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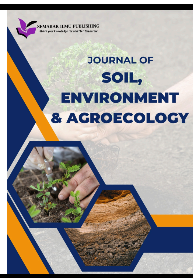

Agroecological Practices in Malaysia – Case Studies

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ABSTRACT

Agroecology is relatively a new term for local community in Malaysia. For agroecology practices to be widely accepted require better understanding of what it is, what are the agroecological attributes, and what are those elements in agroecology. In general, agroecology has ten elements, and it appears none or impossible nearly for any agricultural practices to fully comply with all these elements, but perhaps a combo high number of elements at certain degree of trade-off among those elements would be a feasible approach. In this study, we revealed some of the published practices available in Malaysia, as an example. The intention of the review effort is to reveal where we are currently, and how to move forward. Four case studies are discussed. First, agroecology approaches for cereal crops revealed up to four elements of agroecology have been implemented in the plantation, but also some elements remain unexplored. Second, a comparison has been made between the paddy cultivation by agroecology with conventional cultivation. Agroecology method in paddy farm have shown to save cost, environmentally friendly, and generate produced with better health benefit over the conventional method. Third, the examples of agroecological practices in oil palm plantation displayed many impressive solutions in line with agroecology, but similar with cereal crop practices that it has a limited inclusion of agroecology elements. Some of the agroecology elements can be explored further for implementation in agriculture are resilience, human and social values, culture and food traditions, responsible governance, and circular and solidarity economy.

1. Introduction

Agriculture is an important activity for food supply and food security in a country. However, an aggressive approach to maximum agricultural output without proper impact assessment on the input of chemical compounds utilization and soil physical modification to an agricultural land can be harmful in the long run. For instance, soil salinization due to excessive fertilizer usage. Additional example includes the disruption of ecosystem system balance between prey and predator may lead to a high number of rats requiring predators such as barn owl and leopard cat to counter measure the rodent pests in the field. In an ill-managed agricultural field, the topsoil layer goes through compaction due to loss of organic matter, including compaction by the usage of heavy machinery on site, thus, resulting in increasing running water on the soil surface and eventual soil erosion.

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An environmentally friendly way in managing agricultural field would be directed towards a sustainable agriculture approach. It includes social, environment, and economical aspects into the context of agriculture, however, sustainable agriculture places more emphasis in optimizing and balancing current farming practices for sustainability that often pay attention to technological oriented approach to minimize the environmental impacts. A step above sustainability would be the agroecology approach that rooted in ecological principles and social movements [1]. The measures employ in agroecology are directed towards a harmonize agricultural practices with ecology to achieve a sustainable future. It promotes a sustaining co-existence and interactions between humans, plants, animals, and environment in the presence of agricultural systems.

Agroecology consists of ten elements, and these elements are diversity, co-creation and sharing of knowledge, synergies, efficiency, recycling, resilience, human and social values, culture and food traditions, responsible governance, and circular and solidarity economy [2]. The challenges faced in implementing agroecology are vast. For instance, Prost *et al*., [3] state that farm transition to agroecology would require the involvement of the farm level in exploring futures, farmer creativity stimulation, address power dynamics, research that is more holistic and dynamics assessment frameworks, and emphasizing on-farm experiments, and developing new tools for monitoring transitions. For a sustainable agriculture and food system, Ewert *et al*., [4] pointed out that a fully integrated multiscale systems approach from farm to region and then globe is necessary. At all scales should consider actors, drivers, stakeholders including agroecology approach that is economically viability for farmers and other food system actors, as well as inclusion of promising technologies in the agroecology transformation. In addition, the work by Bezner Kerr [5] reaffirmed the agroecological approach as a transformative way for food systems, that agroecology has adaptive and mitigative potential on climate risk and also to support human health, address food security, balance diet and nutrition in the context of socio-cultural perspective. Their work concludes upscaling agroecology requires planning, policy support and further investigation. Agroecology implementation faces many challenges, not only from consumer to producer, but also from policy maker, practices employed in the field, stakeholders, and so on, that fit within the framework of social, economic, and environment.

