*Asian Journal of Agricultural Extension, Economics & Sociology*

***Volume 41, Issue 5, Page 165-175, 2023; Article no.AJAEES.102178***
***ISSN: 2320-7027***

# Does Organic Farming Ensure Food Security? An Analysis of Developing Countries

**Avinash [a++*] and Vikas Batra [a#]**

[a] *Department of Economics, Indira Gandhi University, Meerpur-Rewari, India.*

***Authors' contributions***

*This work was carried out in collaboration between both authors. Author Avinash performed the review of literature, collecting and analysing data, developing first draft. Author VB did the conceptual and review, final draft, editing and reviewing. Both authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/AJAEES/2023/v41i52038

**Open Peer Review History:**
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/102178

***Review Article***

***Received: 19/02/2023***
***Accepted: 24/04/2023***
***Published: 26/04/2023***

## ABSTRACT

Food insecurity is a major challenge in front of developing countries. Food and Agricultural Organization of the United States (FAO) [1] reported that 2 billion people face moderate or severe food insecurity, of which 1.02 billion are found in Asia, 674.5 million in Africa, and 205.3 million in Latin America and the Caribbean in 2019. Inadequate food creates serious health issues among people, especially children worst affected by it. The situation further deteriorates in developing countries where poverty and population rates are high. The overconsumption of fertilizers in agriculture leads to environmental degradation and severe human illness. The unsustainability of the current agriculture model has raised many concerns about the future demand for food for an ever-growing population. The alternative method as suggested by many experts is Organic farming. The positive externalities attached to organic farming have enormous potential and it plays a very significant role in protecting the environment, providing safe food, and eventually sustainability. Further, linking the goal of food security with organic farming can help developing countries provide

[++] *Junior Research Fellow (JRF);*
[#] *Associate Professor;*
**Corresponding author: E-mail: avinash.eco.rs@igu.ac.in;*

nutritious food and help in protecting the environment. The paper explores the situation of food insecurity worldwide and the current agriculture model performance and failure to achieve food security in many developing countries. The paper also analyses the role of organic farming to attain food security and elaborate on the limitations of organic farming to ensure food security and provides alternative models for improvement in current situations. For this purpose, study uses secondary data from the Food and Agriculture Organization (FAO) for analysis of the food production in these two regions and reviews various research articles, FAO documents, and reports based on conventional and organic farming. The literature was accessed using Google Scholar, Institutions and Government Websites. The conventional farming put developing countries into the dilemma, to ensure food security for its population or protect environment, due to its unsustainability in long run. However, the current status of organic agriculture production is still meagre compared to conventional food production. The low yield in organic farming does not ensure the food security for the distant future but in long run organic farming can ensure the food security. The study recommended policy makers to formulate such policies which ensure sustainable food production without compromising food security in developing countries.

*Keywords: Organic; agriculture; food security; environment; development.*

## 1. INTRODUCTION

The popularity of organic farming is gaining day by day due to its enormous benefits to the environment. According to Willer et al. (2021), the growth of organic farming is constantly rising, from 11 million hectares of organic area in 1999, increasing to 72.3 million hectares in 2019. In the two decades from 1999 to 2019, the organic farming area recorded 555 percent of growth. Apart from this, organic farming is also gaining momentum in developing countries of Asia and Africa. The growth of organic farming in the African region was significant. From a negligible, 0.02 million hectares of organic land in 1999, increased to 2.0 million hectares. While, total organic producers in the African region stood at 8,50,000 from which Uganda (over 2,10,000) has the highest number of organic producers, followed by Ethiopia (2,04,000) and Tanzania (1,49,000). The same pattern of organic farming growth is shown in the Asia region. In 2019, Asia represents 8 percent or 5.9 million hectares of total organic farming land in the world. In two decades, Asia has increased its organic farming land fourteen times. In 2019, Asia consists of 1.6 million producers' organic producers, of which almost 1.4 million belong to India, followed by Thailand with 119,000 producers. However, the area under organic farming is still meagre compared to the current model of agriculture i.e., conventional farming. The current food production system helps countries, especially developing countries, to secure food for their population and supply raw materials to food and fuel industries.

Today Malthus's theory is closely related to the situation which many developing countries refer to as food insecurity. According to Food and Agriculture Organization (2010), "food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". Contrary to food security, "food insecurity exists when people do not have adequate physical, social or economic access to food." While food accessibility is directly associated with the performance of the agriculture sector which helps countries to secure minimum food for their people, especially in developing countries. The rapid growth in the agriculture sector and enhanced technology help farmers to increase agriculture production. According to World Food and Agriculture [2], production of primary crops stood at 9.4 billion tonnes in 2019, 53 percent more than in 2000. Even with the tremendous production of food grain, the situation of food insecurity in many developing countries persists. The reason for persistent food insecurity, according to Sen [3], is not due to inadequate food, there is enough food for everyone, but food insecurity situation arises due to unfair public distribution and profit hoarding by traders. Sen's argument makes sense as the current food production is enough to feed the population but due to leakages in the system, food insecurity persists especially in many developing countries.

