

ENVIRONMENTAL FOOTPRINT AS A PART OF INDICATORS OF SUSTAINABLE AGRICULTURAL DEVELOPMENT IN IRAQ

BASIM H AL-BADRI*

Department of Agricultural Economics, College of Agricultural Engineering Sciences, University of Baghdad, Baghdad, Iraq.

Email: basim.h@coagri.uobaghdad.edu.iq

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ABSTRACT

Based on the data and the reality of the economic environment, and according to indicators and facts of the current performance of the agricultural sector in Iraq, and in light of the future challenges facing Iraqi agriculture for plans and programs to achieve sustainable agricultural development and the problems and determinants of these plans and programs, and to achieve full benefit from the potentials and opportunities available to achieve aspects of sustainable agricultural development in Iraq, and to push the current possible paths for this development toward achieving more technological development and keep pace with contemporary regional and international developments in the aspects of agriculture and foreign trade in agricultural products, and as an attempt to do so, this study sheds light on a set of environmental agricultural indicators (Agri-Environmental Indicators) agricultural environmental indicators (AEI), which approved by the Food and Agriculture Organization of the United Nations in line with the current reality of sustainability in Iraqi agriculture, through the use of data reports issued by the Ministry of planning/Central Bureau of Statistics and the Ministries of Health, Environment, Agriculture and Water Resources. A general trend analysis has been carried out to find out the direction of the environmental performance economically and to know its efficiency and its impact on sustainable agricultural development in Iraq. Besides the use of AEI, we use the quadratic analysis method as a matrix of strengths, weaknesses, opportunities, and threats. It is a common method used when assessing performance. Points and elements of this analysis used to improve performance. If there are untapped power elements, they can be used to improve environmental performance. Work is also done to overcome weaknesses. One of the most important results of this study is that all the factors in the environmental assessment need to be developed and overcoming weakness as a step ward sustainable agricultural development in Iraq.

Keywords: Environmental footprint, Environmental pollution, Sustainable development, Agricultural environmental indicators, Strengths, weaknesses, opportunities, and threats analysis.

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INTRODUCTION

The ecosystem is an integrated unit consisting of limited components according to a delicate system, tampering with this balance, or exceeding the limits in dealing with the environment, and this accompanied by the emergence of various environmental problems that threaten the lives of humans and living organisms. Because the occurrence of any defect or deficiency in the elements or components of this system affect the nature of the reaction, so the natural system loses its balance. The extinction of different types of living organisms because of pollutants or encroachment on natural spaces due to urbanization, industry, or unfair hunting considered one of the causes of imbalance. Environmental, as each type has its different functions in the ecological chain, and the disappearance of any kind creates a gap in the environment that would disrupt the course of nature (Karen, 2011). There are many entities dealing with the topic of sustainable development indicators, whether they are local, regional, or international bodies, and given the existence of a close link between the indicators of sustainable development and environmental indicators, which are part of it (Nafisa and others, 2012). The importance of the subject of environmental indicators in monitoring the environmental situation to conserve natural resources and ensure continued balanced development without harming the environment. Therefore, some composite indicators have emerged recently, such as the Environmental Footprint Index, which depends on agricultural environmental indicators (AEI), which are indicators that are able to describe and evaluate the status and trends the environmental performance of agriculture provides useful indicators for decision makers about the state of the environment and the effects of related policies (Qandil, 2013).

Research importance

The importance of the research comes from the importance of applying modern environmental standards, the most important of them (the environmental footprint) for laying clear foundations for the concept of sustainable agricultural development in Iraq, and thus, the environmental footprint is an important criterion for judging the presence or absence of sustainability in agricultural development.

Research problem

There is a need to use a composite environmental index to measure the environmental footprint – as it is not yet measured in Iraq – similar to the gross domestic product used in the field of economics, the human development index and poverty strategies indicators used in human development, as the absence of the use of environmental indicators in identifying achieving environmental goals leads to the difficulty of measuring environmental performance and benefiting from the various indicators in this regard. This environmental footprint can be used to know the agricultural environmental impacts resulting from the agricultural activity currently, which deprives future generations of opportunities to use resources consciousness in the future.

Research hypothesis

The research assumes that the “environmental footprint” criterion not been applied yet when studying sustainability in agricultural development in Iraq, although it is an important indicator for judging sustainability.

Research aims

1. Review the most important AEI used in Iraq.
2. Study and analyze these indicators according to what are available from the environmental data in Iraq despite its limited number.

