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Review

Tendencies and challenges for the assessment of agricultural sustainability

Mauricio Quintero-Angel[a,b,*], Alejandra González-Acevedo[c]

[a] Universidad Santiago de Cali, Calle 5 # 62-00, Cali 760035, Colombia
[b] Universidad del Valle, Calle 13 # 100-00, Cali, Colombia
[c] Research Group on Territorial Environmental Management GAT, Universidad Tecnológica de Pereira, Carrera 27 #10-02 Barrio Alamos, Pereira 660003, Colombia

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ABSTRACT

Given that agriculture is one of the activities with highest anthropic intervention on ecosystems, this paper focuses on the importance of aligning food production toward sustainability and the need to rely on evaluation methodologies that guide decision-making and take into account social metabolism. It is concluded that a holistic evaluation of sustainability is necessary, which implies including the social dimension as well as the economic and the ecological one and surpassing the linearity of the current evaluation methodologies.

1. Introduction

Recent studies (Rockström et al., 2016, 2009; Steffen et al., 2015) show that human pressure on the biosphere and geosphere is significant, manifesting itself in an accelerated extinction of species, acidification of the oceans, climate change, alteration of biogeochemical cycles among others. According to these authors human activities have reached a scale in which an abrupt global change cannot be overlooked, especially after the industrial revolution due to a higher use of fossil fuels and the intensification of industrial agriculture.

According to Pérez (2007), industrial agriculture is characterized by a growing increase in capital created by humans, represented in agricultural machinery, supplies etc., with the aim of substituting or controlling the natural resource (soil, water, seeds) and the work for capital. The latter generates an artificialization of nature, striving for a maximum homogeneous production.

Broad scientific evidence e.g. (Betts et al., 2017; Ehrlich and Ehrlich, 2009; Foley et al., 2011; Kareiva and Marvier, 2011), demonstrates that industrial agriculture and associated food systems: i) transforms and homogenizes the landscape; ii) reduces biodiversity and promotes genetic erosion; iii) contaminates the air and hydric sources; iv) Puts human and animal health at risk due to the chemical residue in the agricultural products; v) Fosters cultural change and puts traditional knowledge at risk as well as the diversity of non-commercial species among others.

Changes in agricultural practices generated an intensification of industrial production due to the global necessity to guarantee access to food on behalf of the growing population as well as the integration of markets, and globalization.

This propensity toward intensification of industrial agriculture corresponds to a trend in which the tropical regions are affected by agroindustrial modernization. This effect changes all the landscapes and their biodiversity to give way to agricultural monoculture, livestock (pastures) and/or forests (plantations), generating inadequate life quality levels to its inhabitants (Toledo, 2003).

Nevertheless, actions are aimed at reaching sustainability on the agricultural production systems. In this sense three basic questions have been object of study in the last few years (Conway, 1994):

- How to evaluate the sustainability of the agricultural production systems?
- What is the impact of a specific agricultural practice on the sustainability of the rural environment?
- What is the appropriate approach to explore economic, environmental and social dimensions?

Sustainability concept is not new, and it has been widely employed since it was presented by United Nations General Assembly (1987). However, making agricultural production sustainable in the agri-food context requires important changes in production, transformation, distribution and food consumption.

An agricultural product can be cultivated under different production models, nonetheless, its pressure over nature will vary in each historic period. The latter in function of the technical level, the economic importance of the crops in the agro-exporter context, the insertion or not of the local production in food chains, and the way natural resources are used by society.

In this sense, the evaluation of different agricultural practices is

* Corresponding author at: Universidad Santiago de Cali, Calle 5 # 62-00, Cali 760035, Colombia.
E-mail addresses: mangelq@gmail.com (M. Quintero-Angel), bioaleja@utp.edu.co (A. González-Acevedo).

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relevant, since it is possible to redesign them with the appropriate information or to improve them or eliminate them if it is convenient. This can generate useful knowledge for decision making and decisive information for the adequate design of more sustainable agricultural practices.

These changes should be based on the framework of a broad discussion on the socio-ecological implications of sustainability, since there are two opposite interpretations (Ayres, 2007). The weak-sustainability that justifies the use and damage of nature to reach economic growth, while the strong-sustainability highlights the importance of a harmony between nature and economic growth (Munda, 1997).

In this context, the present descriptive research, based on bibliographic revision and analysis by the authors, approaches the society-nature relationship in the context of agriculture and describes social metabolism and the socio-metabolic regimes as theoretical elements for evaluating the sustainability of agricultural practices. In the same way, the effects of agricultural practices on environmental degradation are described, as well as the necessity for a sustainable agriculture, calling upon the need of methodologies that integrate the social, ecological and economic dimensions of sustainability and that surpass the linearity of the current methodologies.

