Management & Economics Research Journal
ISSN 2710-8856
ISSN 2676-184X
University of Djelfa - Algeria
https://www.asjp.cerist.dz/en/PresentationRevue/615

Vol. 05 No. 04 (2023). P. 166-179

Environmental Impact Assessment Challenges and Their Implications for Sustainable Agriculture:

A Critical Review of the DPSIR Model

MECHERI Abdelhamid
a.mecheri@univ-boumerdes.dz

Boumerdes University, (Algeria)

Received :27/09/2023 *Accepted :27/12/2023*

Abstract

This study seeks to discuss the problem of environmental impact assessment of agricultural systems in the light of the sustainable development dimensions, with the aim of revealing the strengths and shortcomings of these models. The paper attempts to provide a critical review of the DPSIR model which was widely used in environmental assessment processes in many regions of the world for its ability to monitor environmental changes, which helps decision makers to respond and identify policies and measures necessary to deal with environmental problems associated with agricultural practices.

✓ Keyword: Environmental Impact Assessment, DPSIR, Sustainable Agriculture.

1. INTRODUCTION

The world's population has exceeded 7.9 billion people, leading to an unprecedented increase in global food demand. Agriculture, as the primary source of food production, plays a pivotal role in meeting this challenge. Responding to this demand requires a sustainable agricultural system that can effectively provide food while minimizing negative environmental impacts.

Nonetheless, traditional agricultural practices characterized by extensive use of chemicals, excessive water consumption, and unsustainable land management have led to severe environmental consequences. It has become clear that such practices contribute to deforestation, water pollution, increasing emissions, and decline of biodiversity. Therefore, assessing the environmental impacts of agricultural practices has become an urgent need to preserve resources and ecological diversity and achieve sustainable agricultural development.

In response to this problem, several environmental impact assessment models have been designed to identify and evaluate potential environmental impacts, such as the Agro-Environmental Indicators (AEI) model, the Environmental Impact Assessment (EIA) model, the Environmental Risk Mapping (ERM) model, the (DPSIR) model and others. These models aim to provide decision-makers with valuable information to guide sustainable development policies before implementing new projects and planning development programmes. Nonetheless, the efficacy and precision of existing environmental impact assessment models in comprehensively monitoring agricultural environmental impacts have been a topic of contention among researchers, international and local organizations, and environmental actors. The challenging aspect of environmental impact assessment models in agriculture raises several problems related to effectiveness, comprehensiveness and evaluative efficiency.

In this context, The study endeavors to offer a critical review of the models employed for assessing the environmental impact of agricultural systems, with a specific focus on how they align with the dimensions of sustainable development, by asking the following questions**: *Are the models used in environmental impact assessment effective enough to monitor the environmental impacts of agricultural systems? Does the DPSIR methodology respond to the dimensions of sustainable development and overcoming shortcomings of environmental impact assessment models for agricultural practices?***

In order to address these questions, it is necessary to examine the most prominent environmental impact assessment models used in the agricultural sector and identify their strengths and limitations. This analysis includes a review of various factors that are often overlooked or inadequately evaluated, such as indirect effects, synergistic effects and complex interactions between different environmental

components. In addition, it requires evaluating the methods and indicators used in these models and ensuring that they are scientifically valid and capable of capturing the nuances of agricultural practices.

Studying the problem of environmental impact assessment and its implications for sustainable agricultural development is of great importance as it helps in addressing the complex challenges facing the environment and ecological diversity in their relationship to agricultural systems. The importance of the study can be summarized in the following points:

- Environmental impact assessment helps identify potential environmental risks associated with different agricultural practices. This enables policy makers and farmers to make sound choices that promote sustainable agriculture, such as adopting more sustainable practices, reducing chemical inputs, and improving resource use.
- Studying the problem of environmental impact assessment enables understanding the social dimensions of agricultural practices, and highlights the role that local communities, Farmers and various stakeholders have a pivotal role to play in preserving the environment, thereby contributing to the advancement of sustainable agricultural development.
- Understanding the problems and challenges associated with environmental impact assessment enables the integration of scientific knowledge and sustainable technical solutions, helps in developing strategies and policies, and works to achieve a balance between agricultural development and environmental protection.