- Conclusion of the environmental footprint of Iraqi agriculture to achieve sustainable agricultural development.

Analysis method and data sources

The environmental agricultural indicators (AEI) that were approved by Food and Agriculture Organization (FAO) of the United Nations through appropriate data for this purpose, are used data of the most recent annual reports issued by the Central Statistical Organization and the Ministries of Health, Environment, Agriculture and Water Resources in Iraq for the years (2003–2017) Where a general trend analysis was conducted to find out the direction of environmental performance, and to know the extent of its impact on agricultural development in Iraq, along with the quad analysis method of the strengths, weaknesses, opportunities and threats (SWOT) to evaluate performance.

METHODS

First - Concepts (Qandil, 2013, 37-39):

- Sustainable development: Sustainable development that meets the needs of the present without harming the ability of future generations to meet their resource needs, and it assumes the preservation of natural assets for future growth and development.
- Environmental footprint: It is the total amount of resources consumed by the population of a particular country, whether from domestic or imported production, and the amount of damage generated from the use of these resources on the ground.
- Biological capacity: The ability of the biological system to produce useful biological materials and absorb waste resulting from human activities now.

Second – The relationship of environmental agricultural indicators to sustainable agricultural development:

Environmental indicators are an integral part of the indicators of sustainable agricultural development and their importance comes from the fact that they achieve the goals of this development by monitoring the status quo and monitoring changes that occur on the environment and natural resources, whether positive or negative, as they measure the extent to which the goal has been achieved, and a strong link is observed between environmental indicators and other sustainable agricultural development indicators, as other factors such as population growth, health, and

others directly or indirectly affect the environment, and are among the environmental indicators. For example, the population growth index is one of the critical indicators that lead to a limit the changes in the environment (David, 2004). In recent years, some composite indicators, such as the environmental footprint, biological capacity, and other environmental indicators for sustainable development, have emerged, and in (Table 1) an explanation of what are the most important AEI as established by FAO.

From the table, the following characteristics can derived for the sustainable development indicators:

- Meet the basic needs of all individuals today
- It assumed that there is continuous growth with justice in distributing this growth to the various groups of society
- Preserving natural assets for use by future generations
- Preserving the environment, including protecting biological diversity.

Note that the table did not include all AEI, but only indicators for which data are available in Iraq.

Third: Study the development of the elements of AEI

Air and climate change

Atmospheric air differs from other natural resources as a (renewable resource) is not exhausted by use, and Iraq is one of the countries most affected by climatic changes due to the circumstances of the wars it passed through and the uses of all types of weapons, including chemical weapons in its faces and lands, and because the area of forests in it constitutes (2.01 %) of his land only (Central Statistics Organization, 2019. 21). The risks of climate changes are not limited to humans only, but also affect the plant and the health of the animal, because they are exposed to the negative effects of global warming, which appeared through the transformation of summer in Iraq into a hotter and more long summer than the rest of the seasons and the expansion of hot days to other seasons other than the summer (Lawson, 2008). Climate change is an issue related to both the environment and development that threatens human life, especially as the balance of carbon dioxide in the air has been disturbed by its emissions resulting from increased human activity and the world has become an urgent and urgent need to plant (a billion) trees to absorb about (250) million tons of dioxide carbon (Nafisa and others, 2012). The United States Environmental Protection Agency and the World

Table 1: The most important agricultural environmental indicators and the most important components of them

Indicator	Elements	Environmental standard
1. Air	Gases, greenhouse gases, and total suspended particles in the air	The amount of CO ₂ emissions, greenhouse gases (CO ₁), and total suspended particles in the air
2. Energy	Energy use indicators	The amount of energy used in the agricultural sector from the total energy used in the country
3. Consumption of nitrogen fertilizers	Nitrogen	Use of nitrogen fertilizers in arable lands and permanent crops (1000 ton/acres).
	Phosphate	The use of phosphate fertilizers in the arable lands and permanent crops (1000 tones).
	Nitrogen and phosphate	The use of nitrogenous and phosphates fertilizers in arable lands and permanent crops (1000 tones).
4. Agricultural lands	Agricultural area	The arable area allocated to it as a percentage of the total agricultural area.
	Change in the cultivated area	Changes in the arable area.
	The area of irrigated agricultural lands	Irrigated area as a percentage of the total cultivated area
	Plastic houses	Greenhouses as a percentage of the total cultivated area.
5. Livestock	Types of crops cultivated.	Area of permanent crops as a percentage of the total cultivated area.
	Density of livestock	The area of orchards and permanent pastures as a percentage of the total cultivated area.
	Cows and buffalo	Total livestock per dunum of agricultural area (total/dunum)
	Sheep and goats	Cows and buffalo as a percentage of the total livestock.
6. Water	Poultry	Sheep and goats as a proportion of total livestock.
	The water used in agriculture	Poultry as a percentage of the total livestock.
		The total water used in agriculture as a percentage of the total water supply