## 2. IMPORTANCE OF CONVENTIONAL FARMING AND EMERGENCE OF ALTERNATE

The current model of agriculture production is a package of new practices of using high-yielding

varieties (HYVs), improved farm equipment, and inputs like chemical fertilizers and insecticides [4]. This package helps agriculture to increase food production significantly. One of the foremost pessimists was Thomas Malthus, famous for his theory of population. The theory state that, the growth rate of the population increases at a geometric rate while the food production grows at an arithmetic rate, an imbalance between these growth rates will ultimately lead countries to fall into a low-level equilibrium trap [5]. However, Malthus's theory was refuted because the agriculture sector grows at a rapid pace which led the food production rate to grow more than the population growth rate. However, a new challenge arises in the food production method. The intensive use of chemical fertilizers causes various environmental degradation, harming public health and economically not feasible [2,4,6,7,8]. Thus, an alternative is required to meet the food demand, income of farmers and concerns of environmental degradation. In this direction, literature favours organic farming from various alternate methods of food production. Organic farming play's crucial role in every aspect of agriculture from environment conservation to providing nutritious and chemical-free food for public health, improving soil fertility and biodiversity, and being economically feasible for small and marginal farmers [9]. Further, organic farming also meets the criteria of sustainable development and helps tremendously in targets of Sustainable Development Goals (SDGs) [10,11]. The optimistic scholars favour organic farming and will contribute significantly to food security. However, the complexity involves in food insecurity makes it hard for developing countries to ensure minimum food for everyone.

There are various dimensions a play for food security (accessibility, affordability, utilization, and stability). And even with tremendous food production, the food insecurity situation prevails. In this direction how organic farming performs in food security is a matter of debate. Even literature also tries to answer the most debatable question: Can organic farming replace fully conventional farming to ensure food security [12]. Thus, the objective of the paper is to review and advance the debate on organic farming in the context of food security in developing countries. This study analyzes the current food production in Asia and Africa region using conventional farming. Further, the study assesses the current status of organic farming and food security in developing countries and provides insights into whether the current status of organic is sufficient to meet food security in developing countries.

## 3. METHODOLOGY

The current study is based on a review of conventional farming and its alternative, organic farming. To show the achievement of conventional farming in the context of food security, secondary data was analysed. The production of wheat and rice in the Asia and Africa regions was undertaken. This will help in understanding the trends in food production in these regions. The study uses secondary data from the Food and Agriculture Organization (FAO) on wheat and rice. The study reviews the negative externalities of current food production and the status of organic farming in the context of food security. For this purpose, various research articles, FAO documents, and reports were accessed using Google Scholar, journals, institutions, and government websites.

## 4. STATUS OF FOOD SECURITY IN DEVELOPING COUNTRIES

According to the estimates given by Food and Agriculture [1], nearly 690 million people were hungry, or 8.9 percent world's population. The estimates also categorize food insecurity into two levels, severe and moderate food insecurity. Severe food insecurity is defined as a person not being able to acquire food for one or more than one day, whereas moderate-level food insecurity is a person who goes out of food occasionally or does not have enough resources to acquire healthy food. The estimates showed that about 750 million people were categorized as having severe food insecurity, while 2 billion people fall under moderate food insecurity. The numbers of food-insecure people mainly belong to developing countries of Asia and Africa region. According to FAO [1], 1027.4 million people who remain food insecure belong to the Asia region, while 674.5 million people from Africa in 2019. The inflated food insecure peoples belong to Asia because it is the most populated region of the world. The prevalence of severe and moderate levels of food insecurity is the main reason for the spreading undernourishment[1] in developing countries. FAO [1] reported Asia and the Pacific region was the hub of 51 percent of the global total of undernourished people, and

[1] *Food and Agriculture Organisation (2010), defined "undernourishment exists when calorie intake is below the minimum dietary energy requirement"*

mostly belongs to the highly populated countries of Southern Asia (257.3 million), followed by South-Eastern Asia (64.7 million). Africa reported 250.3 million undernourished people in 2019 and the situation of food security has been deteriorating since 2014. Moreover, linking poverty and high population with food insecurity further deteriorates the situation of developing countries.