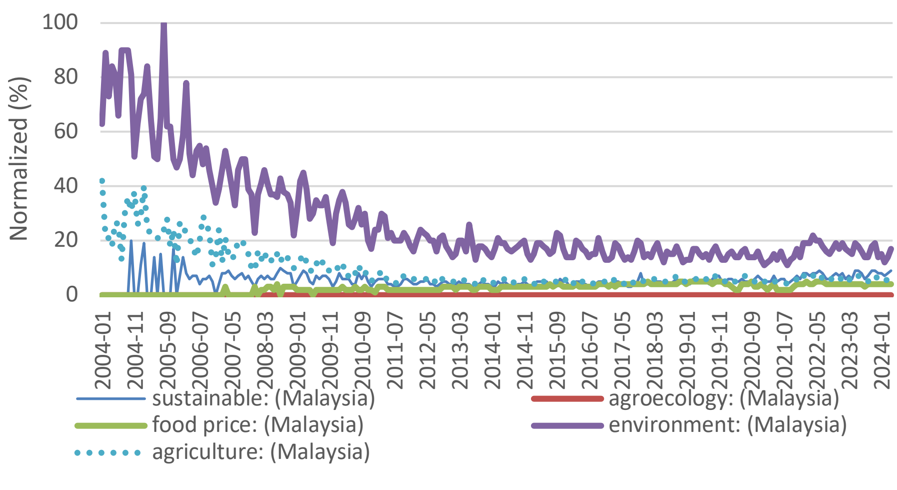

Fig. 1. Google trends in Malaysia based on search keywords (sustainable, food price, agroecology, environment) from year 2004 to April 2024 [6]

In Malaysia, the term agroecology remains the least search term in the internet by many when compared relatively to other terms like environment, agriculture, and so on [6]. Figure 1 demonstrates term environment is highly search by Malaysian which pointing to local familiarity of the concept and awareness. Then sustainable term came second before agriculture on third in recent time. The keyword "food price" is slowly gaining attention from the public as it steadily increases over time until recently, which is in line with the gradual increment of food price in the market. When Malaysia is to compare to the country of the most environmentally friendly country like Denmark, their term environment remained the highest with the term sustainability is significantly inclines towards the environment term than that of the agriculture term (Fig. 2) [7]. Like Malaysia, the term agroecology remained the least in the google search. Evidence suggests that agroecology is unpopular searched word to public even in a highly environmentally friendly country like Denmark.

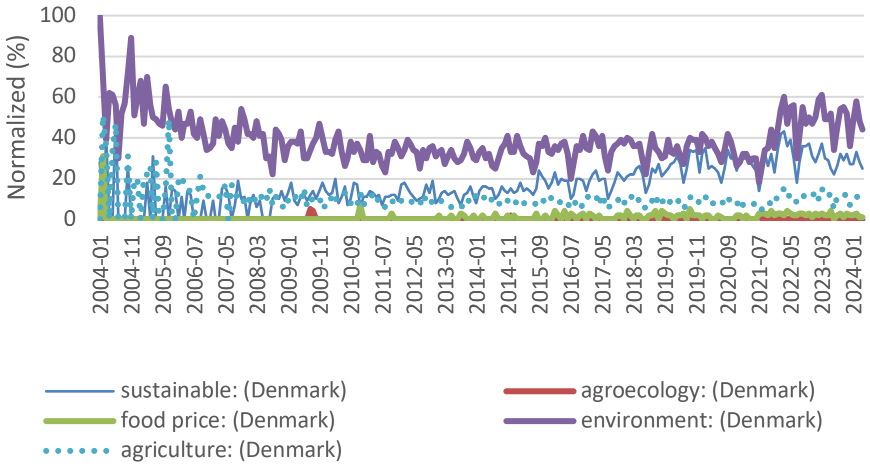

Fig. 2. Google trends in Malaysia based on search keywords (sustainable, food price, agroecology, environment) from year 2004 to April 2024 [7]

Agricultural activities leaning towards agroecology is still very limited in Malaysia. In a new global economy, agricultural management with strong emphasis on the environment and even a strong focus on ecological principles will very much become a new norm of a desirable practice in the future. The intention of this review is to compile, identify, and discuss the success practice of agroecology in Malaysia context so that such information can be easily understood and applied by more local practitioner in the field. Thus, the current work has highlighted the findings of the latest scientific manuscript published on agroecology reported on Malaysia in agricultural activities. Four previous works relating to agroecology have been identified, and they are discussed in the following sections to point out those practical aspects of agroecology that can be emulated by other field practitioners such as farmers.

2. Agroecology Approaches for Cereal Crops

Like any other agricultural system, cereal crops face the need to increase in productivity for local consumption. Often time, high external input with resource intensive application is used to achieve the productivity that could lead to unwanted environmental consequence such as soil degradation and loss in biodiversity [8]. Since soil is associated with soil organic carbon, a degrading soil leads to release of carbon dioxide, a form of greenhouse gases [9], that not only an indication of losing a fertile soil but it initiates a chain of environmental problems including loss in biodiversity. A sustainable ecosystem consists of diverse plant species would be able to supply goods and provide services [10], yet the agroecological practices and its interaction with the environment in the perspective of cause and effect require further study for confirmation [11]. Nonetheless, it is generally accepted to assume climate change will reduce the production from cereal crops [12].

