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## CIRCULAR AGRICULTURE – A NEW PARADIGM OF ECONOMIC DEVELOPMENT

### ABSTRACT

One of the key challenges in the coming years is to produce enough safe and nutritious food for the future generations without exceeding the planetary reserves even more. In circular agriculture, waste is seen as a raw material to produce new valuable products, including crops, food, feed and energy. Another characteristic of the concept is the need to reduce the consumption of resources and discharges into the environment. This article analyzes the concept of circular agriculture as well as the necessary government policies for implementing this concept as the development paradigm. It is highly recommended for governments to promote circular agriculture, especially in the post COVID-19 period, as means to improve different objectives, including better environmental conditions, climate change mitigation, public health, etc. It is also recommended to support and facilitate the development of circular economy principles as well as to implement best practices from existing initiatives around the world.

**Key words:** circular agriculture, sustainable development, nutritious food, agricultural waste, agricultural policy.

**JEL Classification:** Q18, Q53.

### 1. INTRODUCTION

In the global sustainable development context, agriculture plays a crucial role. The agro-industrial sector is currently the largest employer and plays a vital role in the livelihoods of 40% of the population, out of which employment in agriculture totalled nearly 27% of total employment in 2019 (World Bank, 2021).

Although farming is essential for the production of human food, *the expansion of the Earth's population has become a growing concern for the possibilities of producing that much food with limited natural resources left*. According to the latest UN report, *The State of Food Security and Nutrition in the World*, 821 million people are currently undernourished, and this situation was worsening during the last decade. The global population is supposed to reach 9 billion people by 2050, requiring food production to increase by 70% to meet the planetary demand

(Huffpost, 2017). Without necessary reforming the agricultural sector, if nothing changes, around 653 million people will still be already malnourished by 2030.

Considering the fact that the arable land is limited, most of the additional food production required to feed the growing population will depend on sustainable intensification of practices in agriculture, in parallel with a consumer-led shift towards an environmentally safe agriculture.

Although food production has increased, the overuse of non-renewable resources or agrochemicals has harmed the environment, posing another challenge for the humanity. It is to mention that this sector endangers natural ecosystems and accounts for about one quarter of the world's greenhouse gas emissions. The agricultural sector is responsible for non-CO<sub>2</sub> emissions generated on the farm by crop and livestock production activities, as well as for CO<sub>2</sub> emissions caused by the conversion of natural ecosystems, like forest land and natural peatlands to agricultural land use (FAO, 2018). Thus, in 2018, global emissions due to agriculture (on farms and including related land use/land use change) totalled 9.3 billion tons of CO<sub>2</sub>. Within the Sustainable Development Goals (SDGs) adopted by the UN in 2015, *the agricultural sector is given a wide recognition in ensuring the socio-economic progress*. Thus, agriculture represents the main center of Goal 2, in order to achieve zero hunger. At the same time, the agricultural sector is included in Goals 12 (responsible consumption and production), 13 (climate action) and 14 and 15 (related to the conservation of aquatic and terrestrial life).

Nowadays it is already recognized that sustainable development of the agro-industrial sector is an important element of green growth. With in-depth knowledge, modern and updated farm management methods, farmers today can maintain high yields while protecting the environment. As the number of humans on the planet continues to grow, the effects of climate change will worsen and ecosystems will continue to deteriorate. Innovation in today's agricultural food production systems is therefore urgently needed to increase crop and animal outputs, enhance dietary diversity and improve human health while conserving environment and sustaining natural and cultural resources.

That is why moving to the circular economy model can help develop a sustainable form of food production without harming nature, people's health and safe food production. In order to maintain a sustainable lifestyle, agriculturalists focus on certain criteria in order to compete with current sustainability practices. These criteria consist of creating a healthy environment, while ensuring economic profitability in addition to maintaining social and economic equity.

The scope of this article is to analyze the concept of circular agriculture, as well as the foreign experience in implementing circular economy models in the agricultural sector development.

## 2. MATERIAL AND METHODS

The synthesis and methodology of scientific research was determined in the context of the complexity of the topic, the diversity of areas and scientific fields of research by designing and applying a system of classical methods of analysis and synthesis, induction and deduction, as well as observation, statistical methods, analysis and interpretation of data. As information sources, the author used the statistical data of the international statistical database.