Poverty and high population are other issues that most developing countries face. Global Multidimensional Poverty Index (MPI) Report 2020, estimated 558 and 530 million poor people belong to sub-Saharan Africa and South Asia, respectively. The high poverty rate in these regions with fast-growing populations affects the situation of food entitlement for its population. This leads to nutritional insecurity. The concept of food security and nutrition security are interlinked [1]. Food security means access to food all the time, while nutrition intake refers to the minimum intake of nutrition from various food. A country that can be food secure does not guarantee proper nutrition intake. In developing countries, malnutrition, child stunting[2], and child wasting[3] are the outcomes of inadequate food consumption. In 2019, 47 million children who were under the age of five were reported as suffering from severe and moderate child wasting, from which 12.7 and 31.5 million children are reported from Africa and Asia region, respectively. An estimated 74.5 million children were suffering from stunting in Asia and the Pacific in 2019, while Africa reported 57.5 million stunted children. Furthermore, food insecurity hurt every age group of people, especially the poor section of society. There are many life-long and mild diseases associated with insufficient calorie intake. A U.S.-based study by Gundersen & Ziliak [13] showed food insecurity among children was associated with diseases like anaemia, poor health among children, noncognitive performance, asthma, depression, and anxiety. While adults and seniors face issues like mental health issues, oral health problems, iron deficiency among pregnant women, and limited daily activities among seniors.

India is the second most populated country in the world and amongst the largest food producer country in the world. Besides, India is the hub for the food-insecure population in the world. Kadiyala (2012) showed, “In India, almost one in two children are stunted and 40% are underweight. One-third of all Indian women are underweight. Rates of micronutrient deficiency are extremely high, with almost 80 percent of children and 56 percent of women being anaemic” showing the nutrition insecurity among Indian children and women that continued to be alarming till 2020. FAO [1], estimated that about 53 percent of children under age five are not growing well. Further, India also lies into the very high category of child stunting and child wasting. The link between food security and poverty was examined by Pandey and Gautam [14]. They showed backward states like Bihar, Jharkhand, Chhattisgarh, Odisha, and Assam, where poverty is high also score low on the food security index created by them. Moreover, the condition of the prevalence of undernourishment in India, a study conducted by Rawal et al. (2019) showed a different picture of food insecurity in India. They modified the estimation methodology and added new variables like the age and sex of household members and meals consumed outside the home. The result was 12 percent points higher prevalence of undernourishment than reported by the State of Food Insecurity in the World 2015. Thus, even with the tremendous production of food in India, also exporting food to other countries, the situation of food insecurity in India persists.

## 5. PERFORMANCE OF FOOD PRODUCTION IN THE DEVELOPING COUNTRIES

Swaminathan [15] addressed the Third World Prize, in which he said agriculture can be the key to prosperity in third-world countries [16]. Further, food production is the base for food security [15]. The performance of agriculture will help countries to secure minimum food for their people and support economic activity. Currently, the agriculture model that is used by developed and developing countries is the use of chemical fertilizers and modern machines to increase food productivity on fixed land. The current agriculture model helps developing countries reduce the scarcity of food and assures food for all in the country. Proper food access and availability can minimize the risk associated with food insecurity. India, for example, using chemical fertilizers achieved new peaks in food production in the country and become a net exporter. The same pattern is also reported by many other developing countries.

[2] *measures the shorter height than their potential for their age.*
[3] *measures the low-weight-for-height.*