Source: FAO-2014 – AGRI-environmental indicators – FAOSTAT

Table 2: Annual averages of the concentration of carbon dioxide (CO₂) and the total suspended particles in the air (TSP) in Iraq during the period (2003–2024) unit: (Microgram/cubic meter)

Year	Carbon dioxide (CO ₂)	Total suspended particles in the air (TSP)
2003	69.57	25.36
2004	72.57	26.10
2005	72.86	26.43
2006	68.96	24.94
2007	62.49	24.38
2008	72.38	27.49
2009	91.93	32.94
2010	103.51	37.51
2011	110.84	41.04
2012	126.27	45.83
2013	135.17	49.38
2014	141.03	49.49
2015	132.03	47.86
2016	143.23	48.67
2017	122.50	49.99
2018	145.90	51.78
2019	133.65	48.89
2020	144.45	49.67
2021	159.23	52.78
2022	149.45	51.70
2023	150.22	52.34
2024	155.78	51.99

*Allowable limit: 60 mg/cubic meter. Source: 1. Ministry of Health and Environment - Environmental Policy Directorate - Miscellaneous Years - Baghdad. 2. www.energyatls.iea.org.

Table 3: Emission amount from greenhouse gases (carbon monoxide gas) CO₁ in Iraq for the period 2007–2024 (thousand metric tons)

Year	Quantity
2007	100494
2008	102936
2009	103112
2010	105388
2011	110405
2012	366531
2013	400510
2014	250633
2015	222880
2016	245100
2017	200183
2018	300176
2019	390567
2020	400187
2021	450897
2022	477890
2023	483900
2024	490876

Source: 1. Central statistical organization - Years of study - Environmental indicators report - Environment statistics directorate. 2. Ministry of health and environment - technical department

Health Organization have focused on six major pollutants on the basis of which the quality of air pollution is determined, the most important of which are carbon dioxide, carbon monoxide, total suspended particles in the air, nitrogen dioxide, sulfur dioxide, and lead (Frank *et al.*, 2009). Table 2 shows the annual averages for the concentration of the most important air pollutants, which is carbon dioxide.

It is clear from (Table 2 that the high rates of air pollution with carbon dioxide gas and that it exceeds the permissible limits, which are (60) mg/cubic meter, while the total suspended particles in the air were within the permissible limit.

Table 4: Evolution of the percentage of energy used in agriculture and forestry in Iraq during the period (2008–2024) (%)

Year	Energy used in agriculture in Iraq as a proportion of the total energy used (%)
2008	0.54
2009	0.43
2010	0.21
2011	0.39
2012	0.76
2013	1.12
2014	1.34
2015	1.45
2016	1.55
2017	1.44
2018	1.33
2020	1.40
2021	1.34
2022	1.43
2023	1.49
2024	1.51

Source: FAOSTAT- AGRI- Environmental indicators, FAO statistics division

Table 5: Evolution of fertilizer use (nitrogenous and phosphate) in agricultural lands in Iraq over the period (2003–2024) (tons)

Year	Quantity
2003	355698
2004	255293
2005	438985
2006	273694
2007	228060
2008	250966
2009	334911
2010	324911
2011	340820
2012	341570
2013	360900
2014	381080
2015	271330
2016	268140
2017	310850
2018	334578
2019	394589
2020	367892
2021	417689
2022	443278
2023	398711
2024	390050

Source: Central statistical organization/agricultural statistics directorate and the ministry of agriculture/planning department - Baghdad

Table 3 also shows the amount of greenhouse gas emissions (carbon monoxide) CO₁ in Iraq for the period 2007–2024.

Energy

Energy used in agriculture in Iraq.

Table 4 shows the evolution of the percentage of energy used in agriculture and forestry in Iraq during the period (2008–2024).

From Table 4, we see fluctuations in these ratios between the rise and fall of this variable during the study period.

