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Review

A systematic synthesis on the context reliant performance of organic farming

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Abstract: The argument on whether organic agriculture can produce enough food to cater for the world's growing population has been debated severally by various scholars. While organic farming is rapidly increasing, the paramount question is to know how organic farming can yield to viable systems of producing food. This paper aims to identify the benefits and context reliant performance of organic farming as a development trail to sustainable farming. Gathering of articles from different peer review journals was used to develop this paper. The findings of this paper show that organic farming has many potential benefits including higher biodiversity, improved soil, and enhanced profitability as well as supporting local production, with locally produced source inputs. The findings also show that organic farming is environmentally friendly, promotes distribution of resources, and is economically and socially acceptable to mankind. In order to have a clear view of the contribution that organic farming plays on sustainability, further research is necessary.

Keywords: economic; environmental sustainability; food security; sustainable farming

1. Introduction

Agriculture today is one of the major contributors of environmental dilapidation [1], but in respect of major increases in production, more than one billion people globally suffer inadequate food and remain malnourished [2–5]. Organic farming is often suggested as a way-out to this challenge of attaining viable food security. However, it merely constitutes −1% of universal pastoral land and only supplies −1 to 8% of overall food sales in the majority of European and North American nations [6]. Organic is a brand that is recognised and bought by several shoppers, is the fastest emerging food sector in North America and Europe [7]. Assumed that organic farming is a contemporary and preferably extensive farming method and is one of the few legitimately controlled labels in farming, it is imperative to evaluate its benefits and ascertain how it can be improved in terms of its sustainability.

Conversely, the advantages of organic farming are universally contested, although certain scholars encourage it by way of reducing poverty among rural households and also as one of the solutions to our sustainable food security challenges [8–10], while others see it as a drawback of agriculture that would aggravate food shortage and ecological destruction [11–14].

For instance, evidence shows that the per capital food output in sub-Saharan Africa has declined by twenty percent due to a decline in soil fertility over the past 20 years [15–17]. Nevertheless, organic farming offers the chance to improve soil fertility, which in turn will increase food production [18,19]. A similar observation was noted by Schnug et al. [12] on what organic farming can offer; which includes improvement of soil fertility, low cost of production, environmental protection, improve farmers' income and higher prices which serve as a premium for organic products sold in the market.

Organic farming has a distinctive part to play in helping meet an array of goals like; environmental policy goals, and social capability of the organic systems. The environmental policy goals include those associated to fighting desertification and conserving bio-diversity [20], and balancing the magnitudes of global warming through carbon sequestration [21], while the social capability aspect centres on knowledge intensive that can combine traditional and indigenous farming knowledge [18,22]. As a result, the demand for healthier food, free from synthetic pesticide contamination and genetically modified organisms, is increasing the demand for organically produced foods [23,24]. The increase in the demands is related to certain factors such as concern for health [25], safer food [26], and the environment [27]. Improving the environment with the use of renewable resources is thus imperative in the production of safer food that will in turn have a beneficial effect on an individual's well-being [28].

Previous reviews [8,10,29–33] have concentrated on the advantages of organic handling practices. However, this review will discuss a more significant question across the following scopes: benefits of organic farming in the context of its sustainability, yield performance and stability, economic performance, food security and environmental benefits of organic farming. Nevertheless, assumed the yields vary, and that the primary aim of agriculture is production, it is imperative to further asses the achievement of farming methods per unit output [34]. Per unit output influences are mostly pertinent to the environmentally friendly scopes. Our assessment is restricted to cropping methods. Therefore, animal wellbeing in precise is not discussed.

2. Methodology

The purpose of this paper is to present a systematic review of literature based on the context reliant of organic farming as a sustainable farming system. To realize this, appropriate research papers were reviewed; after gathering, assessing, and integrating data from an outsized number of sources. The appraisal was actualized systematically using distinct peer-review and non-peer review papers, books, and authorized publications. The basic short phrases used to explore the information were organic farming and sustainability. The terminologies were joined with economic effects, food security and yields, and environmental effects. The aforementioned terms were used in order to find related researches in developing and developed nations. Publications that were not written in English and those that were not from reliable sources are excluded.

3. Benefits of organic farming

3.1. Sustainability of organic agriculture

The word sustainability which is increasingly being used by researchers that now centre on the usage of earth's natural resources within a sustainable systems context are either inaccurate or non-existent [35,36]. In the perspective of agricultural production, McNabb [37] describes a viable agriculture as economically sustainable, environmentally friendly, resource- conserving, able of sustaining its efficiency and functionality to society over the long run and socially supportive. Therefore, organic agriculture is said to be an appropriate and sustainable alternative for improving food security [28], increasing farmers' income [38,39] and decreasing input cost [40,41], producing healthy food for household consumption [28] and maintaining an eco-friendly environment [42–44].

There are other facts that should be put into consideration when estimating the viability of the finishing crop produce, which may include the cost-effect performance and dietary aspect that makes organic production sustainable [44]. It is also important to note that organic farming offers some arrays of environmental benefits such as evaporation minimization and water saving, biodiversity conservation, and improved soil component, support adaptation approaches, and lessens greenhouse gas emissions as well as energy efficacy [10,45]. A combination of data from multiple studies by Rahmann [46] indicates that biological diversity in organic holdings is greater than in conventional holdings in that out of a total of 396 related studies, 327 instances revealed greater than in conventional holdings. Similarly, a study by Bengtson et al. [47] in a comprehensive meta-analysis of biodiversity in organic farms reveals that, on average, in organic holdings, animals of the same species multiply in richness by about thirty percent while, the fruitfulness of organisms was fifty percent higher in contrast with conventional methods. Faunas' abundance in birds, predacious insects, plants and soil micro-organisms augmented while non-predacious insects and pest did not increase. However, the soil conservation approaches in organic farms have the capability to rebuild degenerated lands and to stop further degeneration in resistless areas [48].