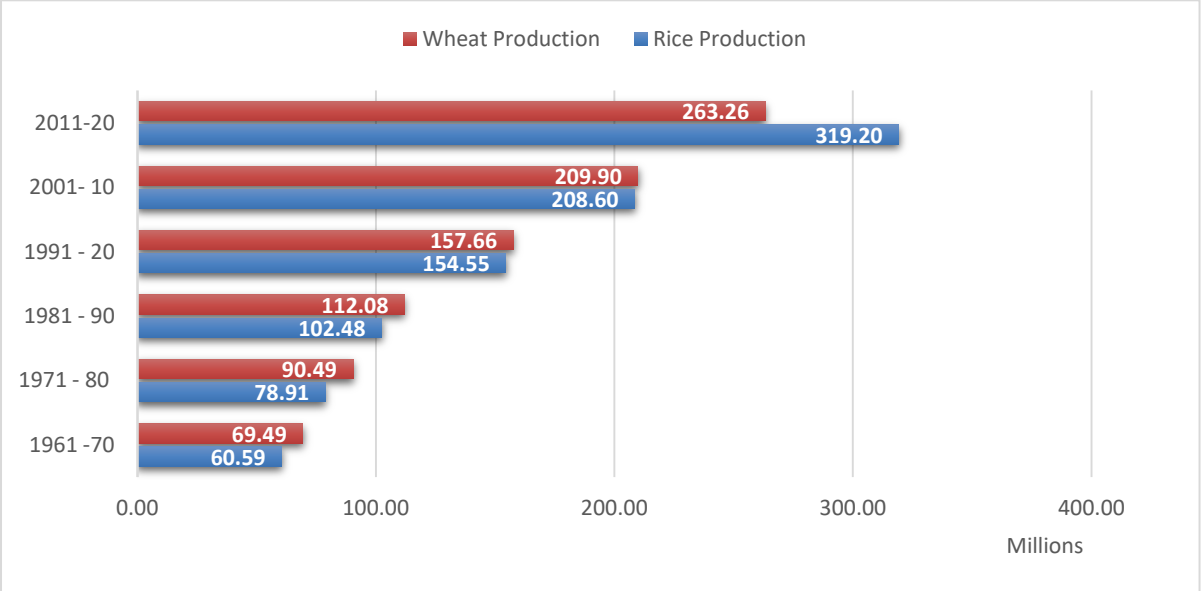


**Fig. 1. Africa region food production (in tonnes) since 1961**
*Source: FAO [41]*

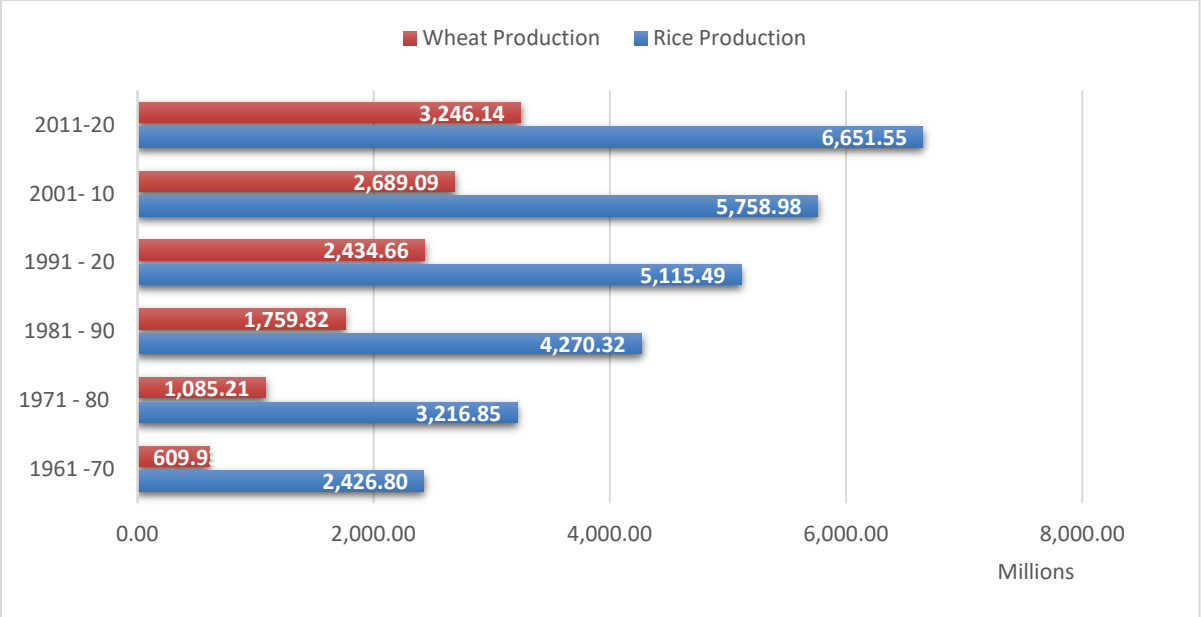


**Fig. 2. Asia region food production (in tonnes) since 1961**
*Source: FAO [42]*

Fig. 1 shows the trend of production of the two most used staple crops, i.e., wheat and rice, from 1961 to 2020. The data was sourced from the FAO database and taken for only two regions: Asia and Africa, which include most of the developing countries in the world. The data shows that after the advent of the green revolution food production grew tremendously. However, the growth of these crops was not the same in two regions, as the data represents. In the Asian region, the growth of wheat and rice was significant; in 1961–1970, the production stood at 609.9 million tonnes and 2,426.80 million tonnes of wheat and rice, respectively. This rising decadal growth of food production stood at 3,246.14 million tonnes of wheat and 6,651.55 million tonnes of rice in the duration of 2011–2020. A similar trend in staple food production was observed in the African region. The production of wheat was 69.49 million

tonnes and 60.59 million tonnes of rice were observed in the time span of 1961–1970. This rising trend in staple foods reached 263.26 million tonnes and 319.20 million tonnes of wheat and rice, respectively, in the time period of 2011 to 2020. The data revealed that the green revolution was more successful in Asia than in the African region. However, the growth of food production may differ significantly country-wise.

Even with the tremendous staple food production, food security prevails and persistence in many in these two regions. The rising population may be a cause for the situation. In 2021, population of the world stood at 7.91 billion and from these 75 percent of the population resides in Asia and Africa region. World population is likely to touch 9.7 billion by 5050 and 10.4 billion by the end of this century [17,18]. Moreover, Ritchie [19], showed that by end of this century more than eight out of ten people on the world belongs to Asia and Africa region. Thus, for these regions to meet the demand for ever increasing population is the highest priority.

