



Ecological footprint as a tool to achieve sustainable development in Egypt (applied to Beheira Governorate)

Wessam Mostafa Emam^{1,a}, and Niveen Sabry Gomaa^{2,b}

¹ Assistant professor, Department of Environmental Planning and Infrastructure, Faculty of Urban and Regional Planning, Cairo University, Giza, Egypt

² Assistant professor, Department of Architecture, Faculty of Engineering, Fayoum University, Fayoum, Egypt

E-mail: ^a wessam_moustafa@cu.edu.eg ^b nsg00@fayoum.edu.eg

Abstract

The environmental dimension is one of the dimensions of sustainable development along with the social and economic dimension, and the goals of sustainable development focus on meeting the needs of current communities while preserving the rights of future generations. To make the best use of the natural environment and protect it from disasters.

In this sense, the research is concerned with the Ecological footprint as one of the environmental assessment tools that help achieve sustainability by comparing the pressure that occurs on environmental resources and their presence by identifying the concept of Ecological footprint and its importance and application to the Beheira Governorate to come up with a set of recommendations that enable decision makers and the urban planner to achieve sustainable urban development.

Keywords: sustainable development – Ecological footprint - Environmental assessments - Beheira Governorate..

ENGINEERING JOURNAL Volume # Issue #

Received Date Month Year

Accepted Date Month Year

Published Date Month Year

Online at <https://engj.org/>

DOI:10.4186/ej.20xx.xx.x.xx

1. Introduction

With global and local trends to preserve the environment, it has become necessary to integrate the environmental dimension into urban planning. The environmental dimension is concerned with studying the environmental determinants and opportunities available in the area to be planned to determine the environmental variables of all types, terrestrial, water and air, and to determine the appropriate planning interactions so that sustainable development can be achieved by responding to the current needs of society while at the same time taking into account the rights of future generations in the available resources..

Environmental assessments are one of the most important factors that help to understand and determine the environmental performance of urban communities through evaluating development projects to see the impact of these projects on the environment and setting environmental principles and standards to reduce potential negative impacts. These environmental assessments include Life Cycle Assessment (LCA), human Appropriated Net Primary Production, Ecological Footprint, Material flow analysis (MFA), Total material requirements, real progress indicator.

The Ecological footprint is one of the environmental assessment tools that help reduce the gap between human activities and biological capacity, as it shows the extent of pressure on environmental resources and their depletion in society, which enables the urban planner to direct development recommendations that limit the depletion of those resources and achieve sustainable development.

Beheira governorate is considered one of the governorates located one of the governorates located on the Mediterranean Sea next to the Delta region, which is rich in environmental resources from agricultural and urban environments, and at the same time, it is exposed to environmental pressures such as environmental pollution and loss of agricultural lands.

From this point of view, the research aims to formulate the environmental and planning requirements and recommendations for Beheira governorate to achieve a balance between urban development and environmental resources through presenting and analyzing the theoretical framework for the concept of the Ecological footprint, its components and how to measure it, and then applying the Ecological footprint assessment of the urban activities in the governorate such as agriculture, pastures, fisheries and carbon emissions to achieve Sustainable development and conservation of environmental resources

2. Research Objectives

The research aims to achieve environmental balance and reduce the depletion of environmental resources by applying the concept of the Ecological footprint in Egypt as a tool of environmental assessment that helps to determine the environmental performance of communities and then formulate a set of recommendations through which sustainable development can be achieved in Egypt.

3. Research Methodology

The research methodology starts with identifying the concept of the Ecological footprint, its measurement methods, its importance and its role in maintaining environmental balance and achieving sustainable development, and determining the methodology for applying the Ecological footprint to the Egyptian governorates. Then applying it to the Beheira governorate as one of the governorates located on the Mediterranean Sea and the Delta, and determining the extent to which development depletes environmental resources. , leading to the formulation of planning environmental controls for the development of Beheira governorate in light of reducing environmental pressures and resource depletion.

4. The concept of ecological footprint

4.1. Definition of ecological footprint

The Ecological Footprint is a measure of the impact of an individual or society on the environment and can be expressed as the amount of resources consumed [1] [2]. It measures the distribution of production and consumption in relation to sustainability [3] [4], it is a measure of the pressure that individuals and society exert on resources [5] [6].



