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Article · March 2020

DOI: 10.5923/j.ijire.20200401.02

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International Journal of Inspiration & Resilience Economy 2020, 4(1): 10-15
DOI: 10.5923/j.ijire.20200401.02

Sustainable Practices in Agroecology for Adapting to Climate Change

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Abstract Climate change and meteorological disasters with growing population and malnutrition require new ways of ensuring the quality of life of people and local communities. However, to ensure life quality, sustainable practices have to be more efficient with less environmental impact. Agroecology as a science and practice of sustainable local development encompasses diverse approaches to designing and managing sustainable agroecosystems that make environmental, economic and societal benefits possible. The article presents sustainable practices in agroecology that are recognized in Slovenia through literature review, focus group, fieldwork and case study. As such practices are less expensive and technologically less demanding, they have practical value in other parts of the world, especially in less developed countries, which are most affected by the negative effects of climate change and poverty.

Keywords Agroecology, Sustainable Development, Self-sufficiency, Climate change, Survey 123, Educational Polygon for Self-sufficiency Dole

1. Introduction

The global mean temperature in 2018 is approximately 1 ℃ above the pre-industrial era and the period 2015–2018 is the warmest period since the beginning of meteorological measurements (World Meteorological Organization, 2019). The main factor for the rising temperature and its consequential negative influence on climatological and meteorological phenomena is the increase in the amount of greenhouse gases, so with its further increase, temperature and its negative effects will rise even more (IPCC, 2013 a). Scientists estimate that by 2100 temperatures could rise by between 1.5 and 4 ℃ compared to the pre-industrial period (IPCC, 2013 b).

The negative impact of rising temperatures is reflected in the bio-physical and socio-economic dimensions of space, as variable weather and meteorological disasters are detrimental to the environment, habitats and biodiversity, as well as to infrastructure, economy and human health. Perhaps the most dangerous consequence is increasing limited capability of communities to satisfy basic needs such as needs for food and water. After a longer decline, the number of malnourished people is rising again, so in 2017 there were 821 million people with insufficient food access, which scientists attribute to climate change. Particularly at risk are African countries with a large proportion of the rural population, where the number of undernourished has doubled in 2017 (World Meteorological Organization, 2019). In addition to climate change, food production faces the challenge of meeting the needs of ever-growing population. There were about 1 billion people during the Industrial Revolution, and approximately 7.5 billion 200 years later today. Trends indicate that by 2100, nearly 11 billion people will live on Earth. The countries with the highest population growth rate are again in Africa (Our World in 2019).

Despite political agreements and technological inventions, scientists warn that humanity is not on track to meet targets to reduce the negative effects of climate change (World Meteorological Organization, 2019). Rapid and drastic actions are needed, if further warming and negative impacts are to be avoided, since carbon budget is limited to approximately a decade with western modern lifestyle (IPCC, 2018).

Because of the increasing negative effects of climate change, population growth and malnutrition, especially in poorer countries, food production systems have to be more resilient, more profitable, cheaper and more environmentally friendly. These conditions are met by agroecology, which as a transdisciplinary activity encompasses natural and social sciences, co-natural and traditional farming methods, and social movements for selfsufficiency, environmental protection and local development (Wezel et al., 2009). The origin of agroecology dates to the beginning of the 20th century, with the aim of producing, processing, distributing and consuming quality food, raw materials, products,

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Published online at http://journal.sapub.org/ijire

services and energy in an environmentally and socially responsible way. In addition to sustainable supply of goods, the concept also includes the provision of other ecosystem services such as climate change mitigation and green job creation, which contributes to the integrated development of regions (Vovk Korže, 2017; Davidovič, 2018).

The article presents a case for agroecology as means for promoting sustainable lifestyle and regional development adapted to climate change. The agroecological approach is particularly suited for economically and technologically less developed countries, which are characterized by low levels of self-sufficiency and high susceptibility to the negative effects of climate change.

The research of useful agroecological practices is focused on agricultural northeastern Slovenia, where vineyards and orchards are located on sunny south facing slopes, and grasslands with wheat, maize and industrial plants fields are in wider valleys. Small self-sufficient farming is predominating. Despite some favorable agricultural conditions, there are also constrains which can be understood as the reason for introducing agroecological practices. Droughts and storms with strong winds and hail regularly occur in summer and frost harms vegetation in spring, also landslides are more likely on steeper slopes and flooding arises on plains. These problems reinforce with climate change.