Fig. 3 shows the world population growth since 1950 to 2021. The rising trend of the population growth is directly correlated to the increasing food production. The world population stood at 2.54 billion in 1951 which comprise population of 1.41 billion and .23 billion of Asian and African region. These two regions constitute 64.41 percent of the population. However, in time period of seventy years, the population has risen and share of these two regions. In 2021, world population stood at 7.91 billion, in which 4.69 billion and 1.39 billion belongs to Asian and African region. This huge population accounts for 76.98 percent. Almost one third of the population of world reside in these two regions and ensuring food for everyone is herculean task for government and institutions. However, to meet the demand of for this huge population, intensive use of chemical fertilizers and pesticides is used in agriculture. However, agriculture production has become more complicated than ever before due to rising literature indicating the ill side of the current agriculture model.

The agriculture production model that is used in most developing countries is a package of high-yielding varieties of seed, chemical fertilizers as an agent of growth, and mechanization for productivity. The unchecked use of pesticides in agriculture caused severe environmental concerns like domestic animals poisoned by pesticides, depredation of natural predators and parasites, further reducing the pollination of vegetables, fruits, and other crops, ground and surface water contamination, loss of biodiversity, reduction in soil fertility [6,7,8,20,21]. The less productivity on land forces farmers to use more expensive fertilizers to maintain the productivity

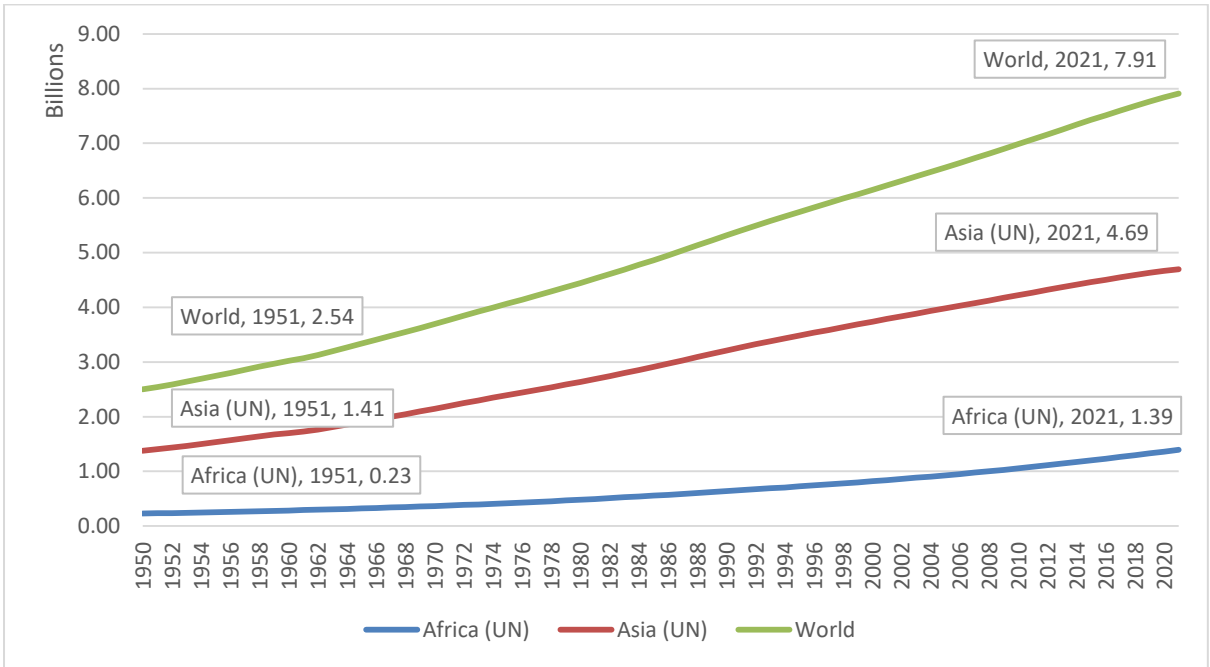


**Fig. 3. World population growth (in billions)**
*Source: United Nations, World Population Prospect 2022*

of the field. This costs farmers more from their income and rise the inequality between rich and poor farmers [22,4,6]. The socio-economic factors also made the situation worse for the farmers. Mariappan & Zhou [23] found out the major concern for the high suicide rate is due to low returns from cultivation, higher input costs, drought, climate change, and socio-economic problems. Further consumers as well as producers both are affected by chemical fertilizers. Donthi [24] studied the cases of farmers unintentionally consuming chemicals used in agriculture. The study revealed 7,437 deaths (an increase from 6,962 deaths in 2019) from "accidental intake of pesticides/insecticides". Chemical-induced food also harms public health at large. Singh [20] (as cited in Pimentel, 1996), showed 80 percent of staple food was contaminated with pesticides in daily food intake. This contaminated food with pesticides residue causes several illness cancer, disturbing reproductive health, harmful for pregnant women, hormone disruptions [25,26,7,20]. Despite the ill side of the current agriculture model, developing countries continuously use this conventional method. Further, changing climate like extreme heat also negatively impact the agriculture production [27,28]. Combining effect of reduced soil fertility, if the unchecked consumption of fertilizer and pesticides continues, and changing climate may further reduce the food production in long run.