A compilation of previous work on cereal crops by Sethuraman *et al*., [13] have demonstrated the implementation of agroecology elements at different countries. It was found that the number of elements applied could vary from one to a maximum of four elements (Fig. 3). The wheat-soybean in the United States implemented diversity element of agroecology, while the wheat-maize-soybean in China applied efficiency agroecology element. Similarly, single element implemented for cactus-sorghum in Brazil. The element was efficiency. Among the cereal crops list out in the figure, Amaranth/Maize-Legumes in Germany successfully implemented four elements of agroecology. They were diversity, efficiency, synergies, and recycling. Malaysia was included under the rice production, as combined with countries such as Indonesia, Thailand, Vietnam, and Cambodia, with the implementation of two elements. The elements were co-creating and sharing knowledge, and synergies [14]. Co-creation knowledge involves blending of traditional and indigenous knowledge, producers' and traders' practical knowledge, and global scientific knowledge. Synergy of agroecology refers to the need for integrated approach to address multiple aspects (e.g. plants, animals, trees, soil and water) at the same time, while in transition to focus on partnership, cooperation, responsible governance, connecting stakeholders at multiple levels [15].

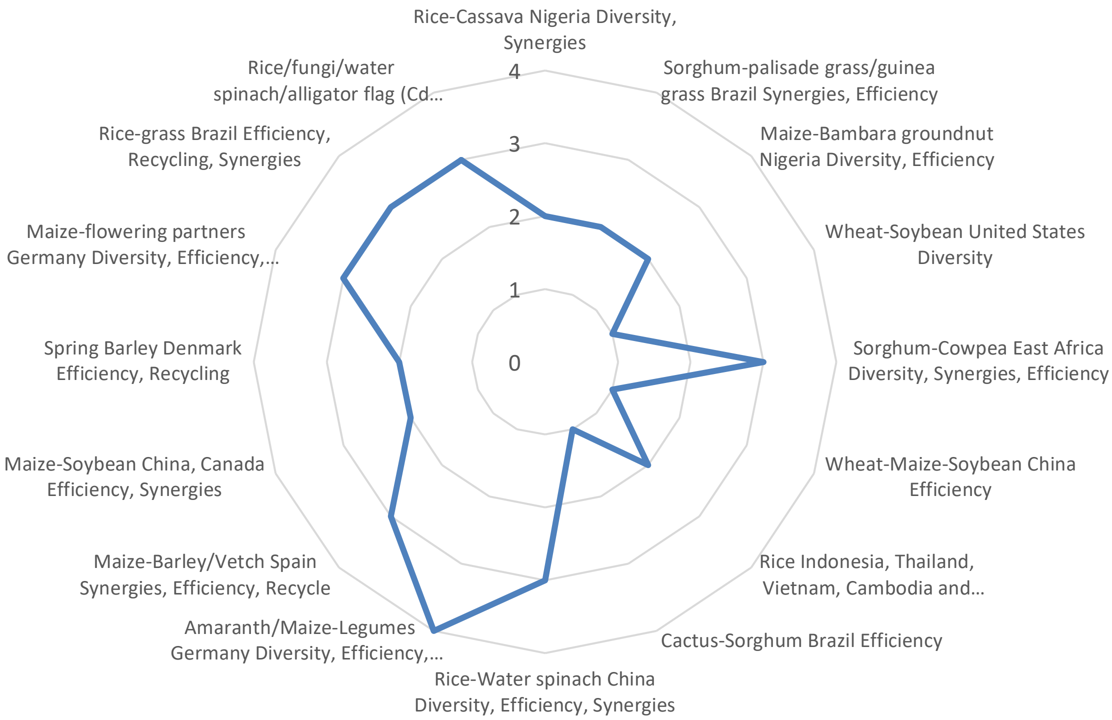

Fig. 3. Elements of agroecology applied in cereal crops at different countries. Retrieved from Sethuraman *et al*., [13]