Through its four axes, the study will address the contextual backgrounds for the development of the concept of agricultural sustainability. It will also discuss the importance of environmental impact assessment models and demonstrate their analytical value in the field of agriculture. The study will seek to identify effective strategies to overcome the potential limitations facing the application of these models. and also attempt to highlight the importance of relying on an approach Integrated and comprehensive to achieve sustainable agricultural development by providing a critical review of the DPSIR model.

2. Sustainable agricultural development: context and concept

The end of the twentieth century marked the rise of significant interest in sustainability, as countries around the world engaged in discussions regarding the challenges arising from development, and related to the impact of industrial and agricultural activities on the environment. These discussions were part of a long process of joint work that began at the end of the sixties with the International Conference on the Rational Management and Protection of Biosphere Resources, organized by UNESCO in 1968. After the World Commission on Environment and Development

published its report in 1987 (Brundtland Report), which bore the title “Our Common Future,” the concept of “Sustainable Development” began to emerge strongly in global political discussions and trends. (Our Common Future, 1987, pp.1-3). It received special attention at the conference United Nations on Environment and Development (UNCED) held in Rio de Janeiro, known as the “Earth Summit” in 1992.

Sustainable development is defined according to the Brundtland Report as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” While environmental protection represents a central goal of sustainable development, it It also seeks to achieve fair circulation of limited resources and reduce pressure on them using more sustainable methods (Our Common Future, 1987, p. 43).

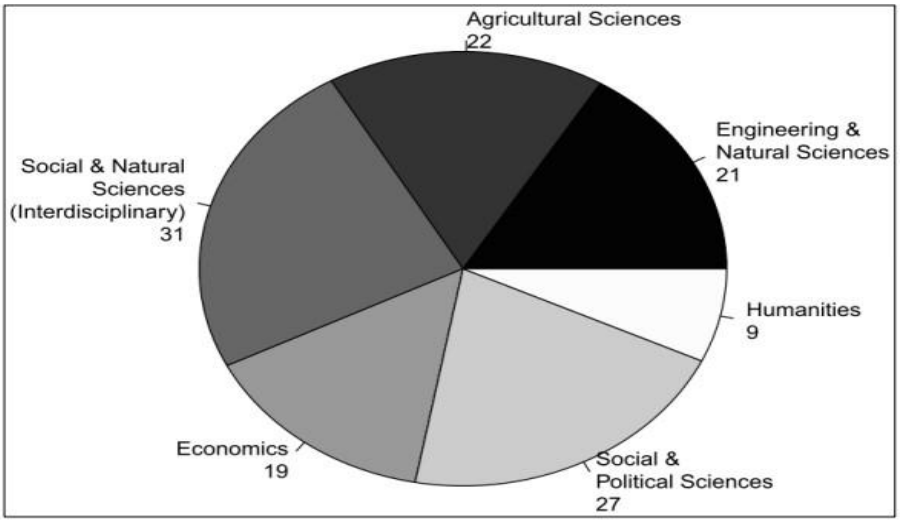
It should be noted that the idea of agricultural sustainability was first published in the year 1798, when Thomas Malthus published his book, “An Essay on the Principle of Population.” Malthus drew attention to the fact that Unlimited population growth could exceed humanity's ability to produce sufficient food, which will lead to famine and wars. Although this has not happened yet due to the role of technological development, modern agricultural techniques, and genetic improvement in increasing the productivity of agricultural production, attention to the harmful effects of productivity has become more Important because of its increasing impacts on the environment and on the exploitation of non-renewable resources (Feher & Beke, 2013, p.74)