Fertilizers

Fertilizers considered very important and necessary production requirements for agricultural production, which the plant needs at specific times, and its lack of direct and significant impact on production. The supply is weighted under the influence of international prices that motivate companies to prefer the external market over the production

of the local market, which made the farms in Iraq between the two problems of the disappearance of the local product or its presence at exaggerated prices in light of the lack of government subsidy for fertilizers except for the main crops (Mckinnon, 2003).

Table 5 represents the data of the Central Statistical Organization and the Ministry of Agriculture to calculate environmental agriculture indicators, which are the quantities used of fertilizers and an analysis of the general trend of the development of fertilizer use in agricultural lands in Iraq during the period (2003–2024) is clear (significant/non-significant) use of each of nitrogenous fertilizers and phosphates fertilizers during the period studied.

Agricultural lands

The management and sustainable use of agricultural lands is what we mean by the sustainability of agricultural lands and is to preserve its

Table 6: The area of cultivated land in Iraq during the period (2003–2024) (thousand dunams)

Year	Cultivated land
2003	13689
2004	13643
2005	14701
2006	14059
2007	14246
2008	14237
2009	10517
2010	12043
2011	13023
2012	12743
2013	14055
2014	15559
2015	6253
2016	6075
2017	6433
2018	11210
2019	15600
2020	14600
2021	12500
2022	11200
2023	12700
2024	11210

Source: Central statistical organization/agricultural statistics directorate - Baghdad.

ability to produce what is allocated to it efficiently and in a manner that is sufficient for the current and future needs of individuals in addition to its ability to absorb any additional materials (pollutants) resulting from development operations, and therefore the land is sustainable when it has the ability to plant production, it maintains the degree of its quality and fertility, its productive capacity, in addition to its new areas of production capacity, the ability to cover the current needs of the population and meet the expectations of population growth, the land derives its importance from the natural resources of which, as well as organisms that live by (FAOSTAT, 2014). Table 6 shows the agricultural lands in Iraq during the period (2003–2024).

Livestock

The general trend of data for the preparation of livestock species in Iraq for the period (2003-2024) was analyzed to calculate the indicators of environmental agriculture as determined by the FAO and based on Table 7.

Water

The sustainable management of water resources means the sustainability of fresh water resources, the availability of water in sufficient quantities with appropriate specifications at rates necessary and sufficient to cover all consumption and non-consumptive uses of current and future generations. In other words, the freshwater resources of a country are sustainable if the average per capita share of this water is not less than the internationally agreed scarcity limit (1000 cubic meters for person per year), and the specifications of water are within the permissible safe limits according to local, regional, and international controls. This means being able to maintain the water ecosystem in a renewed manner that allows the absorption of residues of any development activity of the water resource without deterioration, pollution, or depletion (Krueger, 1997).

Consequently, this is related to the economic, institutional, and social systems associated with the water ecosystem and the regional and international relations that help achieve this sustainability.

The rate of water withdrawal for agricultural uses was as shown in Table 8. By reviewing the data of the table, we can see the following:

SWOT analysis

The SWOT analysis was conducted for analyzing the environmental reality in Iraq as part of the environmental footprint necessary to measure sustainability in agricultural development in Iraq, and the analysis showed the following results:

Table 7: Number of types of livestock in Iraq for the period (2003–2024) (1000 heads)

Year	Cows and buffalo	Sheep and goats	Total	Cows and buffalo percentage of the total (%)	Sheep and goats percentage of the total (%)
2003	3141	8590	11731	11731	73.3
2004	3094	7828	10922	10922	71.7
2005	2917	7712	10629	10629	72.6
2006	2580	7922	10502	10502	74.5
2007	2441	8160	10601	23.0	77.0
2008	2836	9534	12370	22.9	77.1
2009	2848	9787	12270	23.2	76.8
2010	2991	9866	12857	23.2	76.8
2011	3010	10126	13136	22.9	77.1
2012	3100	10382	13482	22.9	77.1
2013	3139	10642	13781	22.7	77.3
2014	3324	10883	14207	23.3	76.7
2015	3522	10991	14513	24.2	75.8
2016	3631	11216	14847	32.3	67.7
2017	3801	11396	15197	25.0	75.0
2018	3909	11370	15200	25.7	74.8
2019	4003	11399	15232	26.8	74.8
2020	4321	11442	15324	28.1	74.6
2021	4333	11678	15456	28.0	75.5
2022	4400	11879	15600	28.2	76.1
2023	4411	11900	15712	28.0	75.7
2024	4425	12221	15789	28.0	77.4

Source: 1. Central bureau of statistics/directorate of agricultural statistics – years of study - Baghdad. 2. Arab Organization for Agricultural Development – Agricultural Statistics Yearbook – Khartoum