## 3. RESULTS AND DISCUSSIONS

The current agricultural system operates linearly through the *extract-produce-consume-discard* model. This means that raw materials are collected, then transformed into products that are further used until they are finally thrown as waste. Value is created in this economic system by producing and selling as many products as possible. A product passes through a supply chain during its path to the consumer, while involving separate actors that try each to obtain the most economic benefit at the lowest possible cost (see Figure 1).



Source: Wautelet, Thibaut, 2018

Figure 1. The linear economy – The ‘take, make and waste’ approach of production

In contrast to the linear model, *circular agriculture* is a new concept and can be viewed as a form of *sustainable agriculture*, where all output must subsequently remain in the system (see Figure 2). The circular economy principles make it possible to use as optimally as possible raw materials and resources. This means that these materials and resources continue to be applied in a way that generates not only the highest economic value but also the least environmental damage. For example, pivot farming requires less artificial fertilizer to produce less CO<sub>2</sub> during production. At the same time, high quality fertilizers such as manure and compost can increase soil carbon retention, which is a natural way to combat climate

change. In addition, this method allows farmers to combat greenhouse gas emissions. Another peculiarity of circular agriculture supposes that fields should be firstly used for food crops, while mixed crops may be added to the rotation. Plants will have a double purpose (for example, leaves, food, stems will represent food for livestock or biofertilizer for soil).



Source: FFTC, 2019

Figure 2. Circular agriculture model

In the circular agriculture perspective, the *3R* principle means – transforming waste streams into valuable resources. Developing waste valorization chains may involve several steps, including the actual separation of waste into streams that can and cannot be upgraded; setting up processing facilities that can generate upgraded products, developing a market for these products, and organizing the trade logistics (Felix, B., Bianchi, C., *et al.*, 2020.). In this circular form of business model, agricultural biomass and food residuals will remain renewable sources. This will result in using fewer chemical fertilizers, which are necessary for the production of food, while using the same acreage and resources.

For example, in animal husbandry, circular farming means, first of all, that roughage and other raw materials are used for the production of field crops, horticulture and food processing, as well as for the rest of the food chain (Zanten *et al.*, 2019). As a result, it is possible to avoid feeding animals with plant proteins, which are also suitable for human consumption.

For farmers, circular farming means using high quality animal-based fertilizers and crop residues to stimulate soil life. For example, the use of manure and food debris in the agri-food chain as a source of nutrients will reduce the quantity of mineral fertilizers required for food production. Chemical based fertilizers will only be used when crops need additional nutrition. Crop farmers will also make the most of their agrobiodiversity through mixed seeding systems and sensible crop rotations. This is possible due to new forms of precision mechanization based on developments in the field of robotics.

As a result of the above mentioned, implementing circular economy principles in agriculture will lead to significant benefits both for farmers and for the environment, contributing to the creation and conservation of natural landscapes.

*The circular economy in the agri-food system is based on 3 major principles:*

1. Plant biomass. Circularity in this case refers to the recovery of productivity gaps, diversification of crop systems, use of organic fertilizers. Recovering

productivity gaps emphasizes the use of nutrient input by recycling manure, crop residues and reusing waste streams or legume species that fix atmospheric nitrogen in soil.

2. The use of agricultural by-products, processing and consumption which should be recycled in the agri-food system. This refers to soil quality, carbon sequestration in soil, use of agricultural production for the production of renewable energy, production of organic and biomaterial fertilizers.
3. The full use of the potential offered by livestock. Technological development and cultural changes in consumption habits can have a substantial effect on the availability and production of low-cost quality feed for animals. The administration of these feeds can contribute to obtain superior quality and quantitative foods in a circular agri-food system.

*Useful practices for the implementation of the circular economy principles in the agri-food sector* should be also mentioned:

*Agroforestry* can bring circular economy principles in agriculture by reducing the dependency on chemical fertilizers and pesticides. Tree planting can also contribute to restoring biodiversity in agricultural landscapes, due to soil fertility increase by increasing the accumulation of organic matter from decaying nature. Farmers should be actively motivated to plant trees and practice agroforestry through promotion of government incentives. Thus, examples may include paying farmers for planting and caring for trees on their farms in exchange for desired ecosystem services (e.g., carbon sequestration) and buyers offering premia to farmers for agricultural commodities produced under certain conditions (e.g. via certification schemes for products such as shade grown organic coffee) (Miller DC, *et al.*, 2017). Major agroforestry initiatives in high-income countries include the USDA Agroforestry Strategic Framework Plan (FY 2011–2016) in the United States, the European Commission’s AGFORWARD program in Europe (FY 2014–2017), Agriculture and Agri-Food Canada’s Agroforestry Development Centre in Canada and the Farm Forestry National Action Statement and the Master TreeGrower Program (supported by the Australian Agroforestry Foundation) in Australia. In Japan, the Satoyama Initiative includes agroforestry concepts, though it covers a broad range of practices (Sarah E. Brown, *et al.*, 2018).