Among the ten elements of agroecology, only five elements were identified and listed out in Fig. 3. They were efficiency, synergies, diversity, recycling, and co-creating and sharing knowledge. The frequently applied element identified on cereal crops was efficiency and it was implemented 13 times for different crops and countries. It was followed by synergy at 11 times, diversity at 8 times, recycling for 4 times, and co-creating and sharing knowledge for one time. Efficiency element of agroecology refers to the minimal external input or none to achieve optimum productivity [16]. Chemical fertilizer is commonly used in agricultural field to increase productivity, due to its proven effectiveness and controllable chemical quality and quantify to often give consistent results. Another contributing factor is the subsidy provided by the government as a method to ensure food security using chemical fertilizer is in a way discouraging the element of efficiency in agroecology [17]. An integrated approach through synergy is indeed another element of agroecology easily benefited by having multiple practices working inline together to achieve a common outcome. For example, managing the agricultural field with conservation tillage enhances soil organic matter [18] leading to a better nutrient storage [19], greater soil water storage capacity [20], reduce daily soil temperature fluctuation, reduce soil erosion [21], and so on. Diversity is obtained when multiple species of cereal crops are planted in the field rather than a single species. Diversity is believed to provide better advantages is increasing agricultural field resilience in time of unpredictable conditions like climate change [22]. A typical example of recycling is rice straws back in the field to replenish soil nutrients [23]. As stated previously, co-creating and sharing knowledge is the incorporation of traditional, indigenous and scientific knowledge for agricultural site improvement and productivity [24].

Other than the five elements stated in previous paragraph, there are other elements of agroecology that are not included in the cereal crops agricultural field implementation. They are resilience, human and social values, cultural and food traditions, responsible governance, and circular and solidarity economy. Thus, it suggests great deal improvement opportunities are available for exploration and implementation in the cereal crops.

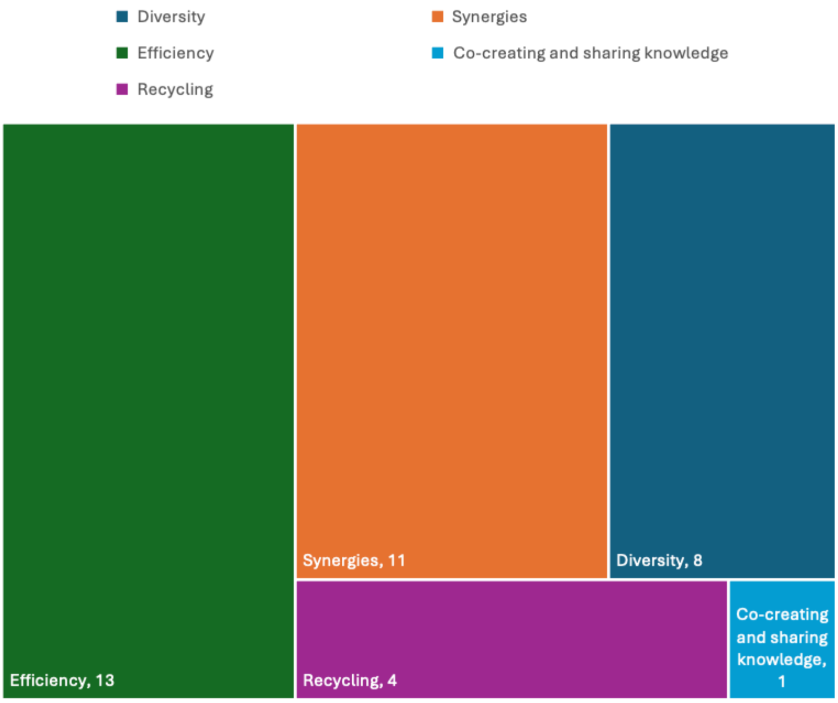

Fig. 4. The number (or frequency) of agroecology elements implemented in the agricultural activities for cereal crops. Retrieved from Sethuraman *et al*., [13]

3. Paddy Cultivation by Agroecology versus Conventional Cultivation

Rice farming is conventionally carried out without much attention to the practice of agroecology. A method in line with agroecology is the system of rice intensification (SRI). Typical/conventional farming is often conducted without seed selection or treatment, whereas method in agroecology the seed would be inundated for a day before seeding, so that it could segregate viable from nonviable seeds. Conventional method in nursery management is flooded with water, and seeds are densely seeded in the nursery, which in contrast with method of agroecology that practice unflooded nurseries with raise beds and sparsely seeded field. A 130 to 500 plants per square meter in conventional compared to less than 16 plants per square meter in agroecology. In terms of water management conventional method uses continuous flood field as compared to alternate wet and dry in agroecology practice. In weed control using mechanical weeding or herbicides whereas hand weeding in agroecology method. Fertilization is commonly relied on chemical based, while agroecology uses organic based fertilizer with complementary from chemical based when needed.

A case study has been presented by Er *et al*., [25] in comparing conventional method in farming paddy and agroecology method. A number of incentives given by the authorities have been pointed out that are Federal Government's Rice Fertilizer Scheme, Rice Production Incentive Scheme, Legitimate Rice Seeds Incentive, Rice Production Incentive Scheme, Yield Improvement Incentive, Minimum Guaranteed Price, and Rice Price Subsidy Scheme [26]. Some of these subsidies could be counteractive to agroecology, for instance, the fertilizer scheme would lead to continuous usage of chemical fertilizer without incentive for organic fertilizer as desirable in agroecology practice. Seed incentive was leaning towards monoculture practice, and rice production incentive on ploughing aid may not encourage farmers exploration into conservative tillage that is more agroecologically friendly approach.