In the late twentieth century, the idea of “sustainable agriculture” gained a prominent position, especially in the United States, Canada, and Western Europe, with the rise of reformist social movements concerned with the impact of agriculture on the environment. These movements opposed environmentally unfriendly agricultural systems and the resulting depletion of non-renewable resources and soil degradation, as well as the harmful effects of chemicals used in agriculture on health, the decline of rural communities, the decline of traditional agricultural values and the deterioration of food quality and worker safety. On farms, increasing demands Gender equity...etc. These worsening problems have become linked to so-called “environmentally unfriendly agriculture,” which is often viewed as unsustainable. While “alternative agriculture” is called “sustainable agriculture” (Hansen, 1996, p.120). In recent years, environmental trends have emerged calling for greater protection of food products, and a special field of knowledge known as “Agroecology” has developed (Hatt et al, 2016, p.216).

The concept of Sustainable Agriculture, like many concepts in the social sciences, encompasses multiple definitions due to the intricate interplay of technical with what is normative in forming the concept (Feher & Beke, 2013,p.75). This diversity is due to the fact that the concept is attracted by

many fields of knowledge, and this is what makes sustainable agriculture a (interdisciplinary) field par excellence. What supports this argument are the findings of Sarah Velten and Julia Levinton, who reviewed 129 articles published in randomly selected scientific journals with the aim of searching for the relationship of sustainable agriculture to different fields of knowledge, (see Figure.1). (Velten and Levinton, 2015,p. 7836).

Fig.1. Distribution of the (129) journal articles concerned with sustainable agriculture regarding the discipline they originate from.



Source: (Velten & Leventon, 2015, p. 7848)

The Consultative Group on International Agricultural Research and the Technical Advisory Committee (CGIAR/TAC, 1989, p. xi) states that (sustainable agriculture) is "the effective management of resources used in agriculture in order to meet human needs, taking into account improving the quality of the environment and protecting natural resources." The American Society of Agriculture defines sustainable agriculture as "Agriculture that maintains (in the long term) the quality of the environment, provides the basic needs of humans for food and fiber, and is economically feasible, which reflects positively on the quality of life for farmers and the rest of society" (Zahm, 2015, p. 110). Abbey Goldman argues that "sustainable agriculture must be ecologically sound, economically feasible, socially just, and culturally appropriate." (Goldman, 1995, p. 294) . While Julius Pretty believes that the sustainability of agricultural systems means "the ability to adapt to shocks and stresses, and the ability to continue for a long period, including achieving a wide range of economic, social and environmental goals." (Julius Pretty, 2008, p. 447)

In general, the literature indicates that there are more than fifty definitions of sustainable agriculture, and this is due to the diversity of the backgrounds of researchers who belong to various fields of knowledge. However, despite the multiple definitions, it is noted that there are many points

of intersection between them, as these definitions are based on the three dimensions of sustainable development: (the economic dimension), (the social dimension), and (the environmental dimension) (See Hansen, 1996,p.118). Meaning that, in addition to its interest in the element of continuity and the right of future generations, it seeks to achieve three central functions that represent the overlapping dimensions of sustainable agriculture, which are: an economic function, an ecological function, and a social function. Anne Waters and his colleagues detail these functions as follows: (Waters-Bayer et al,1995, pp.21-22)

- *The environmental dimension of sustainable agriculture*: meaning agriculture that preserves the quality of natural resources and improves the dynamism of the agricultural (ecoagrosystem), and is based on rational management of resources and uses renewable, non-polluting materials.
- *The economic dimension of sustainable agriculture*: meaning economically viable agriculture that allows sufficient production, profitable returns, and lower costs. Economic feasibility is not only related to economic returns, but is also related to the level of resource conservation and reducing environmental risks.
- *The social dimension of sustainable agriculture*: meaning distributing resources fairly among all members of society to satisfy their needs, protect their rights to use the land, provide them with financial resources and technical support, help them access markets, and enable them to participate in decisions related to agricultural policy.