Fig. 1 ecological footprint components

Source: [7]

4.2. The goal of the Ecological footprint

The objectives of the Ecological footprint are concentrated in the following:

- Evaluation of cities by comparing the ecological services provided with the level of demand on the biosphere in order to save resources and absorb waste
- Encouraging decision makers and the local community to introduce environmental monitoring into their daily practices so that the region can maintain a viable, competitive economy and a healthy, sustainable environment for a long time.
- Preserving the environmental resources available to the individual from overconsumption

4.3. Ecological footprint measurement method

The Ecological footprint can be used and applied at all planning levels, whether it is at the national, regional, local or different sectors level [8]. The research is concerned with applying it at the regional level (governorate) and appropriate to the Egyptian situation.

The biological capacity is compared with the Ecological footprint for the possibility of determining the extent of resource depletion, as the biological capacity expresses the ability of the ecosystem to produce natural resources suitable for human use, at the same time that it absorbs the waste resulting from that use [9]. That is, it determines the capacity of ecosystems To generate community needs of environmental resources BC is measured in global hectares, and represents the elements of biological capacity are (cropland lands, pasture lands, fisheries, built lands and the carbon footprint)

When the EF of a given population exceeds the BC of an active area for that population, it is called an ecological deficit [10]. It is calculated as shown below: [11] [12] [13] [14] [15].

4.3.1. The cropland:

- The cropland footprint calculation method:

First, we need to get the area of croplands for all governorate in Hectares, and the total product weight of the cropland in tons. Second, we need to calculate the rate of production per every hectare of the croplands. Third, we multiply the production rate by YF by EQF by area to get the Ecological footprint EF. Forth, we divide the Ecological footprint EF by the total population of the governorate to get the footprint of the croplands.

- The cropland biological capacity calculation method:

First, we multiply the area by YF by IYF by EQF to get the biological capacity. Second, we divide the biological capacity by total population of the governorate to get the biological capacity per capita indicator.

4.3.2. The cattle pasture

The cattle pasture footprint calculation method:

First, we need to get the area of the cattle pasture for all governorate in Hectares, and the total product weight of the cattle pasture in tons. Second, we multiply the production by YF by EQF by area to get the Ecological footprint EF. Third, we divide the Ecological footprint EF by the total population of the governorate to get the footprint of the cattle pasture.

The cattle pasture biological capacity calculation method:

First, we multiply the area by YF by IYF by EQF to get the biological capacity. Second, we divide the biological capacity by total population of the governorate to get the biological capacity per capita indicator.

4.3.3. Fisheries

- The fisheries footprint calculation method:

First, we need to get the area of the fishing grounds for all governorate in Hectares, and the total product weight of the fishing grounds in kilograms. Second, we multiply the production by YF by EQF by area to get the Ecological footprint EF.

Third, we divide the Ecological footprint EF by the total population of the governorate to get the footprint of the fishing grounds.

- The fisheries biological capacity calculation method:

First, we multiply the area by YF by IYF by EQF to get the biological capacity. Second, we divide the biological capacity by total population of the governorate to get the biological capacity per capita indicator.

4.3.4. The built-up lands

- The built-up lands footprint calculation method:

First, we need to get the area of the built-up lands for all governorate in kilometer square, and the total population of the governorate. Second, we need to calculate the density of the built-up buildings by dividing the total population of the governorate by the area of the built-up lands for all governorate. Third, we multiply the production by YF by EQF by area to get the Ecological footprint EF of the built-up lands.

- The built-up lands biological capacity calculation method:

First, we multiply the area by YF by IYF by EQF to get the biological capacity. Second, we divide the biological capacity by total population of the governorate to get the biological capacity per capita indicator.

4.3.5. The carbon footprint

- The carbon footprint calculation method:

First, we need the total population of the governorate then divide it by 1000, then get the amount of carbon produced by each person in the governorate, then get the amount of carbon that has been got rid. Second, we multiply the amount of carbon produced by each person in the governorate by 65% of the amount of carbon that has been got rid to get the carbon Ecological footprint.