Agroecology practices in a field offer an environmentally friendly approach working in harmony with the social and economic systems. Below are few of the implications of agroecology field worth mentioning:

- A self-sustaining system can be resulted by combining biological with ecological processes, and it complements one another.
- Synergistic effect of ecological and social dimensions can enhance the biological self-sustaining system to result in a better social capital like wood supply, fruits, and so on.
- A self-sustaining system would reduce the requirement of nonrenewable inputs, for example, costly external input such as chemical fertilizer or chemical pesticides.
- A self-sustaining system would in some ways increase the system flexibility in handling external stress like climate change, thus, it increases farmer's farm resilience.
- A resilience system typically embraces practices of agroecology, for example, abundance in soil organic carbon by mulches, plant diversity, conservative tillage, and so on.
- Co-existence of the sustainability pillars as in social, environment, and economic working to complement each other with minimal contradictions and limited trade-offs.

In a similar way, the rice farming using agroecological methods, or better known as the System of Rice Intensification (SRI), offers many potential benefits over the conventional farming method. Below are few of the benefits of agroecology in rice farming:

- It plants early and quickly.
- Low plant density in an area for better plant growth by reducing competition for essential items like sunlight, water, and nutrients.
- Soil in the field high in soil organic matters for better water field capacity and nutrient retention, reduce compaction, thriving organism, hence, optimum medium for root growth and expansion.
- Soil is only provided with adequate water supply and sustaining adequate soil aeration.
- Farm develops through local available resources to minimize external inputs.
- Recycling of waste in-situ to generate and return as organic fertilizer to the farm. Thus, chemical fertilizer can be partially, if not completely substituted, with on-site organic fertilizer to reduce farmer cost.

- Synergistic effects of various nature compliance processes to tend increase farm resilience on disease infection, including pest.
- The synergistic effects also result in better rice yield.
- Synergy also includes co-cultures like farming rice and fish in the same farm so that fish wastes supply as natural fertilizers, while the organic rice farm free from harmful chemicals provide sanctuary grounds for breeding snails and insects for fish food. Co-cultures include others such as rice-frog, rice-duck, and some other double or triple combinations.

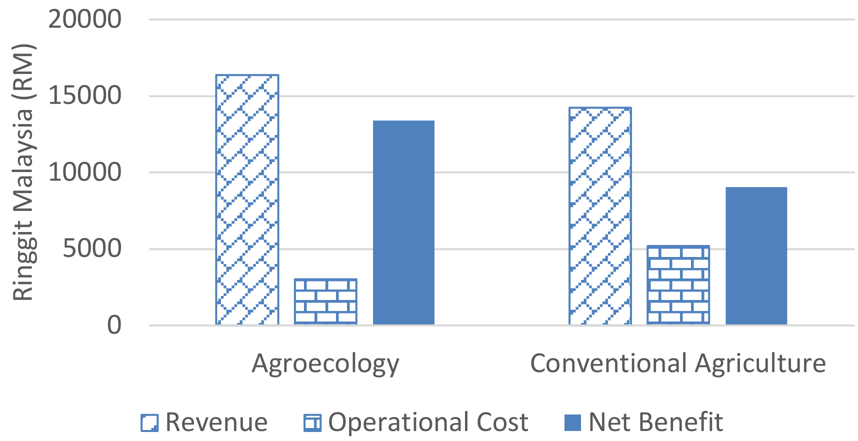

Fig. 5. The revenue, operational cost, and net benefit of agroecological practices compared to conventional rice farming methods. Data retrieved from Er *et al*., [25]

A comparative cost-benefit analysis (CBA) between agroecology and conventional methods on rice farming was conducted by Er *et al*., [19]. The study examined methods over 12 months farming period and the overall results are shown in Fig. 5. The study revealed the revenue from agroecology practices in rice farming was greater than the conventional agricultural practice. The benefit of agroecology was further enhanced when the cost of operating the farm using agroecology method appeared less than the conventional agriculture. Hence, the difference between revenue and operational cost revealed the net benefit of agroecology practice greater than conventional agriculture.