3.The environmental impacts of agricultural systems

Agriculture covers 38% of the land used worldwide, accounts for 85% of water consumption, and is responsible for 80% of the clearings that threaten forests in developing countries. From the mid-nineteenth century to the late twentieth century, that is, in a period of approximately (150 years), humans converted approximately (1 billion hectares) of forests, pastures, and wetlands into agricultural lands. Statistics also indicate that (20 % of African soils are seriously degraded) (Rohila et al, 2017,p.145-146). Most environmental problems are related to agricultural systems, irrigation methods, chemical treatment of soil, use of fertilizers and pesticides, etc. (Bayoumi & Patkó, 2010,p. 88). In light of the world's increasing needs for food, which means an increase in agricultural expansion, there is a major challenge related to the need to reconcile increasing human needs without destroying the ecological balance and depleting natural resources.

Much research confirms that there is a strong relationship between agricultural systems and ecosystem degradation, and these systems generally affect water quality and quantity, soil quality, air quality, and biodiversity. (See Rohila et al, 2017, Davari et al, 2010) Agricultural systems are based

on a set of elements that together constitute the elements of the system (Figure.2), which are input and output. Inputs include two types: (Van der Werf and Petit, 2002,p.121)

1 -*Natural capital inputs* (soil, water, sun, fossil energy...)

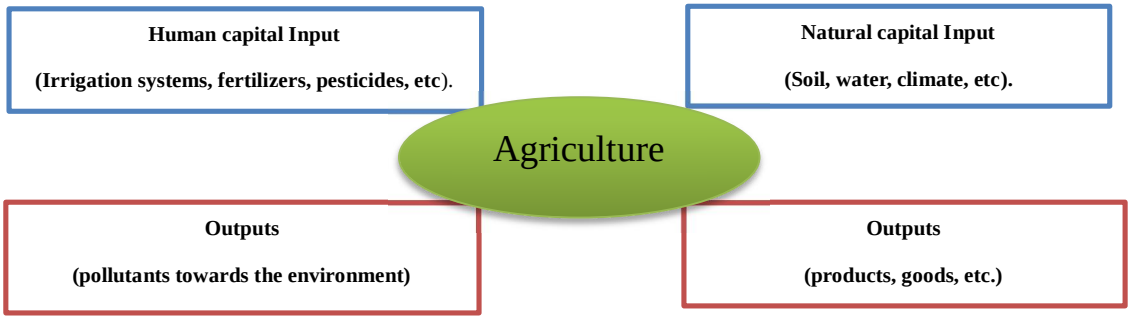
2 -*The human inputs* developed by humans (chemical fertilizers, pesticides, seeds...)

This in turn leads to two types of outputs:

1 -*The desired outputs* represented in various agricultural products.

2- *undesirable outputs*, which are the pollutants that are released into the environment.

Fig.2. Scheme of the agricultural exploitation system



Source: Developed by the researcher based on (Van der Werf & Petit, 2002)

The focus of agricultural systems on production growth following unsustainable patterns has led to negative environmental outcomes in many countries (Our Common Future, 1987,p.57), which threatens the ability of agriculture now and in the future to meet human needs, due to the loss of biodiversity, soil degradation, pollution and depletion of water resources; In addition, there is a decline in the number of agricultural workers and a decline in the rural population (Robinson, 2009,p. 1759)

4. Development of environmental impact assessment models for agricultural systems

The environmental assessment of agricultural systems presents a set of overlapping dimensions related to a group of different fields, but they are in a complex and interacting relationship with each other, namely: the natural environment (water, soil, air, ecosystem), the human element (agricultural policies, agricultural practices: irrigation methods, fertilization), chemical treatments...etc.). It can be summarized as a process that focuses on the mutual relationship and interaction between human (social and economic) and physical (ecosystem) (Van der Werf & Petit, 2002,p.121)

Striving to assess the environmental impact of agricultural practices requires integrating all dimensions of sustainable agriculture (the economic dimension, the environmental dimension, and the social dimension) into an interactive chain that enables the various factors of the agricultural system to be captured, and helps to evaluate its various impacts at all economic, social and environmental levels.