2. Sustainable Practices for Climate Change Adaptation

In agroecology, the key is the application of the fundamental principles of ecology to the research, design and management of agroecosystems that are profitable and economical with natural resources and culturally considerate, socially just and economically viable (Altieri, 1995). Agroecosystems are units of natural resources management that can be at the level of a single cultivated plot, the whole farm or the complete agricultural region. At all levels of agroecosystems, the use of a scientific ecology and ecosystem approach is crucial. That involves reducing energy and matter losses through feedback loops, especially with composting biomass for ensuring soil health and introducing diverse varieties of plants and animals and their useful interactions (Reijntjes et al., 1992 in Altieri, 2002). Promoting biodiversity is of utmost importance as ecosystem services, including the supply of healthy food and climate change mitigation, are associated with greater diversity of organisms (Liere, Jha and Philpott, 2017).

An ecosystem approach is associated with locality, that is with specific resources and constraints of space for the development of agroecosystems. Similarity between agroecosystems and the natural ecosystem in a given biogeographic region makes the agroecosystem more likely to be sustainable (Gliessman, 2000; Francis et al., 2008). Using locally available resources and combining different components such as plants, animals, soil, water, climate and humans to complement each other reduces dependence on external inputs and non-renewable resources, thus promoting the sustainable development of the space (Altieri, 2002). Consequently, because of this uniqueness this implies "locally specific management of agroecosystems … there is no universal formula or technique" (Vovk Korže, 2017, 6).

In addition to local natural resources, local traditional knowledge and skills, which have been developed in a specific environment and tested over a long period of time, are also essential. Such knowledge and skills represent a sustainable coexistence of society in nature and enable the efficient use of natural resources or can replace additional inputs of energy, matter and money into agroecosystems (Dalgaard et al., 2003; Gliessman, 2007). Some of the traditional knowledge and skills encompass simple methods and tools for water and soil conservation and management, promotion of high biodiversity, development of multifunctional farms and landscapes, and social cohesion with collaboration (Altieri, Fernando and Funes-Monzote, 2011).

Although tradition is crucial, it is also important to integrate technological innovations, notably robotics, sensors, remote sensing, modeling and geographic information systems (Selman, 1995; Gkisakis, Lazzaro, Ortolani and Sinoir, 2017; Vovk Korže, 2017). Traditional technologies or low-tech green solutions in the form of ecoremediations are also useful to prevent soil degradation and ensure wastewater treatment (Vovk Korže, 2017). It is beneficial to integrate tradition with high and green technologies in order to design new approaches and farms that are tailored to local circumstances (Nicholls and Altieri, 2018).

Science and technology are crucial, but only the involvement of different stakeholders can enable their use and dissemination (Nicholls and Altieri, 2018). Stakeholder's engagement is a "necessary condition for progress" (Selman, 1995, 13) because only "collective actions translate agroecological principles into practical strategies for soil, water, and biodiversity management to enhance production and resilience" (Nicholls and Altieri, 2018, 3). It is important "to involve all parties, from scientist to producer to processor to marketer to consumer" (Francis et al., 2008, 112). Of particular importance is the involvement of farmers in the innovation process and their cooperation with scientists. In this way, new solutions can be established to enable communities to be environmentally friendly, economically secure and socially responsible, while at the same time being able to provide food for the world's growing population in a fair and sustainable way (Nicholls and Altieri, 2018).

In order to increase the resilience of agroecosystems to economic and environmental challenges, a multifunctional farm is needed, which means the development of various economic activities such as crop and raw material processing, integration of traditional crafts, rural tourism and other services based on farm resources and the workforce (Pažek, Majkovič and Borec, 2005; Rozman et al., 2009; Pažek et al.,

2010). An important factor in rural development may also be the design and maintenance of local or short supply chains of food and other goods. In addition to multifunctional farms, the multifunctionality of individual practice and also whole region is important.

These sustainable practices, such as the ecosystem approach, locality, tradition and technology, diverse stakeholders and multifunctionality, can increase access to healthy food, raw materials and energy in an environmentally and socially responsible way. Thus, the benefits of this approach are flood control, drought mitigation, soil fertility and habitat protection, new jobs and income, increased added value, active rural communities and heritage conservation. To accomplish these, agroecological practices are used, which are concrete activities and tools for realizing environmental, agricultural, social and economic objectives at local and regional level. The purpose of the article is to recognize their presence in Slovenia agricultural region, with ambition for their implementation in other countries affected by the climate crisis and poverty.