The approaches employed to preserve the soil in organic methods include; planting cover crops, moderate or zero tilling of the soil, mulching and contour tilling, and soil coheres as well as terraces [49]. A study by Gattinger et al. [50] indicates that the proportion of organic soil material in organic schemes is remarkably more than in conventional methods. The findings of this research, however, shows that organic material augments water infiltration into the soil and therefore lessen soil disintegration by expanding soil food-webs that enhance the nitrogen (N) sequence within the soil [45], hence conserve water resources. Additionally, in line with the exclusion of manmade manures and pesticides in organic production, the menace of soil, air and water pollutions by synthetic materials is substantially lesser than in conventional methods [51,52]. The organic farming method has a significant benefit with respect to energy use [53–55] as compared to conventional methods. For instance, in organic maize production, fossil fuel materials were thirty-one percent lesser than conventional farms and seventeen percent lesser in soybean production [56]. Similarly, a study carried-out by Mader et al. [57] in Central Europe on organic farming revealed that the fertilizer inputs and energy use were lessened by thirty-four percent to fifty-three percent. Ultimately, without doubt, organic farming has proved to be more significant and appropriate for small-scale farmers because of its dual ability for mitigation and adaptation approaches, both of which improve the environs' resilience to climate variability [50].

3.2. Yield performance and stability of organic system

Given the rising interest for organically made foods, questions relating to the capability of organic techniques to succeed like the modern and imminent universal agricultural demand have been raised [43,44]. Fess and Benedito [44] argued that some authors often allude to low yield productivity as the main barrier impeding the reliance of agricultural collaborators in the capability of organic techniques to meet up with the necessities of the populace. However, yield is habitually the only facet of crop productivity that is mostly debated when relating entire scheme conventional and organic practices.

Generally, crop yield is usually regarded by farmers as the ultimate essential achievement in crop production [44]. The variation in crop produces between organic and conventional techniques has long been viewed as the main problem constraining the acceptance of organic production management by either small or large farmers [44]. The extant literature shows that, studies that have pointed out yield gap between organic and conventional crops include; Pimentel et al. [52]; Badgley et al. [9]; De Ponti et al. [58]; Seufert et al. [45]; Lee et al. [59]; Kniss et al. [60]; and Suja et al. [61]. In their various findings, they observed that most of these studies comprise elements that may generate partiality when explaining the results. Pimentel et al. [52]; Badgley et al. [9]; De Ponti et al. [58]; Seufert et al. [45]; Lee et al. [59]; Kniss et al. [60]; and Suja et al. [61] further added that exploratory weaknesses that often affect the cogency of early studies differentiating scheme produces comprised of; the use of crop species established for conventional high-input schemes, which are likely not have the same high quality potential in a resource-restricted condition, as well as uneven utilizations of fertilizer between schemes. Although numerous exploratory partialities are present, the results of Lee et al. [59]; Kniss et al. [60]; and Suja et al. [61] state that crop yield under conventional management is higher when compared to organic systems, especially among grains and horticultural crops. On the other hand, an insignificant number of studies have investigated considerable produces from organic schemes mainly for forage (buckwheat, alfalfa, and rye) and hay (perennial and legumes) crops compared to conventional schemes [44].

Yields of organic farms in most developing nations are often too low as compared to conventional farms, and this may be a drawback for some farmers in the production system [48,62,63]. Jouzi et al. [48] argued that organic agriculture is advantageous to resource-poor farmers in improving food security and increasing income. The prospective benefits of organic farming depend, conversely, upon a number of vast context specific factors like economic, environmental, social benefits, health and dietary benefits derived in organic foods [37,64,65]. The International Fund for Agricultural Development [IFAD], [66] noted in an assessment conducted in Latin America on small-scale organic farms that these factors require management of a collection of knowledge. However, knowledge should be centred upon farmers' organization, technical support and quality control on food production, which will further contribute to the development of small-scale farmers in ensuring food security, increased income and enhanced livelihoods. Notwithstanding, Table 1, shows a relative evaluation on yield differences between 'organic and conventional' methods as indicated by several scholars.

The meta-analysis on yield difference from various authors has shown different results on yield performance of organic against conventional farming. The differences in the average yield performance may be attributed to different management practices, region and different agro-ecological zones. The average yield performance of organic farming tends to be higher than conventional as reported by some authors in some regions while others reported a lower yield as compared to conventional ones. Though, in some studies, it was observed that organic yields were equal to conventional ones. In general, the findings of various authors show that organic yields are lower than yields in conventional systems.

Table 1. Analysis on yield difference between organic and conventional methods.

Citation	Author's conclusions
[58]	Based on yield average, organic was "80%" higher from those of conventional methods.
	The comparative yield of pre-2004 statistics were statistically related to 2004–2010 figures, signifying that relative yield performance of organic system had not changed.
[45]	Across various produces, yields from organic methods were on average "25%" lower as compare to conventional ones.
	Vegetables and cereals from organic production are reported to have a lower yields than conventional crop, "26% and 33%", respectively.
	Organic fruits and oilseed crops show a slight reduction in yields as compared to conventional ones, "3% and 11%" respectively.
	An improved organic realization of "perennial over annual crops, and legumes over non-legumes" was demonstrated.
	The difference in yield between organic and conventional produces in developing nations is higher than in developed nations, "43% and 25%" respectively.
[67]	Yields from organic cotton systems was "42% lesser than conventional ones during the first rotational cycle, while yields were equal in cycle 2".
	Yields from soybean were "7% lesser" in organic systems than conventional systems.
	Yields from wheat in organic fields was "37% lesser" than conventional counterpart during the first rotational system, but equal afterwards.
[59]	Saleable yield was greater in "conventional than organic onion fields, 71.5 and 55.8 t ha", respectively.
	Freshly harvested conventional onion weight "220.2g/plant" was higher than organic onions "175.6g/plant".
[68]	Multiply scientific studies proved that organic yields were "19.2%" lesser than conventional yields ---signifying a lesser yield difference than formerly found.
	Multiple cropping and crop cycle used in organic approaches lessen the yield gap.
[60]	Hay from organic systems had equal yields or greater than conventional hay crops.
	Organic peach, squash, sweet maize, and snap bean yields were equal to conventional counterparts.
[61]	Equal yield attainment of taro in an organic and conventional management practices, "10.61 and 11.12 t ha", respectively.
	Equal yield traits between organic and conventional approaches under "cormel number, yield per plant, and weight and number of mother corms".