Table 8: Available water resources in Iraq during the period (2003-2024) (billion cubic meters)

Year	Tigers river	Euphrates river	The gross	Water supply for agriculture	Proportion for cultivation (%)
2003	21.54	15.37	37.27	28.90	77.54
2004	44.42	20.54	64.96	55.21	84.99
2005	37.08	17.57	54.65	46.45	84.99
2006	47.93	19.62	67.55	57.39	84.95
2007	37.09	19.33	56.42	47.30	83.83
2008	29.30	14.62	43.92	37.33	84.99
2009	29.11	13.98	43.09	36.95	85.57
2010	28.96	13.54	42.50	36.95	86.94
2011	30.41	17.16	47.57	40.46	85.05
2012	31.50	17.61	49.11	41.12	83.73
2013	33.18	22.84	56.02	41.00	73.18
2014	20.14	17.11	37.25	33.00	88.59
2015	19.85	15.49	35.34	32.00	90.54
2016	36.05	18.70	54.75	38.20	69.77
2017	32.13	17.20	49.33	40.11	81.30
2018	23.41	9.56	32.97	25.22	
2019	76.52	16.95	93.47	76.21	
2020	29.39	20.20	49.59	39.90	
2021	43.10	15.57	58.67	44.56	
2022	36.42	17.88	54.30	45.78	
2023	43.45	18.50			
2024	49.67	21.30			

Source: Ministry of water resources - study years - water policy center - Baghdad

Strengths	Weaknesses
<ol style="list-style-type: none"> 1. Iraq possesses many important resource energies for agriculture. 2. There is a significant annual increase in livestock in Iraq. 3. Iraq is working to introduce modern technologies in agriculture that will preserve the sustainability of resources, especially modern irrigation techniques. 4. Iraq can conclude an agreement with the upstream countries of the Tigris and Euphrates rivers, ensuring a satisfactory share in accordance with the international norms of riparian countries. 5. Presence of strong investment opportunities, as Iraq is an excellent attractor to investments and a promising market if it is stable. 	<ol style="list-style-type: none"> 1. High levels of air pollution, which negatively affects agriculture as external influences. 2. Inefficiency of the green cover to meet the needs of the environment, which necessitates pursuing the horizontal development of the green cover. 3. Insufficient data on some gaseous pollutants such as SO₂, lead and ozone. 4. The lack of accurate data on the impact of pesticide pollution on agriculture and agricultural products.
Opportunities	Threats
<ol style="list-style-type: none"> 1. Existence of efforts by the Ministry of Health and Environment and some groups of environmental activists to control some sources of pollution that negatively affect the agricultural sector. 2. Having sufficient financial resources to control environmental pollution cases in the agricultural sector through projects such as the Million Tree Project. 	<ol style="list-style-type: none"> 1. Pollution rates on agricultural lands in some areas exceed the permissible limits. 2. Increase emissions from carbon dioxide, resulting from increased consumption of petroleum products, cars, and electric power generators, as well as greenhouse gases, the most important of which is carbon monoxide. 3. Desertification of large areas of agricultural land in Iraq, as well as the presence of areas threatened by desertification, aside from population and urban encroachment on agricultural lands, with a serious problem, which is fragmentation and stunting agricultural holdings in Iraq.

Source: Prepared by researchers based on research data

The results and what based on them of conclusions emerged during the review of the research.

Recommendations

The research recommends the following:

1. The necessity of providing an accurate, continuous, and updated database on environmental indicators by governmental and academic institutions in Iraq for the possibility of assessing environmental performance, especially in the agricultural sector in Iraq.
2. A serious trend toward alternative energy sources in Iraq, especially sunlight, to get rid of the many emissions of harmful gases, and this is one of the investment projects that the country can support.
3. Trying to increase and expand green areas inside cities and get them out of urban planning for cities, with more attention to the one million trees project and circulating it in the provinces bordering the desert.

4. Considering fertilizers, pesticides, and irrigation water with salinity levels (as in Basra) are restrictions for a goal function that must be maximized and that is sustainable agricultural development in Iraq.
5. Preserving water resources from waste, irrational use, and pollution to preserve human health, animals, fish, plants, and the environment in general, while continuing with government support for modern irrigation technology programs, especially under surface drip irrigation technology, which has proven very effective when it was applied in Iraq as part of cooperation with the Research Organization for Dry and Arid Lands (ICARDA).

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