In light of the urgent need to address the environmental impact of agriculture while meeting the global demand for food, it has become necessary to ensure that decision-makers have access to accurate and comprehensive information to guide sustainable agricultural practices. Thus, searching for how to enhance multidisciplinary cooperation and integrate modern technologies to develop more effective and comprehensive evaluation models that contribute to promoting sustainable agricultural development.

The pursuit of sustainability depends on assessing the ability of an ecosystem to maintain its levels of productivity over the long term. However, the continuous increase in the quantities of inputs produced by humans (irrigation methods, fertilization, pesticides, etc.) with the aim of increasing production led to an imbalance in the ecosystem, thus reducing natural capital, and thus basic productive capabilities. Meaning that the increase in the use of inputs associated with agricultural systems has led to a deterioration in the environmental situation. Therefore, scientists have developed many approaches (and models) to assess the environmental impact of agriculture by developing indicators and tools to monitor environmental transformations, as an effort to reduce the damage resulting from them, which helps decision-makers and concerned parties make appropriate decisions, which is a basic condition for achieving sustainable agriculture. Most notable among them are: (Payraudeau & Van der Werf, 2005, p.03)

- ***(ERM)*** *Environmental risk mapping*
- ***(LCA)*** *Life cycle analysis*
- ***(EIA)*** *Environmental impact assessment*
- ***(MAS)*** *Multi-agent system*
- ***(LP)*** *Multiple linear programming*
- ***(AEI)*** *Agro-environmental indicators*

These models and the areas and scopes of their application at the regional and global levels will be summarized in the following Table (1):

Table.1. Methods for environmental impact assessment with case studies

Method	Case studies author(s)	Object and scope
ERM: environmental risk mapping	ERM-1: de Koning et al. (1997)	Modelling of the soil nutrient balance as a sustainability indicator: nation scale (Ecuador)
	ERM-2: Giupponi et al. (1999)	Modelling impacts on water quality of alternative land use scenarios with the GLEAMS model and calculation of environmental impact indices: lagoon of Venice catchment (Italy)
LCA: life cycle analysis	LCA-1: Biewinga and van der Bijl (1996)	Evaluation of ecological and economic sustainability of energy crops using a range of indicators, mainly based on LCA: Europe
	LCA-2: Geier and Köpke (1998)	Evaluation of a complete conversion from conventional to organic farming using LCA: extrapolation at the rural area scale (Germany)
EIA: environmental impact assessment	EIA: Rodrigues et al. (2003)	Evaluation of the sustainability of agricultural technology innovation by the EIA method: Field-Farm (Brazil)
MAS: multi-agent system	MAS-1: Petit et al. (2001)	Evaluation of the quantity and quality of groundwater by using hydrological, agronomic and socio-economic models in a multi-agent system: Beauce aquifer (France)
	MAS-2: Becu et al. (2004)	Modelling the impact of catchment irrigation management under social and agronomic constraints in a multi-agent system: catchment scale (Thailand)
LP: linear programming	LP-1: Zander and Kächele (1999)	Optimisation of different production systems described at the farm level with multiple goal linear programming: extrapolation to a regional scale (Germany)
	LP-2: Hengsdijk and van Ittersum (2003)	Optimisation of different production systems to maximise the production targets whilst minimising impacts: farm or regional scale (Mali)
AEI: agro-environmental indicators	AEI-1: ECNC (2000)	Development of "Driving force", "State", and "Response" indicators for environmental impact assessment mainly at macro-level: European agriculture
	AEI-2: Rasul and Thapa (2004)	Evaluation of farming sustainability by ecological, economic and social indicators: micro-regions (Bangladesh)

Source: (Payraudeau & Van der Werf, 2005, p.04)

Examining and comparing previous environmental assessment methods reveals certain deficiencies, which can be summarized as follows:

- Some methods are reductionist, because prioritizing certain variables over others. For instance, some approaches concentrate on agricultural practices and means (such as fertilization, irrigation, technology, etc.) using means indicators, while others emphasize the outcome variables (effect indicators). (Van der Werf and Petit, 2002,p.132)
- A subset of these methods exclusively concentrates on physical variables.
- The majority of these methods exhibit limited applicability within the realm of environmental assessment, both in terms of the scope of evaluation subjects and the range of potential application areas. (Payraudeau & Van der Werf, 2005, p.16)
- The majority of these methods do not adequately account for the interplay among the three dimensions of sustainability: economic, social and environmental dimensions.

As long as the study is based on the approach to sustainable development, which takes all the economic, social and environmental dimensions of development as presented by the United Nations Development Program (UNDP), integrating all these elements into a network of relationships requires

a pluralistic model that takes into account all dimensions of sustainability. This challenge was part of the effort undertaken by the European Environment Agency (EAA), which developed a theoretical model known as the DPSIR model, which is an abbreviation for the Driving Force - Pressure - State - Impact model. - Response.

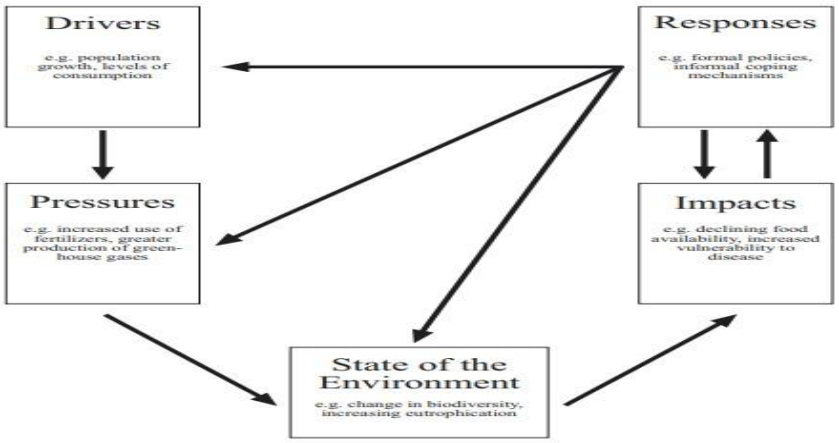
5. The DPSIR model and its applications in the agricultural

The DPSIR model was initially introduced by the US Environmental Protection Agency (USEPA) and then developed by the European Environment Agency (EEA) with the aim of overcoming the shortcomings of previous assessment frameworks such as the (pressure - state - response) (PSR) model proposed by the Organization for Cooperation and Development. In the economic field (OECD) and the (driving force - state - response) (DSR) model proposed by the United Nations (Skondras & Karavitis, 2015,p.199-200)

After its development by the European Environment Agency (EEA), the DPSIR model has been used by many national and international organizations, including the United Nations (UN) in many environmental assessment initiatives, as well as the United States Environmental Protection Agency (USEPA). Most of the literature indicates that this pluralistic model is considered a valuable tool for addressing complex environmental issues related to various human activities, and it is an effective framework for developing indicators, monitoring the state of the environment, and reporting environmental degradation. Moreover, the DPSIR model is considered a useful analytical tool and has been applied to It has a wide scope in the field of sustainable development (Carr et al, 2007,p. 544). The conceptual framework of the DPSIR model consists of the following central concepts, (Carr et al, 2007,p. 545). (See Figure .3)

- **Driving Force:** refers to human activities such as agricultural policies, development projects, market requirements and demographic growth, which drive economic activities and have a direct impact on the environment.
- **Pressure:** It is the pressure of those activities produced by driving forces on the environment.
- **State:** indicates the state of the environment. What is meant is how these pressures are reflected in the environmental situation.
- **Impact:** The impact of these changes on the quality of life and the well-being of humans and society.
- **Response:** refers to the responses, institutional efforts, and policies of decision makers to address those environmental changes and limit their effects.