3. Methodology

In order to identify the presence of agroecological practices in the selected region, multiple qualitative research methods were applied. First, an overview of regional sources such as brochures, maps, tourist guides and catalogs were carried out. After reviewing the literature and available sources, descriptive data were collected focus group, which was carried out with experts from the *Regional Development Agency Slovenske Gorice*. The Agency is primarily engaged with the preparation and implementation of the local development strategy, entrepreneurial consulting for the development of agriculture and tourism, preparation and management of development projects, designing and maintaining the *Ovtar* brand, improving infrastructure and settlements management, training of tourism workers and conducting various events, seminars and lectures. The focus group with four experts was conducted as a semi structured group interview with starting questions about their knowledge and implementation of agroecology, traditional farming and processing techniques and green jobs in the studied area.

The focus group was followed by field work, which was executed with new mobile application designed with *Survery 123 for ArcGIS* tool. The tool allows the creation of functions for capturing the location, production of a list of identified agroecological practices, and a window to capture photographs. Data acquired through the application can be imported into *ArcGIS for Desktop ArcMap*, where it is accessible for further processing and editing.

Finally, a case study of the *Educational Polygon for Self-sufficiency Dole* was carried out. The Polygon is a private property equipped with innovative practices for demonstration of natural resource management for self-sufficiency despite unfavorable natural conditions. Since it represents innovative way of management of scarce natural resources, it was appropriate to study their methods. Research of the practices used on the Polygon was done in the field by observation.

4. Results and Discussion

All the qualitative data gathered with local literature review, focus groups with experts, field work in the studied region and case study of the Polygon were combined in an unsorted list. Further, the content of the list was categorized in two broad categories, which need to be addressed when designing and managing sustainable agroecosystems. These include co-natural practices for the bio-physical dimension of space (management of natural resources, such as water, soil, heat, biodiversity), and social practices for the socio-economic dimension of the space (strengthening social cohesion and responsibility with self-sufficiency, green jobs and community integration) (Table 1).

From the content of the table 1 it can be seen, that in Slovenia many sustainable practices for management of scarce natural resources exist. Common characteristic of these practices is, that they are inexpensive and easily used. Concerning their potential implementation in less developed countries, especially useful are multifunctional practices, such as organic mulch and different beds, which conserve water and improve soil fertility, since there are prerequisites for other activities. Besides these, diversifying plants used in a form of polyculture and mixed planting is important, but also incorporating existing natural vegetation such as grasses and trees. Among the social practices predominantly practices for autonomous self-sufficient lifestyle were discovered, which also includes cooperation with different stakeholders, so that internal market of goods and services can be established.

One of the best practices of sustainable management of agroecosystem in Slovenia is the studied Educational Polygon for Selfsufficiency Dole. The 1.5 ha estate is designed according to the closed system approach, so that minimum inputs are required – all unused biomass is composted, available water harvested, seeds collected, electricity produced and preparation for plant resilience personally made. The Polygon is also engaged in the processing of crops to compotes, sauces, pickled vegetables, teas, spices and juices. In addition to food and energy, sustainable buildings are also set up. Besides mentioned elements, Polygon supports educational, touristic and research activities. Polygon is a good example of practical value of agroecological practices, because this multifunctional property is involved in food and energy production and service activities despite unfavorable natural conditions.

Table 1. Co-natural and social agroecological practices for agroecosystem management discovered in Slovenia with qualitative research methods

	Area	Agroecological practice
Co-natural practices	Water	Green and organic mulch, drip irrigation, buried clay pots, eco-melioration ditches, water retention channels, rainwater collectors, deep seeding, raised and hugel beds, sand filters, constructed purifying wetlands
	Soil	Green and organic fertilization, animal manure, split fertilization, crop rotation, fallow, shallow soil cultivation, no tillage, composting, silica sanding, terracing, coffee sediment, ash, kitchen waste, ground eggshells, biochar, vegetation barriers
	Heat	Ponds, metal outdoor water heaters, stones and bricks, sunny expositions and slopes, greenhouses, hobit house, yurt, compost heat
	Biodiversity	Polyculture, forest garden, under-tree beds, autochthone and allochthone species, perennials, vegetation borders, biological pest control, dense planting, mixed planting, good neighbors, honey plants, habitats for insects and other animals, natural plant products for fertility and against pests and diseases, push and pull systems
Social practices	Self-sufficiency	Food production, traditional processing in the form of drying, pickling, soaking and fermentation, renewable energy generation from solar cells and small windmills, sustainable building, medicinal preparations, recycling and reuse of materials, use of local materials such as wood, stone and gravel, natural preparations for fertility and against pests and diseases, seed collection
	Green entrepreneurship	Food products such as jams, syrups, tinctures, herbal blends, sauces, teas, crafts for processing clay, biomass and rocks, energy from renewable sources such as biomass, ground, sun and wind, tourism, educational programs, short supply chains, online and direct sales, degradable and reusable packaging
	Community integration	Co-operatives, common branding, community-supported agriculture, direct farm sales, charity, community gardens, eco-villages, gender equality, inclusion of vulnerable groups, poverty reduction, social movements, counseling and knowledge transfer, cooperation with international and educational institutions