The summary of the findings from Er *et al*., [19] can be summarized as follows:

- Agroecology practice in race farming appears to increase yield productivity than conventional method.
- The yield productivity increment was based upon beginner practitioner of agroecology method. An experienced practitioner of agroecology will further enhance the productivity more.
- The increase in yield productivity can help to reduce the need for government subsidy in Minimum Guaranteed Price.
- Agroecology practice does not need tillage on soil, thus reducing labor cost. In case tillage and soil levelling are needed, they are needed with less frequency than conventional method.
- Seedling in agroecology method is cheaper by manual transplanting, whereas conventional method using broadcasting method require more seeds, hence increase the cost.
- Pest control by agroecology such as rearing duck as natural pest control is cost saving while harvesting eggs and meat from it.

- In terms of external input such as fuel consumption as in ancillary cost for machinery, consumption in agroecology is lesser than conventional method.

4. Factors Determining Successful Implementation of Agroecology Attributes on Vegetable Farmers

Agroecology is a relatively new term for farmers. Yet some of the agroecology practices are no alien to farmers, for instance, water consumption efficiency, using less or no synthetic pesticides, organic fertilizer, and some other related practices. These practices can be classified as sustainable agricultural practices, which are subsets of agroecology practices. After going through literatures, Tey *et al*., [27] identified six major factors determine the successful implementation of agroecology attributes on vegetable farms. The factors are socioeconomic, environment, organization, information, psychology, and perceived attributes. The agroecology attributes studied by Tey and his coworkers were conservation tillage, integrated pest management, organic fertilizers or compost, crop covers or mulches, crop rotation, and intercropping. These attributes were further refined to subsets contributing to the main attribute. As an example, organization factor was defined by member in institution, certification program participation, and organization participation. In their studies, the relative importance of the factors relation to the agroecology attributes were quantified.

The study was conducted on five regions of Malaysia, which covered lowlands and uplands covering agricultural activity that is intensive open farming. East region of Malaysia, as in Sabah and Sarawak as baseline for comparison, while Northern, Central, Southern, and Eastern in the region of Peninsular Malaysia.

Unsustainable agriculture is associated with non-renewable resources such as petrol, chemical fertilizer, chemical pesticides, and so on. Excessive chemical usage is often associated with produce exceeding maximum residual levels, water resources contamination, aquatic livestock contamination, which will eventually find its way to human body [28,29]. Thus, identifying factors with significant influence on agroecology attributes may help with decision in streamlining policy towards agroecology adoption.

Financial capital and access to finance appears top the list in affecting conservation tillage (Table 1). It appears that when the greater finance capital and access is available, the greater the conservation tillage implementation. Conservation tillage refers to limited soil tillage to reduce soil aggregate disruption, plant residues on soil surface, and reduce occurrence of soil erosion [30]. Farm size and practice organic farming came in third and fourth strong positive relations. It could be that farmer with greater farm size is well informed the benefit of having conservation tillage that conserve the soil quality. Farmer practicing organic farming could be aware of the benefit in using compost from the reuse on-site agricultural wastes not that it is environmentally friendly but to reduce the cost from using fertilizer. It appears that farmers from northern and east coast regions are inclined to conservation tillage than other regions. Farmers society and cooperation increased the likelihood of conservation tillage adoption [31]. To lesser extent conservation tillage depends on usefulness of information, intention to adopt, and compatibility. The information usefulness is referred to informal way like farmer’s mouth-to-mouth sharing, and formal way such as extension services by authorities, universities, etc. The usefulness includes easily accessible information, easily understandable information, and relevant information, thus, likely adoption. However, a high number of full-time labourers appear to discourage conservation tillage adoption and the reason for such observation is not known. In addition, the perceived relative advantage of conservation tillage does not encourage implementation, and similarly, the reason is unknown.

Intercropping is strongly driven by farmers who are married, and easy access to finance. The land used for long duration in farming is likely to practice intercropping. The practice is dominance in decreasing order from Southern to Central, Northern, and East coast regions of peninsular Malaysia. As in conservation tillage, information usefulness is affecting intercropping adoption. To a lesser extent, adoption in intercropping occurred when it is perceived compatible with farmers practices. Female farmers tend to increase the likeliness of intercropping practice. Surprisingly, high working hours in on-farm impedes the practice of intercropping, while flat land appears discouraging intercropping.

Cover crop or mulches is highly depending on gender like male and formal education of farmer. When land is farmed with living livestock, it increases the likeliness of cover crop practice. East coast region implements cover crop more likely than other regions. Farmers with land ownership practice cover crop than those farmers practicing land renting. This is followed by organizational membership and habit. Those with negative relations on cover crop practices are married farmers, lowlands, Southern, Central regions, and participation in a certification program.