Source: Adapted from Fess and Benidito (2018).

The meta-analysis study of the data presented above report yield over a period of time, showing dissimilarities between systems over time. However, the statistics propose that for the duration of the conversion period, the first three to four years of organic production, which is about the same time necessitated to conclude one full crop cycle, organic techniques are susceptible to lesser produces [44], thereafter by periodic rises as the soil attribute and microbe populations are rebuilt, after which the yield difference is notably lower or no longer prevalent (Table 1). The comparative meta-analysis piloted by Ponisio et al. [68] further showed that multiple cropping and extending rotation cycle can further decrease the yield difference between conventional and organic methods by four to nine percent. Furthermore, it should be noted that nitrogen that is available in organic systems is determined by the level of nitrogen minerals, which is greatly determined by soil temperature. Thus, it is probable that greater yield differences between systems occur for "early season crops" compared to "mid and late season crops" that are sown into warm soils with larger micro-organism activity.

It is therefore important to note that on yield average, organic crops were eighty percent higher [58], signifying that there is a prospect for small-scale farmers when they convert to organic management. Additionally, yield differences tend to be higher in organic crops, especially in developing nations [45]. This signifies that farmers can produce surplus which in turn can be exported to developed nations resulting into financial gains for the farmers through the export of their produce.

3.3. Economic performance of organic farming

Yields are considered as a vital harvest to producers, and for that reason it is directly allied to the monetary performance and the utmost aim of the farming process, as well as the livelihood of families and communities involved [44]. It is thus feasible that if the cost-effect achievement of organic schemes is akin to those of conventional practices, then more farmers would think about shifting to organic management system. Fess and Benedito [44] noted that the economic performance of a crop can be evaluated by lessening the overall expense of agricultural inputs required for production from the current market price of the harvest. Fess and Benedito [44] further argue that regardless of the clearly unrelated input practices, a number of current studies specify that the overall expenses related with production were largely comparable. These variations were accredited primarily to the use of labour and synthetic inputs, specifically the control of pest using mechanical method. A number of studies that have compared comparative analysis of organic to conventional crops includes; Crowder and Reganold [69]; Sgori et al. [70]; Bett and Ayieko [71]; and Fess and Benedito [44]. Their studies focused on the financial competiveness of production techniques and found out that labour expenditures were seven percent higher in organic methods as compared to their conventional counterparts. However, the augmented labour expenditures were counterbalanced by the cost related with the use of fertilizers and pesticides in conventional systems. Similarly, Bennett and Franzel [72] noted that the augmented labour force needed for organic production has been recommended as a means to enhance rural firmness in Latin America, Mediterranean area, and Africa, through the reallocation of assets to the underemployed, possibly resulting to economic enhancements for the neighbouring communities. Therefore, the role of organic farming cannot be underestimated as it has been proved to have a positive impact on the economy of a nation, through the provision of increased manpower, leading to rural stability.

Crowder and Reganold [69] while relating the global competitiveness of organic farming in an innovative meta-analysis, indicate that organic techniques were significantly more cost-effective in spite of lower crop harvests, obtaining twenty-two to thirty-five percent higher net present value (NPV) in contrast to conventional ones. Generally, the economic performance of organic schemes is said to rely on the "premium prices" attained at the market [44]. According to Bett and Ayieko [71], the price of organic produces is usually thirty percent higher than those of the non-organic produces. Nevertheless, the break-even premium entailed to counterpart the economic performance of conventional schemes, factoring in the roughly twenty percent lesser yields of organic fields, demands that premium prices need to be only five to seven percent greater than the price of the conventional ones [69]. Crowder and Reganold [69] also argue that the consistency and economic suitability of organic methods is greater than that of conventional processes. Thus, it is vital to retain ethics that ensue in excellence products to keep consumer trust. However, "premium prices" attached to organic products, coupled with the potential long-term profitability offered by organic produces should provide attractive motivations to organic producers to make the transition to organic production more lucrative. Table 2, shows a relative evaluation of economic performance between organic and conventional cropping methods.

Table 2. Economic performance between organic and conventional cropping techniques.

Citation		Author's conclusions
1.	[40]	Total revenues for organic systems were higher than conventional ones, US "$286" and "$78" acre, respectively. In conventional systems cost-effect risk was higher than organic ones with similar rotation cycle of three years.
2.	[67]	Higher gross margin (21%) was observed in conventional systems during the first length of the two years rotation but after the second phase organic gross margin were higher. Different variable cost in conventional production (cotton-38%, soybean-66%, and wheat-49%) respectively, was greater compared to organic systems. Costs of labour were the same in both production systems.
3.	[73]	Overall life progression cost of conventional lemon was higher (€180,533) than organic production (€178,074 ha) respectively. Costs of producing conventional oranges were greater compared to organic ones, €154,110 ha, and 133,159 ha, respectively.
4.	[74]	Initial and imminent expenses of conventional and organic olive productions were the same. Costs of soil management were greater in organic olives compared to conventional ones. Earnings were greater in the organic systems than conventional counterparts due to premium price and subsidies applied. Organic systems experienced greater internal rate of return [IRR] of 3.51% than conventional counterparts 3.37%.
5.	[69]	Costs of labour in organic production were 7% higher than conventional ones. NPV of organic farming was lesser 27% than conventional ones 23% when price premiums are not attached. When premiums are attached, organic systems were 22–33%, more cost-effective than conventional ones. Overall costs, NPV, total revenues, and benefit/cost ratios for organic were higher compared to conventional ones over 40 years study period.
6.	[71]	For low input organic agriculture, NPV was higher as compared to conventional ones in Kenya.
7.	[39]	Soybeans from organic system were more profitable than conventional ones Organic system had a higher mean performance of profitability (11–15%) greater than conventional ones, but was allied with higher risk.