*The recycling and reuse of irrigation water* can reduce pollution, ensure more water conservation and provide additional resources for recharging aquifers. If adequately treated and safely applied, wastewater represents a valuable source of both water and nutrients, contributing to food and nutrition security and the improvement of livelihoods. However, water recycling plants have generally been energy intensive and produced sludge that can be difficult to discard. Newer technologies may be able to alleviate this problem by developing new sludge by-products that promote recycling at net zero energy cost by capturing biogas. Biogas, a by-product of the treatment process, can be used to offset the energy consumption of the facility (UN, 2021). In Europe, the implementation of the Urban Waste Water Treatment Directive (91-271-EEC) has already contributed to

obtain treated wastewaters of quite high quality that could be reused for certain applications or improved by polishing steps for uses with higher quality requirements (EC, 2001). Recycling and reuse could be promoted through policy instruments such as charges and tariffs, increasing their cost effectiveness and acceptability, while much care must be taken while addressing water quality issues (M. Molinos-Senante, *et al.*, 2013).

*Mixed farming* may imply a switch away from mono-crop agriculture to growing a set of interdependent crops where the cultivation of one creates favorable conditions for others on the same land. Beneficial exchanges of resources are repeated all over the farm, so that just like in nature nothing goes to waste but is instead cycled to another part of the farm. Crop diversity becomes an effective practice to reduce inputs, manage soil fertility and enhance resilience, and the combined production of different crops and legumes can increase yields in a sustainable way. Mixed crop-livestock farms have lower costs, are less sensitive to market and price fluctuations and result in lower levels of nitrogen pollution.

*Organic Agriculture* is a production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than using inputs with adverse effects. Organic Agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and good quality of life for all involved (IFOAM General Assembly, 2008). Organic farmers use practices that maintain and improve fertility, soil structure and biodiversity, and reduce erosion; reduce the risks of human, animal, and environmental exposure to toxic materials, fine-tune farming practices to meet local production conditions and satisfy local markets. Despite fast growth, there are still a whole set of obstacles to the adoption of organic farming, which vary from personal interests to existing regulations; weak infrastructure; misconceptions and cultural biases, etc. Some countries, nonetheless, have already set ambitious goals for developing organic agriculture. Bhutan has set the goal of becoming the world's first 100 per cent organic nation. In 2010, Denmark adopted an action plan to encourage organic farming and consumption in the country. At present, the country has the highest market share of organic products in the world (UN, 2021).

A comprehensive set of policies, technologies and institutions are needed to promote the adoption of circular agricultural practices. Public policies that place high value on achieving sustainable use of natural resources can encourage smallholder farmers to adopt new technologies in areas such as drip irrigation, precision agriculture, rainwater harvesting and crop productivity. Smallholder farmers' access to new technologies and skills can be facilitated through international cooperation for technology transfer and capacity development.

There should be strengthened incentives to promote circular agriculture. Existing policies could be reviewed in order to eliminate those subsidies in agriculture, energy and transportation that undermine the sustainable use of natural resources. Savings resulted from elimination of subsidies that incentivize the

overuse of natural resources could be directed towards compensatory income support to small farmers, and targeted smart subsidies to achieve specific circular agricultural practices, as well as necessary agricultural research. To promote the development of circular agriculture, some developed countries have promoted a whole set of laws and regulations. It is to mention the USA *Pollution prevention law*, which actively promoted the development of sustainable agriculture, as well as the *Farm security and rural investment act* from 2002, the legislation to implement land fallow, wetland protection, environmental quality incentive to provide a subsidy, at the same time to increase investment in science and technology of agriculture circular economy research, and publicity (Palmer, L., 2018).