Table 1
Factors affecting agroecology attributes of conservation tillage, intercropping, and cover crop or mulches

	Conservation tillage	Intercropping	Cover crop or mulches
Positive relation	1. Financial capital 2. Access to finance 3. Farm size 4. Practice organic farming 5. Northern region 6. East coast region 7. Organizational member 8. Usefulness of information 9. Intention to adopt or continue using 10. Compatibility	1. Married 2. Access to finance 3. Duration of land used for farming 4. Southern region 5. Central region 6. Northern region 7. East coast region 8. Usefulness of information 9. Compatibility	1. Male 2. Formal education 3. Keep livestock on farm 4. East coast region 5. Land ownership 6. Organizational member 7. Habit
Negative relation	1. number of full-time labourers 2. Relative advantage	1. Male 2. On-farm working hours 3. Flat land	1. Married 2. Lowlands 3. Southern region 4. Central region 5. Participation in a certification program

Note: Information retrieved from Tey *et al.*, [27]

Crop rotation is another agroecology practice, and its adoption strongly depends on formal education (Table 2). The dependence, in decreasing order, on crop rotation are factors such as financial capital, farm size, environmental issue, and so on. Nonetheless, the perceived complexity of crop rotation practice does not deter farmers adoption. Like conservation tillage, crop rotation is negatively related to the number of full-time labourers, flat land, and so on.

On organic fertilizer or compost, male, financial capital, and access to finance are three most dominance factors. Farmers involvement in as organizational member plays an important role in implement compost in farmland. Also, intention to adopt, strong habit, and perceived compatibility will enhance organic fertilizer adoption. Nevertheless, farm composting is negatively related to age, institutional participation, and perceived relative advantage.

Table 2
Factors affecting agroecology attributes of crop rotation, organic fertilizer or compost, and integrated pest management

	Crop rotation	Organic fertilizer or compost	Integrated pest management
Positive relation	1. Formal education 2. Financial capital 3. Farm size 4. Presence of environmental issue 5. Duration of land used for farming 6. Southern region 7. Relative advantage 8. Complexity	1. Male 2. Financial capital 3. Access to finance 4. Southern region 5. Northern region 6. Organizational member 7. Intention to adopt or continue using 8. Habit 9. Compatibility	1. Male 2. Keep livestock on farm 3. Southern region 4. Participation in a certification program 5. Usefulness of information 6. Intention to adopt or continue using 7. Habit
Negative relation	1. number of full-time labourers 2. Flat land 3. East coast region 4. Intention to adopt or continue using	1. Age 2. Institutional participation 3. Relative advantage	1. Farming experience 2. Flat land 3. East coast region 4. Relative advantage 5. Compatibility 6. Complexity

Note: Information retrieved from Tey *et al.*, [27]

5. Oil Palm Plantation: Example of Agroecology Practices

Palm oil is one of the largest vegetable oils consumed in the world. The plantation is often found in tropical forests and peatland areas, where it has important sanctuary for biodiversity and carbon storage. Conversion of the land into palm oil plantation will lead to loss of biodiversity [32] and release of greenhouse gases that may contribute to climate change. In responding to the need of reducing ecological impacts, and to create a better future for all stakeholders, agroecological practices seem to be a reasonable approach for implementation because it covers social, environment, economics with strong emphasis on agriculture activities. Bessou *et al.*, [33] layout gather a few examples of agroecology practices applied in the oil palm plantation. The success stories are good examples can be emulated by other oil palm plantation.

Recycling of energy and materials in the oil palm plantation is perceived beneficial in the aspect of economics and environment. The oil palm complete cycle of 25 years needs frequent influx of energy and materials, while it is generating continuous outflux. Any output that leaves the process chain will result in the wastage form of either energy or materials. Recycling could reap potential benefits in reducing input need and shield the environment from degrading substance that could pollute water resources in rivers or ocean. Additional benefit includes fertilizer partial replacement because recycling materials may contain high amounts of natrium, potassium, magnesium, and so on. Plant uptake from these materials limit the chain reaction leading to the release of greenhouse gases and some other environmental problems such as eutrophication, acidification, and resource depletion. Plant fibres, shells, kernel cracking, and palm oil mill effluents recycling could result in reducing methane emission by biogas captured and reused for on-site or off-site electricity, thus reduce fossil fuel consumption. These materials can also be used for compost formulation as fertilizer to replace chemical based fertilizer. Some other benefits of recycling materials include the soil organic matters improvement by empty fruit bunches for better soil water holding capacity [34], soil heat insulation, nutrient holding ability, hence, soil fertility [35].