5. The role of the Ecological footprint in achieving sustainable development in Egypt

The environmental dimension represents one of the dimensions of sustainable development along with the social and economic dimension. Sustainable development aims to meet the needs of current societies while preserving the rights of future generations to available environmental resources by achieving optimal utilization of resources. We find that among the 17 sustainable development goals of the United Nations there are 4 goals Urges the importance of sustainable use and preservation of environmental resources, and they:

Goal 11 Make cities and human settlements inclusive, safe, resilient and sustainable.

Goal 12 Ensure sustainable consumption and production patterns.

Goal 14 Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

Goal 15 Protect terrestrial ecosystems, combat desertification and halt land degradation and loss of diversity.

According to the Living Planet Report 2000 prepared by the World Wide Fund for Nature, the total global consumption of natural resources has increased steadily by 50 percent since 1970, and this may not correspond to natural resources, as the Earth's natural resources have decreased by more than 30 percent, due to urban overpopulation, fig2 shown that Ecological footprint in Egypt more than 150% greater than its biocapacity [7]. So it is necessary to consider the environmental impacts of these urban areas,

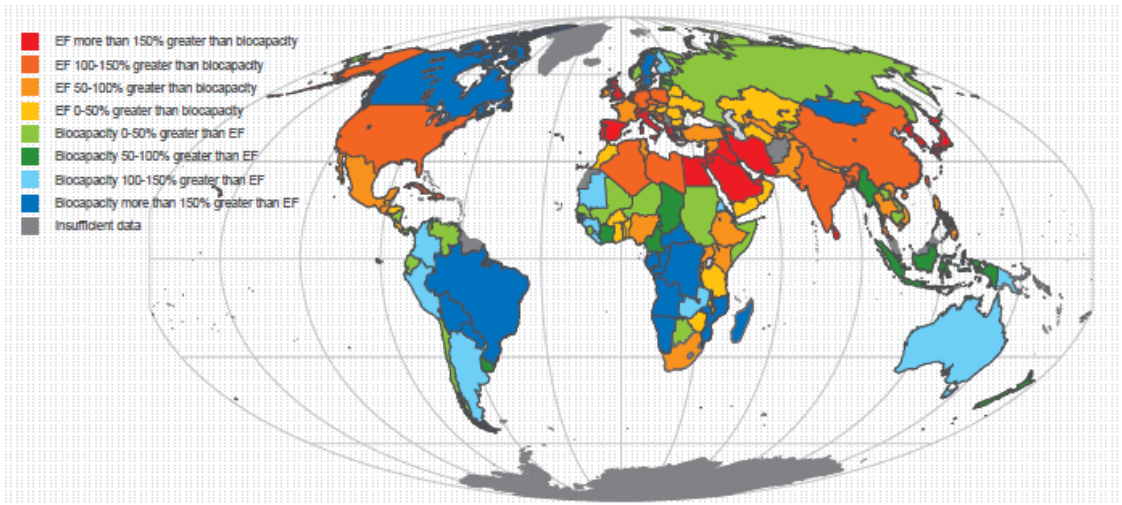


Fig. 2 Ecological creditor-debtor status, indicating the Ecological Footprint to biocapacity ratio

Source: [7]

And according to The Global Footprint Network as the figure 3 shows the environmental creditor and debtor countries in the world, it is clear that Egypt is one of the environmental debtor countries and has an environmental deficit, meaning that it has a depletion of environmental resource. And figure 4 shows that Egypt biological capacity is (0.4) and the Ecological footprint is (1.8), meaning that the environmental deficit represents (-1.4).