## 6. THE ALTERNATIVE MODEL OF AGRICULTURE

However, the unsustainability of conventional farming is also not a suitable option for food production. An alternative production system i.e., organic farming is recommended by many experts. This approach abstains from the use of chemical fertilizers, instead in this farming organic fertilizers, green manure, vermicompost, and bio-fertilizers are used. Using these fertilizers has no risk or trivial contamination of soil or water [9] However, organic farming is not risk-free as it is still developing. The constraints that are associated with organic farming such as low yield, niche market, conversion period, low-scale production, etc. Yield is a crucial factor in the situation of food security. The proponent of conventional farming Norman Borlaug quoted in an interview that "Producing food for 6.2 billion people (now 7.4 billion) … is not simple." He added, "[Organic approaches] can only feed four billion–I don't see two billion volunteers disappear" as cited in the post by Pollack [29]. Literature also supports the low-yield argument in the case of organic farming. Globally, the organic yield was 10% less when compared to conventional farming [30]. According to Seufert [31], a meta-analysis study compares the yield of organic and conventional farming. The study reveals that organic farming grows lower yield, ranging from 5%, 13%, and 34% when rain-fed regions, best practice is used under organic farming and both techniques are most comparable respectively. Similar results are found in a study by Forster [32] where yield in the case of wheat is less than 27% in the first crop cycle additional crops like soybean and cotton was also found to be a larger yield gap compared to conventional farming. Singh & Grover [20] conducted a study to examine the organic farming viability in Punjab revealing that organic wheat yield is lower when organic farming is undertaken as comparing it to conventional wheat (compensated by the premium prices). Manjunathan and Puttaswamahia's [33] reported lower yields for both crops in the case of organic yield compared with conventional farming yield. Another constraint that drags backwards organic farming is the conversion period. In the shift from conventional farming to organic farming, the conversion period usually lies between 1-4 years as mentioned by [11]. In this period, the yield from the farm is very low as compared to conventional farming [24]. This infers that the farmer has to sacrifice years of income or earns less income in between this period. Bachmann (2011) analyzed the potential of organic cotton farming, in which he finds out that during the conversion period of the first two years, the yield is lower in organic cotton. Another area of organic farming that needs attention large scale organic production. Panneerselvam [34] analyzed the impact of large-scale organic conversion of food production in the states of Tamil Naidu and Madhya Pradesh, India. And reported that converting organic as the only food production system will reduce by 3-5% food production. This will further aggravate the situation of food insecurity in the country. However, optimistic scholar favours organic farming in the long run.

Badgley et al. [35] estimate that organic farming could produce sufficient food on a global per capita basis. Further, developing countries have more potential to grow organic food than developed countries. But on the contrary, Connor [36] criticized Badgley and does not support the analysis. Another study by Ehyhorn et al. [37] showed a comparable yield in organic and

conventional farming. Hulsebusch's (2007) as cited in Schoonbeek et al., [38] view on organic farming is optimistic, and the reason this with "in the long run, organic farming will save natural resources and no cultivation is a loss". Thus, in the long run, organic farming can significantly help to meet food security. The long-run perspective of organic farming is that it has the potential to meet the challenge of food security within the framework of sustainability [38,39,40,11].

## 7. CONCLUSION

Today the world needs a food production system that is sustainable and able to meet the requirement of food for the world population. However, the current model of agriculture only ensures food security at the cost of sustainability. The data on food production in Asia and Africa regions shows the tremendous food production from the advent of the green revolution. Many developing countries ensure food security because of the success of the green revolution. However, new challenges arise as extensive use of chemical fertilizers and pesticides degrades the environment, harms public health, and becomes infeasible for farmers. The present agriculture model for food production is harming the climate and is unsustainable in the long run. The alternative approach i.e., organic farming which sustainable and environment-friendly. Rapid growth in organic farming all over the world implies the importance and points to the alternative to the current agriculture model. However, the achievement of the current agriculture model is tremendous and helps developing countries affirm the food security in the country but to ensure sustainable food security, an alternative approach is required. The study found that even with the benefits associated with organic farming, there are many constraints like lower yield, niche market, and conversion period, associated with organic farming. Thus, for developing countries, the large-scale adoption of organic farming can also provide a long-lasting solution, not the selective one. In conclusion, despite the benefits associated with organic farming, it is difficult to ensure food security in developing countries.