Empty fruit bunches, which conventionally assumed as solid wastes, are generated as part of the palm oil production. One tonne palm oil production resulted in one tonne empty fruit bunches [36]. A conventional handling of empty fruit bunches would be landfilling disposal and incineration. However, realizing the intrinsic nutrient values as fertilizer, and its harmful effects to result in water and air pollution when handle in a certain way like burning, a more environmentally friendly approach is required to reduce any potential harmful effect and greenhouse emission. Empty fruit brunches are a useful substance to improve soil quality. It can be used as mulches on topsoil, due to its natural degrading organic matters. It contained high value of nutrients, when applied on soil, the gradually degrading substance provides slow release of essential nutrients for plant uptake for growth and benefiting organisms living within and above the soil. When empty fruit bunches are used in complement with mineral fertilizer, it has shown improvement in soil chemical properties such as organic carbon, nitrogen, phosphorus, and CEC [37]. Physical improvements include soil permeability increase for better water penetration and drainage, the ability for soil water holding ability for plant used, and better flocculation of soil particles for better soil resistance towards erosion [38]. In biological perspective, soil organic matter contributes part of the necessity in improving soil condition for cultivating diversity of plant and organisms, as medium to prolong carbon storage, and support primary production [39].

Compost is an effective method in handling oil palm solid wastes like empty fruit bunches. Compost refers to the transformation organic matter biologically by microorganisms succession known as degradation on organic matter into stabilize humus, nutrients, and soil carbon [40]. The process of composting can include other substances like palm oil mill effluent, ashes, and decanter cake. Bukhari *et al*., [41] reported an estimate of 63.18 M tonne of palm oil mill effluent and 7.26 M tonne of empty fruit bunches produced in 2013, Malaysia. Co-composting of empty fruit bunches and palm oil mill effluent is an effective method to achieve total recovery on all chemical elements [42].

Pest affecting oil palm, Rhinoceros beetle, is common in Southeast Asia [43]. The decaying oil palm left over on the field is a suitable breeding ground the beetle. It affects the palm growth and yield, and in severe condition it causes palm death. Burning measure is not recommended because of environmental problem it creates and the need to fulfil the principles and criteria of Roundtable on Sustainable Palm Oil (RSPO). Chemical treatment is common [44], but it causes environmental [45] and health problems. A synergistic approach includes the use of empty fruit bunches as attraction together with pheromone to increase catches up to two or four times than single method approach [46]. The use of such method without any toxic insecticide could reduce damage up to 90 percent. However, a wider range of synergistic approach such as empty fruit bunches, pheromone, and biopesticides may be a more effective combination [47].

Another pest control management worth mentioning is the rats that feed on oil palm fruit pericarp, apical tissue, immature palm petiole bases [48]. Conventional treatment is expensive anticoagulant rodenticides, which may reach unintended target living being. Increasing resistance to the chemical usage has been reported [44]. An environmentally friendly approach would be the use of barn owl in the oil palm plantation to feed on rats [49]. Although the effectiveness of rat population dynamics impacted by barn owl is not conclusive, combo predators such as felids, civets, and mongooses have been reported play a vital role in controlling the population dynamics [50].

6. Conclusion

Agroecology has ten elements in it. Of those elements, diversity, co-creation and sharing of knowledge, synergies, efficiency, and recycling are common elements placed into agricultural practices. The remaining elements such as resilience, human and social values, culture and food traditions, responsible governance, and circular and solidarity economy are yet to received wider acceptance. Four published examples of good agroecological practices have been discussed. Agroecology approaches for cereal crops have revealed that there are few elements remained untouched in cereal crops plantation practices, which explain a lot more opportunities for improvement in those elements. When paddy cultivation by agroecology with conventional cultivation, it appears agroecological practices outperform conventional methods in many ways such as cost of running farm with little or none of the subsidies, environmental benefits, including social aspects of farmers such as better health, community involvement in sharing knowledge, diversity in income sources, and better soil productivity in sustainable farming. While on agroecology attributes on vegetable farmers in Malaysia, it turns out that only conservation tillage, integrated pest management, organic fertilizers or compost, crop covers or mulches, crop rotation, and intercropping are assumed dominance representative of sustainable agriculture, and yet they are just subsets of agroecological practices. Factors like male, access to finance, financial capital, and formal education appeared frequently in determining the success of implementing agroecological practices. Lastly, the examples of agroecological practices in oil palm plantation do reveal some good practices in line with agroecology. For example, recycling of materials and energy, empty fruits bunches in improving soil quality, co-composting of empty fruit bunches and palm oil mill effluent, and biological controls on insects and animals. Although the achievement is impressive, it reveals very primitive exploration of agroecological practices that have a lot more areas for improvement, as in resilience to climate change, human and social values like female and disadvantage local community, culture and food traditions, responsible governance as in stakeholders' consultation, and circular and solidarity economy like sustainability in self-sufficiency with reducing import.

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