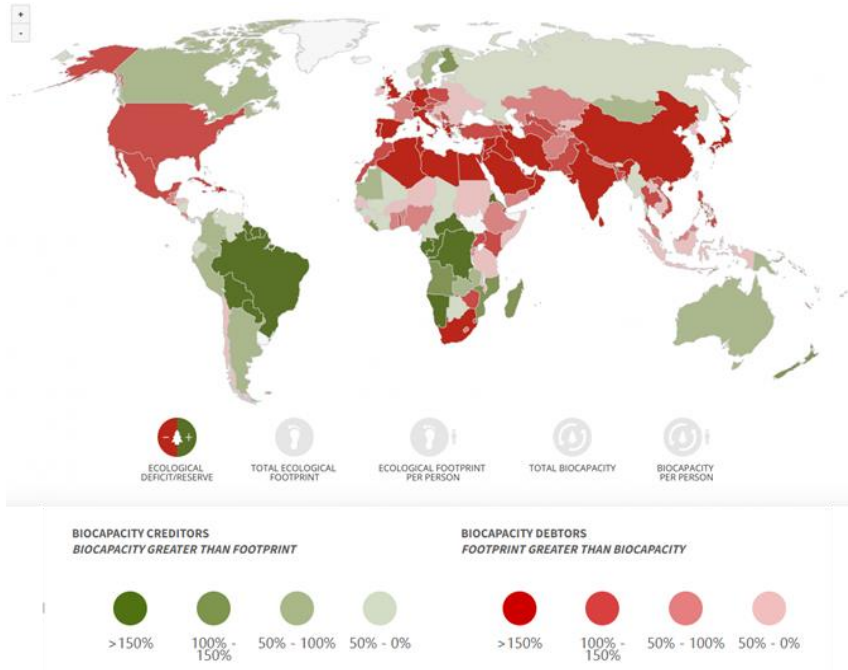


Fig. 3 Environmental creditor and debtor countries in the world

Source: [13] <https://data.footprintnetwork.org>

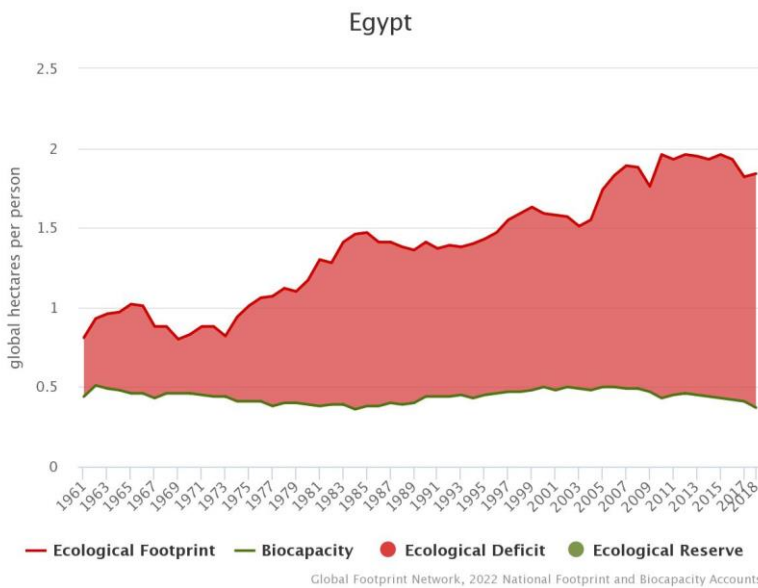


Fig. 4 Global Footprint Network, 2022 National footprints and biolocapacity accounts

Source: [16]

Thus, the importance of environmental assessments and the Ecological footprint, which shows the current environmental performance, and thus clarify the extent of the current depletion of environmental resources so that rational dealing with those resources can be achieved and thus achieving sustainable development, as the importance of the Ecological footprint according to the Organization for Economic Co-operation and Development OCDE becomes clear in assessing environmental resources, monitoring and managing resources Environmental, knowledge of the risks associated with the deficit in environmental resources, the development of policies to preserve environmental resources, measure the extent of progress towards the objectives of preserving environmental resources.

6. Ecological footprint in Beheira Governorate

Beheira Governorate is one of the governorates that overlooks the Mediterranean Sea and is bordered by the Rosetta branch and the Delta governorates (Kafr El-Sheikh, Gharbia, and Menoufia) to the east, and Giza Governorate to the south, as well as the governorates of Alexandria and Matrouh to the west. And the absence of natural obstacles such as mountains or other natural obstacles that impede communication between different regions. The governorate is also characterized by the availability of an important water front on the Mediterranean Sea, as it is interspersed with Lake Idku, which extends parallel to the coast line and up to the borders of the eastern governorate at the city of Rosetta and the borders of the Nile branch as shown in fig.5.