Source: Adopted from Fess and Benedito (2018).

The findings of Crowder and Reganold in the data presented in Table 1, suggest that organic systems were significantly more profitable in spite of their lower yields, attaining twenty-two to thirty-five percent higher net present value (NPV) in contrast to conventional ones. Although, findings show that organic produces are more lucrative as a result of the premium price they attain when selling the products (Table 2). As a result of the premium price in organic production, there is a greater effective net cash flow that resulted to a reduced period of attaining an effective net cash flow. However, if premiums are not applied to these produces, the economic gains of organic production could be lessen below conventional ones. Quite a number of current studies contrasting profitability confirmed that organic systems receive more financial gain than conventional ones. Reliably, higher NPV and IRR have been reported across different crops like field crops and tree fruit grown within the organic system in contrast to conventional system (Table 2). The figures show that the financial gains earned differ based on crop and the country at which they are grown. Notwithstanding, the organic revenues were not consistently sizeable over conventional production, but it was noted that they may offer adequate incitement subject to the financial condition of the producer/farmer, especially for those in developing nations and evolving markets.

Generally, the financial figures outlined from a number of studies show that the cost-effective achievement of organic systems is dependent on the premium prices attained at the market. At present, the price of organic produces is basically thirty percent higher than those of non-organic ones as highlighted in (Table 2). It is therefore imperative to note that premium prices are significantly higher than the break-even prices. The prospective longstanding profitability offered by organic produces should therefore offer attractive incitements to farmers to make the conversion to organic management.

3.4. Organic farming and food security

At the 1996 Food and Agriculture Organisation (FAO) on World Food Summit, as cited in the work of Pérez-Escamilla [75] the term food security is described as the capability of all individual at all time to have access to adequate, non-toxic, and nourishing food to sustain a healthful and lively life. For all individuals to be food secure; the pillars of food security must be considered. These pillars are summarized into four dimensions as noted by FAO [76]; Aborisade and Bach [77]; and Pérez-Escamilla [75] as food availability, accessibility, utilization or affordability, and stability. Kanu [78] highlighted in a review on organic farming that food accessibility is attained when households and individuals have adequate sources to consume a suitable diet.

Several studies have indicated that organic farming could add significantly to farmers' food security and enhance farmers' livelihoods [18,50,78,79]. However, if organic farming is to play a significant part in providing sustainable food security and viable incomes, it needs to be accessible to resource-poor farmers. Organic farming by its approach has realised three of the Sustainable Development Goals. These goals are summarized by Setboonsarng and Gregorio [28] in Table 3.

This approach however, relies on five variables to realize its proposed purpose such as human, natural, physical, social, and financial development, hence supporting and forming these variables will help to mitigate many of the factors that inhibit food security in the world [80].

Table 3. Summary of the potential and realized benefits of organic farming in relation to the Sustainable Development Goals.

Goal	Potential contributions
SDG 1: Eradication of extreme poverty	Provide incomes to resource-poor and marginal farmers. Low cash costs suitable to resource-poor and marginal farmers. Sustainable production. Higher incomes from premiums of organic produce. Labour-intensive nature can help absorb excess rural labour and can lower rates of rural-urban migration for work.
SDG 2: Zero hunger	Diversified cropping system, mitigate risks of crop failure. More nutritious food. Enhance productivity and sustainability of productive bases. Helps protect genetic resources.
SDG 3: Good health and well-being	Non exposure to chemicals improves health and promotes healthy lifestyles.

Source: Adopted from Setboonsarng and Gregorio (2017).

3.5. Organic farming and environmental benefits

3.5.1. Biodiversity

Agricultural land use is not only the prime driver of biodiversity loss [81], but methods of producing food that also rely on several guidelines and underpinning ecosystem services like soil nutrient cycling, pest regulation and crop pollination from biodiversity are also some of teeming causes of biodiversity loss [82]. Restoring biodiversity loss in agricultural methods of producing food requires practices such as organic farming handling methods of food production. The advantages of organic handling for biological diversity of flora and fauna on plantations are comprehensible, with a distinct rise in living organism richness of forty to fifty percent across various taxa [20,47]. The impact of organic farming on species richness is less clear, ranging from one to thirty-four percent as indicated by [62]. However, some scholars have asserted that the frequently perceived species abundance upshot [47,83] might be determined by an elementary control group outcome at higher organism compactness [20].

In general, it appears that plants [83] and bees [84] are more advantageous from organic handling, although other arthropods and birds benefit to a lesser extent [83,85]. It was observed that higher advantages of organic handling are seen in basic landscapes with high agricultural land cover [83] and lesser habitat quality [84] and in regions with intensive agriculture [85]. There is evidence that clearly shows that organic farming has a resilient influence on biodiversity in arable methods (for instance, cereal) as compared to grassland methods [83,85] and a stronger influence based on individual fields than at the farm scale [85].

Due to the significance of habitat transformation for biodiversity loss, an evaluation of the influence of farming methods on biodiversity has to control yields, which a small number of studies have carried out to date [86,87]. The studies of both Gabriel et al. [86] and Schneider et al. [85] proposed that there are trade-offs between the biodiversity advantages of organic handling yields. However, Gabriel et al. [86] further argued that although previous studies had revealed higher organic advantages for biodiversity per unit area in basic landscapes [50,88,89], in a diverse and low-productivity landscapes, biodiversity per unit efficiency might be of better advantage specially from organic handling practices. Reasons given by these scholars were due to lesser yield variance between organic and its conventional counter-part.