2. Social metabolism and socio-metabolic regimes

An important element for the study of agricultural sustainability stems from the recognition of social metabolism. The theoretical proposal of ecological economy recognizes that aside from social formation and the historic moment, human beings appropriate, produce, circulate, transform, consume and excrete products, materials, energy and water, that come from the natural world in a process known as social metabolism (Toledo, 2008).

Social metabolism, according to González de Molina and Toledo (2014), is related to a series of metabolic processes that start with *appropriation,* when a group of human beings uses products, materials, energy and water from nature (input/entry) and ends with the processes of *excretion,* when waste is deposited, emanations or residues to nature (output/exit).

These authors adduce that there are some interior flows that are related to the processes of: i) *transformation:* implies all the changes produced over the products extracted from nature that are not consumed in their original way. ii) *circulation*: it is present when a human group stops consuming all that it produces and also stops producing what it consumes. This triggers economic exchange; the elements that are extracted from nature begin to circulate, transformed or not. And iii) *consumption*: this process can be understood from the existing relation between human, social and historically determined necessities and the subjects proportioned by the three first processes [appropriation, transformation and circulation] (González de Molina and Toledo, 2014).

Social metabolism is based on an organicist analogy by stating that any social system reproduces itself culturally by communication, as well as biophysically (like population, the built infrastructure, artifacts and livestock) through the continuous energetic and material exchange with its natural environment and eventually, with other social systems (Fischer et al., 2010).

According to Sieferle (2003), in the history of mankind on the planet, regardless of the historic moment and the biogeographic conditions, certain methods of production and human subsistence can be distinguished by some fundamental systemic characteristics, originated in the way human beings use and transform nature.

In the perspective of Singh et al. (2010) when a society interacts with nature, it does so through the exchange (at times involuntary) of matter and energy; and intentionally through the application of certain technologies and labor with the aim of increasing the benefits obtained from nature. This link with nature generates environmental impacts and a reciprocal relation of co-evolution that conduces to a situation in which both systems depend on each other mutually, influence and limit themselves.

For Fischer and Haberl (2007) this reciprocal relationship is maintained thanks to a reciprocal exchange of matter and energy between both systems; an Exchange that according to Singh et al. (2010), generally keeps some typical patterns of biophysical interaction that can remain for long periods in a more or less dynamic balance, which are denominated socio-metabolic regimens.

In the history of humanity, for Singh et al. (2010), the socio-metabolic regimes, correspond to the human methods of subsistence, such as the regime of hunters-harvesters, the agricultural or the industrial regime, each one characterized by practices associated to the use of natural elements and the work and demographic patterns that generate a certain set of environmental impacts.

3. Ecological degradation in food production and the need for new sustainable paradigms in agriculture

From the neolithic period, different human groups have developed agriculture, devising processes for the obtention of seeds, sowing, plantation maintenance, harvest and exchange and commercialization of food. In many cases these activities have altered the dynamic balance of ecosystems, and in the Anthropocene, the agriculture is recognized as a primary driver of global change and as the main contributor to environmental risks (Foley et al., 2011).

The degradation of ecosystems (their structure, dynamic and evolution) for food production can be explained in two ways:

- By the appropriation processes of natural resources and environmental services, where any intervention generates negative impacts on environment;
- By disposing residues to the environment. According to González de Molina and Toledo (2014) these emanations should be analyzed by both the quality as well as the quantity of the materials of the residues, meaning if they are recyclable or not by nature or if they surpass or not the natural recycling capacity.

Nevertheless, when the appropriation of nature is done disregarding the productive vocation of the ecosystems, its capacity to renovate itself and its existence is threatened. This in turn generates certain changes that end up affecting society (Toledo, 2008). For example, a reduction on crops productivity or the use of agrochemicals to attenuate the loss of soil fertility. In these cases the farmer spends a great amount of time recovering the ecosystem, generating additional negative pay offs causing the producer to overexploit its labor to balance the relation.

It could be considered that nature generates penalizations to wrong decisions made by the producer, accumulating in time and space, which could lead to a collapse of the material base and even the disappearance of populations, states or civilizations, requiring sustainable interventions over the ecosystems (González de Molina and Toledo, 2014).

Nonetheless, processes such as the circulation, transformation and specially consumption increase the pressure over nature. According to González de Molina and Toledo (2014) in human history the volumes of materials-products that circulate as well as the distances covered before they are consumed, have increased. Going from the non-merchant and non-monetary trade, to the trade mediated by money, private property and markets. The latter results in a vast network of trades that is intimately linked to the transformations where the old relation, direct and almost immediate between appropriation and consumption gets blurred (González de Molina and Toledo, 2014). These authors argue that at a global level and at the beginning of the XXI century, consumption constitutes a powerful factor that demands incentive and even subordinates the other metabolic processes.

Examples around the world could explain the important role of consumption. For example, a global increase in the levels of meat consumption, is recognized as one of the greatest threats to tropical