implement to increase the access to food. When determining policy, it is important to analysing policy changes to identify what the policy is supposed to achieve, analyst identify precisely how the policy will be implemented and who will get maximum benefit. Policymakers are aware of the need to modify and expand the formerly applied 'economist' approaches to adjust, the social implications of economic reform programs including aspects of food security.[20]

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[18] *Worku, Alemayehu & Terefe, Kenamelkamu. (2023). Effect of Climate Change on food Security. Institute of field and vegetable crops, Novi Sad*

[19] *Yan, Sun., (2020). Research of financial Support for Agricultural Development. Science Publishing Group. Vol. 5, Issue 1, pp 21*

[20] *Masriadi, fauziah Luluk., Gusmailina, la mena & Indaryati. (2024). Addressing the Global food security crisis and energy shortages: Innovative Solutions and Policy interventions for sustainable development. The International Journal of Science in Society*

Certain policies contribute to improved food security and to identify practical and acceptable alternative to cushion the immediate impact of policy change. Analysing policies to improve food security, a distinction can be made between supply & demand. Food supply determines availability food demand is an expression of the ability to gain access to food, and both availability and accessibility have to be ensured to achieve food security.[21] Policy Intervention to promote food security characterised as emphasize on food production and supplies, primarily aimed to improve access to food. Approaches to promote food security, as per the primary objectives and points of intervention, aware of the fact that due to multiple macro – micro economic linkages; there is a close interaction between demand and supply factors. In order, to be effective and sustainable, increased food supplies need to be absorbed by increased demand.[22] Household food security occurs when there is adequate access to healthy and affordable food. Limited dietary variety or inability to eat nutritious food, skipping meals or running low on food & being unable to maintain socially prescribed food norms and behaviour. Food insecurity is a significant public health concern given the high prevalence and negative consequences for nutrition, health and well being.[23]The evolution of food policy, the major policy instruments deployed, intervention in food marketing system and the current status of food security. In developing countries characterized by large segments of the rural population dependent on food production for livelihood and by the high incidence of poverty, food insecurity and malnutrition, the strategy to improve food production that combine improved technology transfer, price support to food process and supply of inputs at reasonable prices to farmers, improvements in food marketing system, employment generation, direct food assistance programmes and improvement in the access to education and primary health care.[24]

Government Interventions during COVID – 19

During COVID 19, policy recommends effective interventions to increase food and nutrition security in LMICs, as food security interventions need to be adapted to safety and hygiene standards and be flexible and neglect earmarked funds since adaptability of interventions is essential to provide needs based aids. Sub national and target group disaggregated data can inform policy decisions assuming the functioning of food security systems. During COVID 19 potentially subsidising inputs which help to stimulate the use of fertilizers, improved seeds pesticides, fuel and machinery. Since, there is shortage of labour market closures and changes in downstream processing and retail storage & processing interventions also minimize both quality & quantity.

Investment in transportation infrastructure, power irrigation and storage networks is needed to sustain its functioning. Financial and technical support for small and medium sized enterprises (SMEs) including the development of e – commerce particularly important to sustain consumers' food and nutrition security (FAO, 2020a). Improving social safety nets and transfers through innovative delivery mechanism. Mid day meal programmes by take home rations or cash transfers and promoting and maintaining food fortification scheme is vital to ensuring access to nutritious foods and improving health of many. (Fore et al., 2020; WEP, 2020b). Geographical targeting could support the roll out of programmes in suitable areas

[21] *Timmer, Peter. C (2010). Preventing food crises using a food policy approach. The Journal of Nutrition. Vol 140, Issue 1 pg 224S – 228S*

[22] *Anderson, Per Pinstrop. (2000). Food policy research for developing countries: emerging issues and unfinished business. Vol 25, Issue 2, pg 125 - 141*

[23] *S. Taylor. Daphne & Phillips. Truman., (1990). Optimal Control of food insecurity: A Conceptual framework. American Journal of Agricultural Economics. Vol 72, Issue 5 p 1304 - 1310*

[24] *Abdulai, Awudu & Kuhlgatz, Christian (2012). Food security policy in developing countries. Pg 344 - 369*

or clusters. Decentralised targeting strategies that rely on communal knowledge can be another approach to better incorporate knowledge. Impact of COVID 19 differ significantly between food supply chains and within countries and even local communities.

Improving Soil health and Fertility

High food demands and the shortage of new agricultural land development in the future will require doubling crop yields using sustainable use of means. Make a substantial contribution to global sustainability of the agricultural lands by translating scientific knowledge on soil function into practical methodologies to evaluate the sustainability of the management. Increased productivity and economic reforms to smallholders farming in a sustainable manner is a central challenge to achieving global poverty reduction and environmental management objectives (FAO, 2012a)[25]

Intensive efforts are underway to improve crop yields with lower input requirements and enhance sustainability of yield through improved biotic and biotic stress tolerance traits. Significant efforts are focused on gaining a better understanding of the root/soil interface and associated microbiomes as well as enhancing soil properties. Highlighting the urgent requirement to transform agriculture and the food sector to achieve food and nutrition security, ecosystem sustainability, economic growth and Social equity over the coming decades.[26]

Enhancing Crop Resilience

Integrating production systems and intelligently mitigating climate change offers myriad opportunities for innovation in agro ecological production systems. The need for new ways to co – create and share knowledge about sustainable agriculture is a priority for ensuring that users access new type of information, technologies & practices. Greater participation by farmers, consumers and local organisations in researching, marketing and guaranteeing the sustainability of food and agricultural products has new pathways for dynamic learning processes.

Conclusion

Food security faces many challenges in contemporary world. Sustainable agriculture, reuse of resources, investment in modern agriculture, Multilateral agreement and actions are suitable solution for food crisis. Encourage innovative Strategy as a most sustainable increase in diet quality productivity; Growing in yielding crop and social protection programs are necessary for reviving the atmosphere of food security. Climate change is another issue that consider to solve by the use of technological approaches, Nitrogen fertilizers and water resources require for irrigation. Food security is directly dependent on the food chain and associated with food system process. Financial aid require to improve the agriculture sector by increasing productivity and return on investment. Development of Industry and Service industry plays vital role in promoting agricultural development; needs re – establishing economic balance and economic growth to provide the basic structure for sustainable economic growth to food security; micro – macro economic linkages are there as interventions. In order, to be effective and sustainable increased for food supplies that need to be absorbed by increased demand. Require food sector to achieve food and nutrition

[25] *Tahat, Monther., Alananbeh, K., Othman, Yahia., leskovar, Daniel. (2020). Soil health and Sustainable Agriculture. Sustainable Soil health management. Sustainability, 12 (12), 4859*

[26] *Naan, Jesse., Mahama, George, Yahaya, Iddrisu & Prasad, P. V. V (2017). Conservation Agriculture for small holders in Rainfed Systems: Promises and Performance*

security, economic sustainability, economic growth & social equity; to overcome the food security crisis require improved biotic & biotic stress tolerance traits. Better understanding of the root/soil interface and associated microbiomes as well as enhancing soil properties.

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