3.5.2. Soil quality

Soil quality in relation to soil healthiness has frequently remained at the fundamental of organic beliefs [90]. Soil formation and soil mineral replenishment are vital supporting means for producing food [82]. On the other hand, soil dilapidation and soil attrition, which currently have a negative effect on outsized areas of land as a result of the continual use of croplands and rangelands, impend present and imminent ways of producing food and are a crucial sustainability challenge for agriculture [91].

Various meta-analyses and quantitative studies have revealed that soils under organic management systems have higher organic carbon content [50,88,89,92]. Similarly, studies have also classically identified reduced soil erosion from organic farms due to enriched soil composition [93,94], but more studies are required to quantify these variables [62]. Primary studies for instance, Mäder et al., [57]; Stockdale et al., [95]; Watson et al., [96] have equally revealed enhancements in other soil health and richness specifications such as soil mineral condition and or soil physical properties under organic handling. In spite of these generally positive influences of organic handling on soil specifications, the soil fauna does not appear to be species rich in organic soils [47,83], but it is more rich in soils that are organically managed [47].

Nevertheless, it is important to note that the amount of organic matter inputs, such as composts or animal manure, has a greater impact on soil organic carbon content [89, 50, 88]. However, there is poor understanding of other prospective significant drivers, like the presence of legumes in crop rotation [50], or of the influence of organic farming on soil quality per unit output [93,94].

3.5.3. Climate change mitigation

Agriculture, which is accountable for about 22% of universal anthropogenic greenhouse gas (GHG) emissions, including deforestation [97], is a major contributor to climate change. Agricultural greenhouse gas emissions from croplands and pasture (excluding livestock methods) are mostly in the form of N_2O emissions from agricultural soils (from fertilizer and manure application and crop residue management), CH_4 emissions from paddy cultivation, and CO_2 emissions through energy use for instance, for fertilizer production and machinery use [97].

Generally, both N_2O and total GHG emissions per unit area appear to be lesser under organic handling for most crops [88,98,99]. Studies of organic achievement for CH_4 emissions from rice paddy are limited [62]. The review by Skinner et al. [98] is centred on a single-field study. Conversely, the partial proof proposes higher CH_4 emissions from organic paddy handling [100]. Overall, organic farming leads to reduced energy use due to avoidance of artificial fertilizers [32,88,99]. Typically, organic agriculture increases soil organic carbon content [50], which is frequently argued to contribute to carbon sequestration [21]. Due to uncertainties about the eventual fate of stored carbon; how long the sequestration will continue; whether it will be permanent and the counterfactual on how the carbon inputs would otherwise have been used, and its potential for climate change mitigation through carbon storage in agricultural soils remains heavily contested [101]. Thus, this study does not consider soil carbon storage as a climate change mitigation option here.

Due to the importance of land conversion for CH_4 emissions that is, deforestation for agriculture represents about 7% of global anthropogenic CH_4 emissions [97], per unit output effects are mostly important for climate change mitigation. Emerging evidence on GHG emissions has clearly shown that GHG emissions per unit output mostly comes from modelling and life-cycle analysis studies and show high variability in outcomes [88,99]. On the other hand, N_2O emissions per unit output appear to be higher under organic management because of lower yields [98], whereas CH_4 emissions from paddy soils per unit output might be even higher than per unit area [100]. However, energy consumption per unit output tends to remain lower in organic management system, but with high variability [32,88,99].

To date, quite a number of studies have identified background factors driving GHG emissions in organic against conventional systems. Lee et al. [102] revealed that the benefit of organic management in relation to energy consumption is lower for vegetables and fruits, whereas the benefit in terms of GHG emissions was higher in mono-cropping systems compared to multi-cropping and with outcome measures based on area rather than output [102].

4. Conclusion

Agriculture centred on organic ethics is fast growing and becoming well known as a promising major contributor towards fighting poverty and hunger, attaining food and nutritional security as well as eco-friendly environment. This is despite the fact that some scholars have criticised it as a drawback to agriculture. Organic farming has some clear advantages and favourable features. For instance, its beneficial impact on local biodiversity, high performance in some conditions, or a livelihood for resource-poor farmers in some circumstances cannot be understated. However, many unresolved questions and concerns remain, like Nitrogen availability, accessibility, and impact on Nitrogen losses from the soil.

It is also significant to mention that the comparative achievement of organic farming to conventional farming differs substantially. It is highly reliant on context and that estimates of the average performance of organic farming have limited practical use. This study shows superior differences in yield between the two systems, for biodiversity of "plants and pollinators in arable methods and simple landscapes". Conversely, the key factor facing the production of organic food system is the capability of the system to increase yields as compared to conventional schemes. Organic techniques indicate some advantageous system oriented skill, which is essential for enhancing prolonged sustainability and improving biological diversity and is beneficial for farmers who are resource poor.

The stated goals of organic farming are achieving optimal agro-ecological systems which are socially, ecologically and economically sustainable. In addition, a global shift to organic farming may not only have the prospective to support food production levels but also conserve and improve agricultural soils fertility and health, which in turn increases fauna biodiversity in the soil. Thus, the sustainability and investments of organic farming should be supported by several stakeholders since it can mitigate some of the teeming challenges posed by climate change.

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Conflict of interest

There is no conflict of interest.