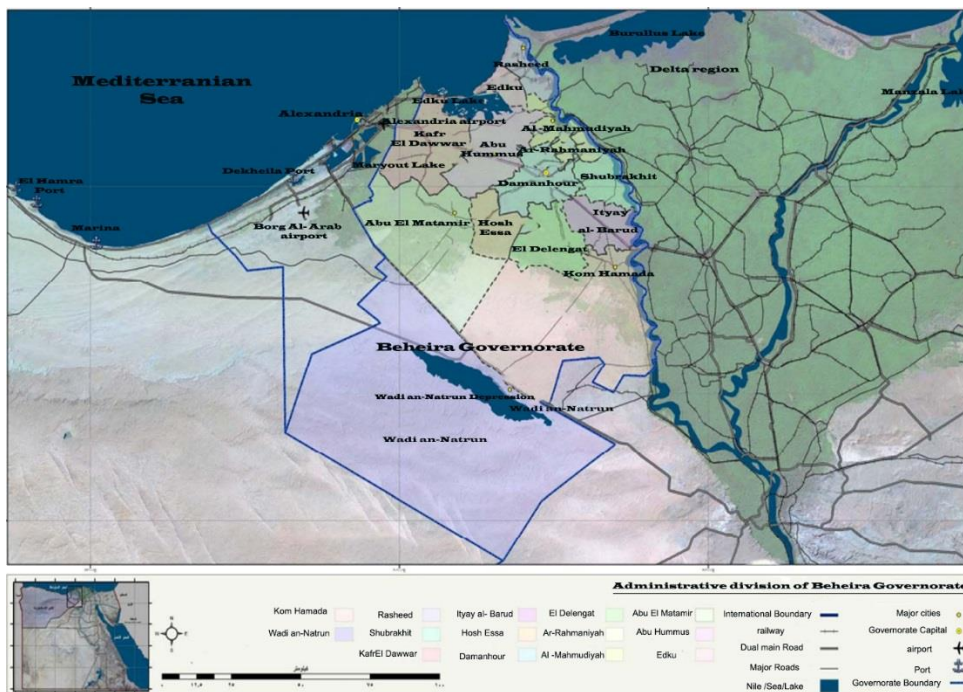


Fig. 5 The privileged location of Beheira Governorate

Source: modified by the author from [17]

The following is a calculation of the ecological footprint of Beheira Governorate

Table 1. The cropland

Source:	Area (acre)	922534
	Production	13468300
	Area in hectares	384536.7
	Production in thousands of tons	21468.3
	Production rate	17.91
	YF	1
	EQF	2.51
	EF	17288274
	Population size	6271613
	Ecological footprint	2.76
	YF	1.32
	IYF	0.99
	EQF	2.56
	BC	1286432
BC per capita	0.21	

calculated from [17] [18]

It is clear from table1 that there is pressure on the agricultural land resource estimated at about 2.55, which indicates the depletion of that resource and the need to take mechanisms to limit its depletion during development.

Table 2. The cattle pasture

Meat (ton)	12380
Milk (ton)	26847
total	39227
total in thousands of tons	39.23
area in acres	37.54
Area in hectares	15.19
population	6171613
YF	1
EQF	0.46
EF	6.99
Ecological footprint	1.1324E-06
YF	1.93
IYF	1

EQF	0.43
BC	1.3E+01
BC per capita	2.0E-06

Source: calculated from [17] [18] [19]

From the analyzes obtained in Table 2, it is noted that there is no depletion of the pasture resource, as the environmental footprint is estimated to be less than the biological capacity, which directs to maintaining the environmental balance of the resource.

Table 3. Fisheries

Production volume in tons	180511
production volume in kg	180511000
area in acres	12550
area in hectares	5271.00
production capacity	34246.03
population	3362185
EF	0.002
YF	1
EQF	0.37
Ecological footprint	0.001
YF	1
IYF	1
EQF	0.35
BC	1844.85
BC per capita	0.0005

Source: calculated from [20]

It is clear that there is a depletion of fisheries resources resource in the Beheira Governorate, as shown in Table No3., where its environmental footprint is slightly higher than the biological capacity, which confirms the importance of directing urban plans not to deplete that resource.