## 8. RECOMMENDATIONS

The present study reviews the current food production system i.e., conventional farming. The literature points out that in long run the extensive use of chemical fertilizers has negative impact on environment and public health. Organic farming emerges as alternative to conventional farming. There are wide positive externalities attached to organic farming. Further this method also meets the criteria of sustainable food production that provide nutritious food without harming the environment. Although, the negative externalities attached to conventional farming developing countries still using conventional farming in order to ensure food security. Thus, a complicated issue come in front of the policy makers. The developing countries with huge population and persistence food insecurity, policymaker requires to formulate robust and fundamental policies. The study recommends that in order to shift from conventional to alternative farming (organic farming), robust mechanism should be formulated that does not affect the food security.

## ETHICAL APPROVAL

I/We declare that the manuscript was prepared following the protocols of the Helsinki Declaration or similar ethical statements.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. FAO, IFAD, UNICEF, WFP and WHO. The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets. Rome, FAO; 2020.
   Available:https://doi.org/10.4060/ca9692en
2. FAO. The State of Food and Agriculture 2021. Making agrisystem more resilient to shocks and stresses; 2021.
   Available:https://doi.org/https://doi.org/10.4060/cb4476en
3. Sen A. Poverty and Famines an Essay on Entitlement and Deprivation (1st ed.). Oxford University Press; 1981.
4. Ladejinsky W. How Green Is the Indian Green Revolution? Economic and Political Weekly. 1973;8(52):133–144.
   Available:http://www.jstor.org/stable/4363316
5. Thirlwall AP. Growth and Development with Special Reference to Developing Economies (6th ed.). Macmillan Press LTD; 1999.

6. Narayanan DS. Organic farming in India : Relevance, problems and constraints; 2005.
7. Pimentel D. Green Revolution and Chemical Hazards. The Science of The Total Environment. 1996;188(Suppl. 1): S86-S98.
8. Randive K, Raut T, Jawadand S. An Overview of the Global Fertilizer Trends and India's Position in 2020. Mineral Economics. 2020;14.
DOI: https://doi.org/10.1007/s13563-020-00246-z
9. Reganold J, Watcher J. Organic Agriculture in the Twenty-First Century. Nature Plants. 2016;2:1-8.
DOI: 10.1038/NPLANTS.2015.221
10. Šeremešić S, Dolijanović Ž, Simin MT, Vojnov B, Trbić DG. The future we want: Sustainable development goals accomplishment with organic agriculture. Problemy Ekorozwoju. 2021;16(2):171–180.
Available:https://doi.org/10.35784/pe.2021.2.18
11. Setboonsarng S, Gregorio EE. Achieving sustainable development goals through organic agriculture: Empowering poor women to build the future. ADB Southeast Asia Working Paper Series. 2017;2(15):1–26.
Available:http://www.adb.org/publications/corrigenda%0Awww.adb.org
12. Eyhorn F, Muller A, Reganold JP, Frison E, Herren HR, Luttikholt L, et al. Sustainability in global agriculture driven by organic farming. Nature Sustainability. 2019;2(4): 253–255.
Available:https://doi.org/10.1038/s41893-019-0266-6
13. Gundersen C, Ziliak JP. Food insecurity and health outcomes. Health Affairs. 2015;34:(1830–1839).
Available:https://doi.org/10.1377/hlthaff.2015.0645
14. Shrestha K, Shrestha G, Pandey P. Economic Analysis of Commercial Organic and Conventional Farming in Kathmandu Valley. The Journal of Agriculture and Environment. 2014;15:58-71.
15. Swaminathan MS, Bhavani Rv. Food production & availability-Essential prerequisites for sustainable food security. Indian J Med Res. 2013;138:383–391.
16. Wei TK. (Ed.). Science and Sustainable Food Security Selected Papers of M S Swaminathan. World Scientific Publishing. 2010;3.
17. Roser M, Ritchie H, Ortiz-Ospina E, Rodés-Guirao L. World Population Growth. Our World in Data; 2013.
Available:https://ourworldindata.org/world-population-growth
18. United Nations Department of Economic and Social Affairs, Population Division. World Population Prospects 2022: Summary of Results. UN DESA/POP/2022/TR/NO. 2022;3.
Available:https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf
19. Ritchie H. More than 8 out of 10 people in the world will live in Asia or Africa by 2100. Our World in Data; 2019.
Available:https://ourworldindata.org/region-population-2100
20. Singh IP, Grover D. Economic Viability of Organic Farming: An Empirical Experience of Wheat Cultivation in Punjab. Agricultural Economics Research Review. 2011;24: 275-281.
21. Srivastav AL. Chemical fertilizers and pesticides: role in groundwater contamination. In Agrochemicals Detection, Treatment and Remediation: Pesticides and Chemical Fertilizers. LTD; 2020.
Available:https://doi.org/10.1016/B978-0-08-103017-2.00006-4
22. Bowonder B. Impact Analysis of Green Revolution in India. Technological Forecasting and Social Change. 1979; 15:297-313.
23. Mariappan K, Zhou D. A Threat of Farmers' Suicide and the Opportunity in Organic Farming for Sustainable Agricultural Development in India. Sustainability (Switzerland). 2019; 11(8).
Available:https://doi.org/10.3390/su11082400
24. Reddy Donthi N. Pesticide Poisoning in India Challenges of Data and Management in Public Health. 2021;45.
Available:https://doi.org/10.4172/2157
25. John DA, Babu GR. Lessons from the Aftermaths of Green Revolution on Food System and Health. Frontiers in Sustainable Food Systems. 2021;5:1–6.
Available:https://doi.org/10.3389/fsufs.2021.644559