References

1. Foley JA, Ramankutty N, Brauman KA, et al. (2011) Solutions for a cultivated planet. *Nature* 478: 337–342.
2. Raja N (2013) Biopesticides and biofertilizers: ecofriendly sources for sustainable agriculture. *J Biofertil Biopestici* 4: e112.
3. Roser M, Ritchie H (2013) Hunger and undernourishment. *Our World in Data.* Available from: https://ourworldindata.org/hunger-and-undernourishment.
4. McGuire S (2015) FAO, IFAD, and WFP. The state of food insecurity in the world 2015: meeting the 2015 international hunger targets: taking stock of uneven progress. *Adv Nutr* 2015: 623–624.
5. Webb P, Stordalen GA, Singh S, et al. (2018) Hunger and malnutrition in the 21st century. *BMJ* 361: k2238.
6. Lernoud J, Willer H (2017) Current statistics on organic agriculture worldwide: area, operators, and market. In: *World of organic agriculture, statistics and emerging trends.* FiBL and IFOAM-Organic International, Frick and Bonn, 36–75.
7. Willer H, Lernoud J (2019) *The world of organic agriculture. Statistics and emerging trends*. Research Institute of Organic Agriculture FiBL and IFOAM Organics International, Frick and Bonn, 1–336.
8. Halberg N, Sulser TB, Høgh-Jensen H, et al. (2006) The impact of organic farming on food security in a regional and global perspective. In: *Global development of organic agriculture: Challenges and Prospects*. CABI Publishing, USA, 277–322.
9. Badgley C, Moghtader J, Quintero E, et al. (2007) Organic agriculture and the global food supply. *Renew Agr Food Syst* 22: 86–108.
10. Reganold JP, Wachter JM (2016) Organic agriculture in the twenty-first century. *Nat Plants* 2: 1–8.
11. Trewavas A (2001) Urban myths of organic farming. *Nature* 410: 409–410.
12. Schnug E, Haneklaus S, Rahmann G, et al. (2006) Organic farming-stewardship for food security, food quality, environment and nature conservation. *Aspects Appl Biol* 79: 57–62.
13. Connor DJ (2008) Organic agriculture cannot feed the world. *Field Crops Res* 106: 187.
14. Leifeld J, Angers DA, Chenu C, et al. (2013) Organic farming gives no climate change benefit through soil carbon sequestration. *Proc Natl Acad Sci* 110: E984.
15. Chauvin ND, Mulangu F, Porto G (2012) Food production and consumption trends in sub-Saharan Africa: Prospects for the transformation of the agricultural sector. UNDP Regional Bureau for Africa. New York, NY, USA, 1–76.

16. Tully K, Sullivan C, Weil R, et al. (2015) The state of soil degradation in Sub-Saharan Africa: Baselines, trajectories, and solutions. *Sustainability* 7: 6523–6552.
17. Stewart ZP, Pierzynski GM, Middendorf BJ, et al. (2020) Approaches to improve soil fertility in sub-Saharan Africa. *J Exp Bot* 71: 632–641.
18. Morshedi L, Lashgarara F, Farajollah Hosseini S, et al. (2017) The role of organic farming for improving food security from the perspective of Fars Farmers. *Sustainability* 9: 2086.
19. Röös E, Mie A, Wivstad M, et al. (2018) Risks and opportunities of increasing yields in organic farming. A review. *Agron Sustain Dev* 38: 14.
20. Crowder DW, Northfield TD, Gomulkiewicz R, et al. (2012) Conserving and promoting evenness: organic farming and fire-based wildland management as case studies. *Ecology* 93: 2001–2007.
21. Scialabba NEH, Müller-Lindenlauf M (2010) Organic agriculture and climate change. *Renew Agr Food Syst* 25: 158–169.
22. Sharma AK (2014) Organic agriculture programming for sustainability in primary sector of India: action and adoption. *Productivity* 55: 1–17.
23. Naveena KP, Arunkumar YS (2016) Consumer preference for organic food products in Southern Karnataka: an analysis of socio-economic factors. *Mysore J Agric Sci* 50: 202–206.
24. Singh A, Verma P (2017) Factors influencing Indian consumers'actual buying behaviour towards organic food products. *J Cleaner Prod* 167: 473–483.
25. Pellegrini G, Farinello F (2009) Organic consumers and new lifestyles: An Italian country survey on consumption patterns. *Br Food J* 111: 948–974.
26. Mohamad SS, Rusdi SD, Hashim NH (2014) Organic food consumption among urban consumers: Preliminary results. *Procedia-Soc Behav Sci* 130: 509–514.
27. Oroian CF, Safirescu CO, Harun R, et al. (2017) Consumers' attitudes towards organic products and sustainable development: a case study of Romania. *Sustainability* 9: 1559.
28. Setboonsarng S, Gregorio EE (2017) Achieving sustainable development goals through organic agriculture: empowering poor women to build the future. In: *Asian Development Bank (ADB), Southeast Asia Working Paper Series* 15: 1-26.
29. Stolze M, Piorr A, Häring AM, et al. (2000) Environmental impacts of organic farming in Europe. Universität Hohenheim, Stuttgart-Hohenheim, 1–143.
30. Stockdale EA, Lampkin NH, Hovi M, et al. (2001) Agronomic and environmental implications of organic farming systems. *Adv Agron* 70: 261–327.
31. Lotter DW (2003) Organic agriculture. *J Sustain Agric* 21: 59–128.
32. Gomiero T, Paoletti MG, Pimentel D (2008) Energy and environmental issues in organic and conventional agriculture. *Crit Rev Plant Sci* 27: 239–254.
33. Gomiero T, Pimentel D, Paoletti MG (2011) Environmental impact of different agricultural management practices: conventional vs. organic agriculture. *Crit Rev Plant Sci* 30: 95–124.
34. Rigby D, Cáceres D (2001) Organic farming and the sustainability of agricultural systems. *Agric Syst* 68: 21–40.
35. Purvis B, Mao Y, Robinson D (2019) Three pillars of sustainability: in search of conceptual origins. *Sustain Sci* 14: 681–695.
36. Park J, Seaton RAF (1996) Integrative research and sustainable agriculture. *Agric Syst* 50: 81–100.
37. McNabb DE (2019) Pathways to Sustainable Agriculture. In: *Global Pathways to Water Sustainability*. Palgrave Macmillan, Cham, 185–199.