In the EU member states, the Common Agricultural Policy is aimed at supporting farmers and developing rural areas, increasing agricultural productivity, ensuring a stable supply of affordable and high-quality food, as well as sustainable management of natural resources and combating climate change (EC, 2019).

The agricultural policy of the EU, as a common policy for all its member states, is managed and financed at the European level from the EU budget. For example, the UK has spent 4%–5% of the EU Common Agricultural Policy Fund on agricultural environmental protection since 1993. In Germany, a “green ecological agriculture” plan was introduced in September 2001, and has made severe restrictions on exogenous substances pollution or damage to the ecological environment caused by improper operation. (Xiqiang Xia, Junhu Ruan, 2020).

On June 1, 2018, the European Commission put forward proposals for the development of *the EU Common Agricultural Policy (EU CAP) after 2020*. The main areas of the state support within the EU CAP are:

- direct payments aimed at maintaining incomes and rewarding farmers for environment-friendly agriculture and the creation of necessary public goods, the price of which cannot be obtained in market conditions;
- market measures aimed at overcoming risks in the functioning of the market;
- rural development measures, which are associated with the implementation of national and regional programs aimed at solving the problems of rural development.

The CAP is financed through two funds as part of the EU budget:

- The European Agricultural Guarantee Fund provides for the implementation of support measures such as direct payments and market support measures;
- The European Agricultural Fund for Rural Development finances rural development.

The EU roadmap also involves implementing the *Farm to Fork strategy*, as well as a series of actions by the year 2030 aiming to fully introduce sustainability into the EU economy and, at the same time, reinforce the position of agricultural biotechnology firms.



Source: Retrieved from the EC web page. Available at [https://ec.europa.eu/food/horizontal-topics/farm-fork-strategy\\_ro](https://ec.europa.eu/food/horizontal-topics/farm-fork-strategy_ro)

Figure 3. The Farm to Fork strategy

The Farm to Fork strategy proposes some measures (see Figure 3) aimed to reduce the use of chemical pesticides by 50% in the next 10 years. The European Commission will also take measures to reduce the use of fertilizers by 20% by 2030. Also, the Community Executive aims to plant 3,000 million trees in the European Union and to drive forward the development of organic farming with the goal of 25% of total EU farmland being used for organic farming by the year 2030 (Seipasa, 2021). At the same time, it is to mention that besides the legislative issues, other measures are also proposed to raise citizens' awareness of the importance of reinforcing the sustainability of the food system through food waste reduction or food labelling.

The 2018 OECD agricultural policy report and evaluation puts forward the following policy recommendations (Kutay Cingiz, Justus Wesseler, 2019):

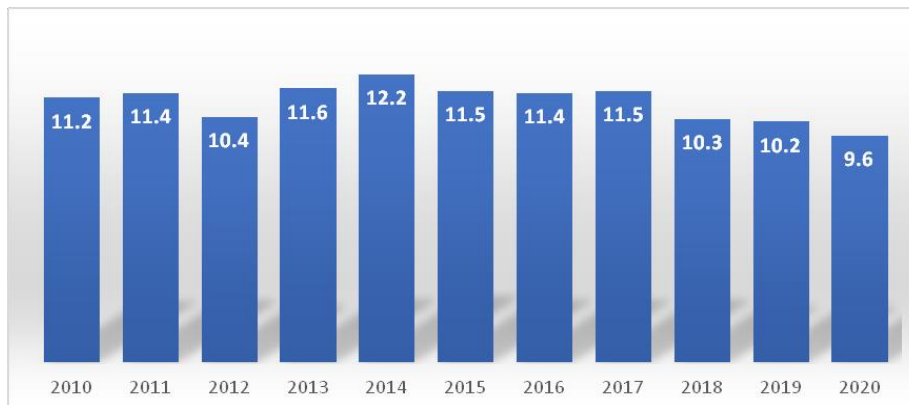
- Elimination of policies that are causing disincentives at increasing productivity, sustainability and resilience;
- Redirecting the agricultural support for the overall benefits of the society;
- Ensuring knowledge transfer and generation between public and private sectors;



- Increasing the use of information, education, regulation, payments and taxes, to achieve environmental and climate change goals;
- Increasing farm-income support measures by critical evaluation of the financial and well- being situation of farm households;
- Developing policies to match the opportunities and challenges.

Sustainable development of agriculture has been a priority of the *Republic of Moldova*, being reflected in the policies and strategies developed in the last decade. But the actual situation of agricultural development still shows an insufficient effectiveness of the practical implementation of measures provided in national legislation.