Picture 1. Agroecological practices at Educational Polygon for Self-sufficiency Dole (foto: Davidovič, Vovk Korže)

By linking different practices, new activities and sustainable ways of living in rural areas can be shaped. One option is to establish so called agroecological lighthouses that can foster the "efficiency, diversity, synergy, and resiliency" of rural and community areas (Nicholls and Altieri, 2018, 7). These are multifunctional demonstration farms, which, together with appropriate policies, can act as generator of local and regional development, by radiating the knowledge and skills to students, experts and local communities (Nicholls and Altieri, 2018). At the same time, agroecological lighthouses can be a source of income in the form of a green business. An example of such an agroecological lighthouses is the Educational Polygon for Selfsufficiency Dole, which disseminates knowledge on co-natural production, healthy lifestyle and green jobs to the region (picture 1).

The advantages of implementation of recognized agroecological practices are lower investment funds, less bureaucracy, resilience, democracy and sustainability. In addition, more authentic attitude towards nature is promoted, which is a prerequisite for an environmentally responsible lifestyle much needed today. It is important to point out that a single agroecological practice has limited impact. Integrated design and management of an agroecosystem with many agroecological practices with respect to the resources and constraints of the specific space is needed.

Most common criticism of this approach is that small farms cannot have a greater impact on space and society. However, half of the world's food is produced on small traditional farms, accounting for a quarter of the world's agricultural land, so obviously small-scale farming is successful and productive. In addition, most traditional small family farms provide food for communities without additional external inputs and despite climate change (Nicholls and Altieri, 2018). In this way, enough food for rural and urban areas can be produced at the micro level.

One of the biggest obstacles for upscaling agroecological practices is poor policy support. One of the most appropriate policies for strengthening agroecological practices and rural development is (green) public procurement, but when implementing policy, it is important to implement several integrated policies, as a single one is not enough (Nicholls and Altieri, 2018, 18).

Even though agroecological practices are transferable, they are also space specific. Because research presented in this article is limited to rural continental area in temperate climate, not all useful practices are discovered. Some other practices, which are useful in arid areas are fog nets and solar distilleries for water harvesting, drip irrigation for reduced water consumption, zai holes for water retention, stone walls and moringa tree plantations to prevent desertification and increase biodiversity and windmills for mechanical work or electricity. For more efficient implementation of agroecological practices to design and management of sustainable agroecosystems additional location specific research is needed.

5. Conclusions

Food and water availability and management of natural resources is a major topic which should be addressed more rapidly and drastically. Scientists indicate that modern lifestyle needs to change in next decade, if climate crises is not to be worsened. Some climate related problems can be solved with developing technologies, but because they are financially and knowledge intensive, their implementation is limited, especially in less developed countries, which contribute the least to the climate change, but will experience most of its negative effects. This makes it more important to explore less expensive and simpler alternative solutions, which are adaptable to specific local conditions.

One alternative solution is agroecology, the science and practice of integrated local and regional development. With agroecological principles, such as ecosystem approach, locality, tradition and technology, diverse stakeholders and multifunctionality, one can design and manage sustainable agroecosystems. The article was concerned with recognizing the agroecological practices, which encompass practical methods and tools for providing food, water and income in a more environmentally and socially responsible way. Different qualitative research methods enabled the discovery of many useful practices for management of bio-physical and socio-economic dimensions of agroecosystems. These include practices for harvesting and retaining water, increasing soil fertility, diversifying biodiversity and promoting selfsufficiency, green jobs development and cooperation. Many agroecological practices are based in traditional knowledge, which is adapted to specific environment, so tradition can serve as an inspiration for innovations.

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