38. Ton P (2013) Productivity and profitability of organic farming systems in East Africa. An Ifoam presentation at the East African Organic Conference, Dar es Salam, Tanzania, 1–60.
39. Kamali FP, Meuwissen MPM, de Boer IJM, et al. (2017) Evaluation of the environmental, economic, and social performance of soybean farming systems in southern Brazil. *J Cleaner Prod* 142: 385–394.
40. Cavigelli MA, Teasdale JR, Spargo JT (2013) Increasing crop rotation diversity improves agronomic, economic, and environmental performance of organic grain cropping systems at the USDA-ARS Beltsville Farming Systems Project. *Crop Manage* 12: 1–4.
41. Ndungu SK (2015) Economic analysis of smallholder organic vegetable production system in Kiambu and Kajiado counties of Kenya. Dissertation, Kenyatta University, 1–102.
42. United Nations Environment Programme (2008) Best practices for organic policy: what developing country governments can do to promote the organic agriculture sector. Available from: https://www.unenvironment.org/resources/report/best-practices-organic-policy-what-developing-countries-can-do-promote-organic.
43. Reganold JP (2016) Can we feed 10 billion peopleon organic farming alone? *The Guardian* 8–14.
44. Fess TL, Benedito VA (2018) Organic versus conventional cropping sustainability: a comparative system analysis. *Sustainability* 10: 272.
45. Seufert V, Ramankutty N, Foley JA (2012) Comparing the yields of organic and conventional agriculture. *Nature* 485: 229–232.
46. Rahman S (2002) Technological change and food production sustainability in Bangladesh agriculture. *Asian Profile* 30: 233–246.
47. Bengtsson J, Ahnström J, Weibull AC (2005) The effects of organic agriculture on biodiversity and abundance: a meta-analysis. *J Appl Ecol* 42: 261–269.
48. Jouzi Z, Azadi H, Taheri F, et al. (2017) Organic farming and small-scale farmers: Main opportunities and challenges. *Ecol Econ* 132: 144–154.
49. Kilcher L (2007) How organic agriculture contributes to sustainable development. In: Organic Aagriculture in the Tropics and Subtropics: Current status and Perspectives. Kassel University Press, Germany, 31–49.
50. Gattinger A, Muller A, Haeni M, et al. (2012) Enhanced top soil carbon stocks under organic farming. *Proc Natl Acad Sci* 109: 18226–18231.
51. Baker BP, Benbrook CM, Lii EG, et al. (2002) Pesticide residues in conventional, integrated pest management (IPM)-grown and organic foods: insights from three US data set. *Food Addit Contam* 19: 427–446.
52. Pimentel D, Hepperly P, Hanson J, et al. (2005) Environmental, energetic, and economic comparisons of organic and conventional farming systems. *Bio Science* 55: 573–582.
53. Ziesemer J (2007) Energy use in organic food systems. Natural Resources Management and Environment Department Food and Agriculture Organization of the United Nations, Rome, 1–28. Avaliable from: http://indiaforsafefood.in/wp-content/uploads/PDF/energy-use-oa.pdf.
54. Smith LG, Williams AG, Pearce BD (2015) The energy efficiency of organic agriculture: A review. *Renew Agric Food Syst* 30: 280–301.
55. Jespersen LM, Baggesen DL, Fog E, et al. (2017) Contribution of organic farming to public goods in Denmark. *Org Agric* 7: 243–266.
56. Lotter DW, Seidel R, Liebhardt W (2003) The performance of organic and conventional cropping systems in an extreme climate year. *Renew Agric Food Syst* 18: 146–154.

57. Mäder P, Fliessbach A, Dubois D, et al. (2002) Soil fertility and biodiversity in organic farming. *Science* 296: 1694–1697.
58. De Ponti T, Rijk B, Van Ittersum MK (2012) The crop yield gap between organic and conventional agriculture. *Agric Syst* 108: 1–9.
59. Lee J, Hwang S, Ha I, et al. (2015) Comparison of bulb and leaf quality, and antioxidant compounds of intermediate-day onion from organic and conventional systems. *Hortic Environ Biotechnol* 56: 427–436.
60. Kniss AR, Savage SD, Jabbour R (2016) Commercial crop yields reveal strengths and weaknesses for organic agriculture in the United States. *PloS one* 11: e0161673.
61. Suja G, Byju G, Jyothi AN, et al. (2017) Yield, quality and soil health under organic vs conventional farming in taro. *Sci Hortic* 218: 334–343.
62. Seufert V, Ramankutty N (2017) Many shades of gray—The context-dependent performance of organic agriculture. *Sci Adv* 3: e1602638.
63. Meemken EM, Qaim M (2018) Organic agriculture, food security, and the environment. *Annu Rev Res Econ* 10: 39–63.
64. Forman J, Silverstein J (2012) Organic foods: health and environmental advantages and disadvantages. *Pediatrics* 130: e1406–e1415.
65. Mie A, Andersen HR, Gunnarsson S, et al. (2017) Human health implications of organic food and organic agriculture: a comprehensive review. *Environ Health* 16: 111.
66. International Fund for Agricultural Development (2002) Thematic evaluation of organic agriculture in Latin America and the Caribbean. Avaliable from: http://www.ifad.org/evaluation/public_html/eksyst/doc/ thematic/pl/ organic.pdf.
67. Forster D, Andres C, Verma R, et al. (2013) Yield and economic performance of organic and conventional cotton-based farming systems–results from a field trial in India. *PloS one* 8: e81039.
68. Ponisio LC, M'Gonigle LK, Mace KC, et al. (2015) Diversification practices reduce organic to conventional yield gap. *Proc Royal Soc B* 282: 20141396.
69. Crowder DW, Reganold JP (2015) Financial competitiveness of organic agriculture on a global scale. *Proc Natl Acad Sci* 112: 7611–7616.
70. Sgroi F, Candela M, Trapani AMD, et al. (2015) Economic and financial comparison between organic and conventional farming in Sicilian lemon orchards. *Sustainability* 7: 947–961.
71. Bett EK, Ayieko DM (2017) Economic potential for conversion to organic farming: a net present value analysis in the East Mau Catchment, Nakuru, Kenya. *Environ Dev Sustain* 19: 1307–1325.
72. Bennett M, Franzel S (2013) Can organic and resource-conserving agriculture improve livelihoods? A synthesis. *Int J Agric Sustain* 11: 193–215.
73. Pergola M, D'Amico M, Celano G, et al. (2013) Sustainability evaluation of Sicily's lemon and orange production: an energy, economic and environmental analysis. *J Environ Manage* 128: 674–682.
74. Mohamad RS, Verrastro V, Cardone G, et al. (2014) Optimization of organic and conventional olive agricultural practices from a Life Cycle Assessment and Life Cycle Costing perspectives. *J Cleaner Prod* 70: 78–89.
75. Pérez-Escamilla R (2017) Food Security and the 2015–2030 Sustainable Development Goals: From Human to Planetary Health: Perspectives and Opinions. *Curr Dev Nutr* 1: e000513.