In the Republic of Moldova, the agricultural sector prevails in national economy, with a contribution by 9.6% to GDP (NBS, 2021). Although the share of agriculture in the generation of Gross Added Value decreased in the last years (see Figure 4), the Republic of Moldova still remains an agrarian country, and agriculture is a strategic branch of the economy. This tendency, especially in low income and developing countries, is explained by the high prevalence of the sector of services in GDP, with the agricultural sector registering a decline due to lack of investments and high dependency on weather conditions. Thus, food security is regularly affected by weather conditions. Drought, floods and other extreme natural phenomena (torrential rains, hail, storms and frost) occur regularly and have a significant impact on the standard of living and the rural economy as a whole. The country regularly suffers from severe drought that affects food security and living standards in rural areas and creates significant economic shocks, as well as decline of agricultural yields, decrease in vegetation areas, increase in feed and decrease in cattle.



Source: NBS, 2021

Figure 4. Share of agricultural economic activity in the generation of gross domestic product of the Republic of Moldova

At the same time, the Republic of Moldova does not produce high value-added agricultural products, as they require new production technologies, investment in equipment and machinery, irrigation and strict regulations in the field of food safety, which leads to low profitability and capacity and low export competitiveness.

Malnutrition levels among the Moldavian population are low in all categories: stunting, wasting, underweight. Food insecurity is not a major challenge for the country, but can still be felt in low-income households, when high production and price volatility affect food availability and access. Most food-insecure households are men-headed and located in vulnerable urban areas (World Bank, 2015).

Water resources for agriculture are scarce, while irrigation infrastructure is almost inexistent in small-scale farmers. Projections on climate change, manifested through increased rainfall variability and overall drop in rainfall, show an increased demand for irrigation water and a decline in available surface water resources. As a result of the above-mentioned, the domestic agricultural sector needs to be reformed according to the existing challenges and main problems faced by farmers and requires a complete overhaul of the existing production potential.

In order to maintain access to profitable market segments, to gain and increase access to new export markets through diversification, especially in the conditions of EU enlargement, modernization of the Moldovan quality management system, food safety, animal health and plants are of major importance. This reform should be performed in line with the sustainability principles, which would allow harmonizing the development of agriculture with maintaining the ecological balance. Limited access to relevant technical assistance and to adequate financial resources, insufficient water resources and technologies for irrigation are some of the main barriers to the adoption of circular economy practices by local farmers. Deeper knowledge of the intimate mechanisms of sustainable agriculture, perfectly integrated into the general harmony of nature, can be a negligible asset in the fight to ensure food security in our country. It is necessary to identify more effective state mechanisms in order to stimulate the sustainable development of agriculture according to circular economy principles and, in this way, create the conditions for achieving the general objectives of sustainable development.

#### 4. CONCLUSIONS

- Developing policy and institutional mechanisms to deliver relevant extension and financial services to farmers in a timely and efficient way is important for developing the circular agriculture. The first step should consist in strengthening the early warning, weather, and hydrological information systems, accompanied by public-private mechanisms of compulsory insurance against natural hazards, which would be accessible to small-scale farmers.

- The integration of livestock and agriculture sectors should become a priority in order to ensure climate change mitigation benefits. Any improvement in agriculture land management, such as conservation agriculture and improved pastures, will protect below-ground carbon storage, contributing to climate change mitigation. An important mitigation potential of the agricultural sector could also be achieved in the forestry sector, by means of reforestation, improved forest management practices, and reduced rates of illegal logging.
- In order to cope with the fast pace of change and increased uncertainty, circularity must be considered as a target that will be achieved through the development of technical, policy, governance and financing frameworks that will support agricultural producers involved in the innovation activity. That is why a strong institutional and legislative framework is needed that would encourage eco-friendly activities by imposing regulations and costs for actions that deplete or degrade natural resources and facilitate access to innovation.
- Sustainable agricultural practices are based on full use of technology, research and development, which allow greater integration of local knowledge. That is why the state should strongly support investments in circular economy activities in agriculture, as well as partnerships between technical and investment-oriented organizations.

## 5. ACKNOWLEDGEMENT

This paper was supported by the State Program 20.80009.0807.22 Development of the mechanism for the formation of the circular economy in the Republic of Moldova

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