Fig.3. DPSIR Model



Source : (Carr et al, 2007,p. 545)

According to the DPSIR model, human activities (agricultural, consumption, demographics, market, etc.) are considered (as a driving force) to generate significant (pressures) that affect environmental elements (air, water, soil, biodiversity, etc.). This is reflected in Environmental changes affect the (condition) of the ecosystem, including (humans, plants, animals). This condition produces a set of (economic impacts) (standard of living, level of production, food prices, etc.) and another set of (social impacts) (social cohesion). , conflict over resources, public health, social lifestyles including justice, social movements, gender differences...etc.) As for (environmental impacts), they relate to (ecological imbalance, soil, water and air pollution, desertification, deforestation, biodiversity... etc.), all of these changes impose a set of "responses" in the form of regulatory, legal, economic, or voluntary decisions, to form a feedback loop that works to modify the system , (Carr et al, 2007,p. 545)

The analytical and practical value of applying the DPSIR model in the field of agricultural activity lies in that:

- A pluralistic model that introduces a set of variables belonging to different areas of human activity, including agricultural practices, and also includes three dimensions of sustainability (the economic dimension, the environmental dimension, and the social environmental dimension)
- It is an explanatory model because it links a group of variables in an interconnected causal chain that helps to understand the various aspects of the phenomenon of agricultural activity, explains the processes associated with it and evaluates its environmental impacts at all levels. (Stanners et al, 2007,p.131)

- It is a flexible and open model that can be adapted to quantitative and qualitative analysis approaches. (Skondras & Karavitis, 2015,pp.200-201)
- It is a practical model that has proven effective in environmental assessment processes in many regions of the world due to its ability to monitor environmental changes, which helps decision-makers to respond and determine the necessary policies and measures to deal with environmental problems. (Carr et al, 2007,p. 552)

Despite its usefulness in analyzing environmental impacts and its role in guiding the decision-making process, the DPSIR model has faced criticism from many specialists because it oversimplifies complex interactions within (social-environmental) systems, because it reduces the multifaceted nature of environmental issues to a linear chain (cause -result), which potentially ignores the complex dynamics and nonlinear relationships that exist in reality.

Its focus on human-induced driving forces, such as population growth and economic factors, has also been seen as neglecting broader drivers such as political structures, cultural values and technological progress. This limit understanding of the underlying causes and hinders effective policy interventions. One of the criticisms faced by the DPSIR model is that it relies heavily on qualitative assessment methods, which may lack accuracy and hinder comparisons and quantitative analysis, which may limit the ability to measure and monitor environmental impacts effectively and limit its application and effectiveness in decision-making processes.

6.Conclusion:

The use of environmental impact assessment models in the context of sustainable agricultural development offers many benefits and at the same time is not without challenges. While these models provide a systematic approach to understanding causal relationships between human activities, environmental pressures and their resulting impacts, they also face limitations that hinder their effectiveness. A major challenge lies in the availability of data and harmonization of methodologies across different regions and agricultural systems. In addition, stakeholder engagement and multidisciplinary cooperation are essential to ensure that evaluation models take into account local contexts and integrate social and economic factors.

Therefore, to achieve sustainable agricultural development, it is important to continue evaluating and improving environmental impact assessment models. These models must also go beyond measuring individual effects and take into account synergistic effects, cumulative effects and trade-offs associated with agricultural practices. It must also take into account the social and economic dimensions of sustainability.

In conclusion, although there are challenges in using the DPSIR model, it represents a useful and valuable tool for understanding and addressing the environmental impacts of agricultural development. Therefore, addressing its limitations by enhancing cooperation, integrating modern technologies, and integrating various complex causal dynamics, enables decision makers to make informed choices that promote sustainable practices, reduce environmental degradation, and increase the adaptation of agricultural systems, paving the way for a more sustainable and resilient agricultural sector that meets the needs of current and future generations.

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