76. Food and Agriculture Organization. (1996) Rome Declaration on World Food Security and World Food Summit Plan of Action. Available from: http://www.fao.org/DOCREP/003/W3613E/W3613E00.HTM.
77. Aborisade B, Bach C (2014) Assessing the Pillars of Sustainable Food Security. *Eur Int J Sci Technol* 3: 117–125.
78. Kanu M (2018) Organic Farming - Stewardship for Sustainable Agriculture. *Agri Res Tech* 13: 1–7.
79. Udin N (2014) Organic Farming Impact on Sustainable Livelihoods of Marginal Farmers in Shimoga District of Karnataka. *Am J Rural Dev* 2: 81–88.
80. United Nations Conference on Trade and Development (2013) Wake up before it is too late: Make agriculture truly sustainable now for food security and changing climate. Geneva, Switzerland, 1–341.
81. Joppa LN, O'Connor B, Visconti P, et al. (2016) Filling in biodiversity threat gaps. *Science* 352: 416–418.
82. Bommarco R, Kleijn D, Potts SG (2013) Ecological intensification: harnessing ecosystem services for food security. *Trends Ecol Evol* 28: 230–238.
83. Tuck SL, Winqvist C, Mota F, et al. (2014) Land-use intensity and the effects of organic farming on biodiversity: a hierarchical meta-analysis. *J Appl Ecol* 51: 746–755.
84. Kennedy CM, Lonsdorf E, Neel MC, et al. (2013) A global quantitative synthesis of local and landscape effects on wild bee pollinators in agroecosystems. *Ecol Lett* 16: 584–599.
85. Schneider MK, Lüscher G, Jeanneret P, et al. (2014) Gains to species diversity in organically farmed fields are not propagated at the farm level. *Nat Commun* 5: 1–9.
86. Gabriel D, Sait SM, Kunin WE, et al. (2013) Food production vs. biodiversity: comparing organic and conventional agriculture. *J Appl Ecol* 50: 355–364.
87. Hodgson JA, Kunin WE, Thomas CD, et al. (2010) Comparing organic farming and land sparing: optimizing yield and butterfly populations at a landscape scale. *Ecol Lett* 13: 1358–1367.
88. Tuomisto HL, Hodge ID, Riordan P, et al. (2012) Does organic farming reduce environmental impacts?–A meta-analysis of European research. *J Environ Manage* 112: 309–320.
89. Leifeld J, Fuhrer J (2010) Organic farming and soil carbon sequestration: what do we really know about the benefits? *Ambio* 39: 585–599.
90. Howard SA (1940) An Agricultural Testament. Oxford University Press, New York, 228.
91. Lal RATTAN (2001) Soil degradation by erosion. *Land Degrad Dev* 12: 519–539.
92. van Huylenbroek G, Mondelaers K, Aertsens J, et al. (2009) A meta-analysis of the differences in environmental impacts between organic and conventional farming. *Br Food J* 111: 1098–1119.
93. Siegrist S, Schaub D, Pfiffner L, et al. (1998) Does organic agriculture reduce soil erodibility? The results of a long-term field study on loess in Switzerland. *Agric Ecosyst Environ* 69: 253–264.
94. Auerswald K, Kainz M, Fiener P (2003) Soil erosion potential of organic versus conventional farming evaluated by USLE modelling of cropping statistics for agricultural districts in Bavaria. *Soil Use Manag* 19: 305–311.
95. Stockdale EA, Shepherd MA, Fortune S, et al. (2002) Soil fertility in organic farming systems–fundamentally different? *Soil Use Manag*e 18: 301–308.
96. Watson CA, Atkinson D, Gosling P, et al. (2002) Managing soil fertility in organic farming systems. *Soil Use Manag*e 18: 239–247.
97. Grosso SJD, Cavigelli MA (2012) Climate stabilization wedges revisited: can agricultural production and greenhouse-gas reduction goals be accomplished? *Front Ecol Environ* 10: 571–578.

98. Skinner C, Gattinger A, Muller A, et al. (2014) Greenhouse gas fluxes from agricultural soils under organic and non-organic management—A global meta-analysis. *Sci Total Environ* 468: 553–563.
99. Meier MS, Stoessel F, Jungbluth N, et al. (2015) Environmental impacts of organic and conventional agricultural products–Are the differences captured by life cycle assessment? *J Environ Manage* 149:193–208.
100. Qin Y, Liu S, Guo Y, et al. (2010) Methane and nitrous oxide emissions from organic and conventional rice cropping systems in Southeast China. *Biol Fertil Soils* 46: 825–834.
101. Powlson DS, Whitmore AP, Goulding KW (2011) Soil carbon sequestration to mitigate climate change: a critical re-examination to identify the true and the false. *Eur J Soil Sci* 62: 42–55.
102. Lee KS, Choe YC, Park SH (2015) Measuring the environmental effects of organic farming: A meta-analysis of structural variables in empirical research. *J Environ Manage* 162: 263–274.