26. Nicolopoulou-Stamati P, Maipas S, Kotampasi C, Stamatis P, Hens L. Chemical Pesticides and Human Health: The Urgent Need for a New Concept in Agriculture. Frontiers in Public Health. 2016;4:1–8.
Available:https://doi.org/10.3389/fpubh.2016.00148

27. Ahmad J, Alam D, Haseen MS. Impact of climate change on agriculture and food security in India. International Journal of Agriculture, Environment and Biotechnology. 2011;4(2):129–137.

28. Lesk C, Rowhani P, Ramankutty N. Influence of extreme weather disasters on global crop production. Nature. 2016; 529(7584):84–87.
Available:https://doi.org/10.1038/nature16467

29. Pollack J. Green Revolutionary. MIT Technology Review; 2007.
Available:https://www.technologyreview.com/2007/12/18/270625/green-revolutionary/

30. MacRae R, Frick B, Martin R. Economic and Social Impacts of Organic Production Systems. Can. J. Plant Sci. 2008;87:1037-1044.
Available:www.nrcresearchpress.com

31. Seufert V, Ramankutty N, Foley JA. Comparing the Yields of Organic and Conventional Agriculture. Nature. 2012; 485:229-232.
DOI: https://doi.org/10.1038/nature11069

32. Forster D, Andres C, Verma R, Zundel C, Messmer MM, Mäder P. Yield and Economic Performance of Organic and Conventional Cotton-Based Farming Systems - Results from a Field Trial in India. PLoS ONE. 2013; 8(12).
Available:https://doi.org/10.1371/journal.pone.0081039

33. Manjunatha T, Puttaswamaiah S. Comparative economic analysis of organic and conventional farming in Karnataka. Indian Journal of Economics and Development. 2021;17(4):757-766.
DOI: https:/doi.org/10.35716/IJED/21106

34. Panneerselvam P, Hermansen JE, Halberg N, Arthanari PM. Impact of Large-Scale Organic Conversion on Food Production and Food Security in Two Indian States, Tamil Nadu and Madhya Pradesh. Renewable Agriculture and Food Systems. Cambridge University Press. 2015;30(3): 252–262.
Available:https://doi.org/10.1017/S1742170513000501

35. Badgley C, Moghtader J, Quintero E, Zakem E, Chappell MJ, Avilés-Vázquez K, et al. Organic agriculture and the global food supply. Renewable Agriculture and Food Systems. 2007;22(2):86–108.
Available:https://doi.org/10.1017/S1742170507001640

36. Connor DJ. Organic agriculture cannot feed the world. Field Crops Research. 2008;106(2):187–190.
Available:https://doi.org/10.1016/j.fcr.2007.11.010

37. Eyhorn F, van den Berg M, Decock C, Maat H, Srivastava A. Does organic farming provide a viable alternative for smallholder rice farmers in India? Sustainability (Switzerland). 2018;10(12): 1–15.
Available:https://doi.org/10.3390/su10124424

38. Schoonbeek S, Azadi H, Mahmoudi H, Derudder B, de Maeyer P, Witlox F. Organic Agriculture and Undernourishment in Developing Countries: Main Potentials and Challenges. Critical Reviews in Food Science and Nutrition. 2013;53(9):917–928.
Available:https://doi.org/10.1080/10408398.2011.573886

39. Thakur DS, Sharma KD. Organic farming for sustainable agriculture and meeting the challenges of food security in 21st century: An economic analysis. Indian Journal of Agriclture Economic. 2005;60(2):205–219.

40. Azadi H, Schoonbeek S, Mahmoudi H, Derudder B, de Maeyer P, Witlox F. Organic agriculture and sustainable food production system: Main potentials. Agriculture, Ecosystems and Environment. 2011;144(1):92–94.
Available:https://doi.org/10.1016/j.agee.2011.08.001

41. FAO, ECA and AUC. Africa Regional Overview of Food Security and Nutrition 2020: Transforming Food Systems For Affordable Healthy Diets. Accra, FAO; 2021.
Available:https://doi.org/10.4060/cb4831en

42. FAO, UNICEF, WFP and WHO. Asia and the Pacific Regional Overview of Food Security and Nutrition 2020: Maternal and child diets at the heart of improving nutrition. Bangkok, FAO; 2021. Available:https://doi.org/10.4060/cb2895en



*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*https://www.sdiarticle5.com/review-history/102178*