Table 4. The built-up lands

Built area (m ²)	5082.02
EQF	4.218

YF	1
Population	6171613
Area/population	0.0008
EF	0.0035
YF	1.32
IYF	0.99
EQF	2.56
BC	17001.43
BC per capita	0.0028

Source: calculated from [18]

The environmental footprint of built-up lands is higher than its biological capacity, as shown in Table No.4, which indicates a depletion of the buildable land resource.

Table 5. The carbon footprint

Population	6171613
Population in thousand	6171.61
The amount of carbon produced per person	9.95
The amount that is discarded	3.7
Ecological footprint	1.8

Source: calculated from [18]

Table 5 shows the carbon footprint, which is estimated in the governorate at about 1.8, which is higher than the global average carbon footprint

Table 6. The Ecological footprint of urbanization in Beheira Governorate

components of the Ecological footprint	Ecological footprint	biological capacity	environmental deficit
The cropland	2.76	0.21	-2.55
The cattle pasture	0.000001	0.000002	0.000001
Fisheries	0.0006	0.0005	-0.0001
The built-up lands	0.0035	0.0028	-0.0007
Ecological footprint	1.8		
The Ecological footprint of urbanism	4.56	0.21	-4.35

The total Ecological footprint of the urbanization of the governorate is about 4.56, and the biological capacity of the governorate is about 0.21. Thus, it is clear that there is pressure on the environmental resources in the governorate because the Ecological footprint is higher than its biological capacity by about 4.35, and therefore there is great pressure on the resources in the governorate and the need to reduce pressure on them in order to reach environmental balance so that it can For ecosystem services to be produced efficiently without negatively impacting them.

It is noted that the agricultural land resource in the governorate has an Ecological footprint of about 2.76, and the biological capacity for each individual is 0.21, which means that there is a depletion of the agricultural land resource and it must be reduced. It must be dealt with appropriately and preserved. As for the environmental carbon footprint in the governorate, it is 1.8, which is more than the global average of the carbon footprint estimated at 1.7. As for fish farms, the Ecological footprint is higher than the biological capacity by about 0.0001 only, which means that conservation puts some pressure on those. The resource is being depleted at a small rate because there is a small difference between them that needs to be stopped and preserved. As for the built-up lands, it is clear that the Ecological footprint is higher than the biological capacity of the individual, meaning that the governorate has exhausted all the lands suitable for building.

7. Discussion

The optimal use of environmental resources is one of the goals of sustainable development for urban communities, as there are 4 goals of the United Nations Sustainable Development Goals that are directly related to preserving environmental resources and using them in a sustainable manner. Many studies have emphasized the importance of environmental assessments by determining the environmental performance of urban communities, which Including the environmental footprint, which is characterized by determining the extent of depletion of its environmental resources by comparing it with the biological capacity, which was applied to the governorate of Al-Beheira and deducing the depletion of its environmental resources.

8. Conclusion

The Ecological footprint is considered one of the most important environmental assessment tools that help achieve sustainable development by determining the pressure on environmental resources and the extent of their depletion, and thus the possibility of determining appropriate controls and requirements that help preserve those resources.

And by applying it to the Beheira governorate, it became clear that there is a depletion of resources in the governorate, especially the agricultural land resource, as the difference between its environmental footprint and biological capacity is about x. Fisheries are depleted, as their environmental footprint is higher than the biological capacity by a slight difference of about .0001 and therefore it needs to be dealt with carefully with a balance in the pasture resource.

9. Recommendations

Through research and applied study, it is concluded that the use of the Ecological footprint in Egypt is necessary to provide decision makers with taking appropriate policies and mechanisms for each governorate according to its specificity, as it is effective in knowing the risks that may occur from the depletion of resources and identifying the resource that is being depleted so that it can be dealt with and preserved, and thus the possibility of Achieving sustainable development, especially with global and local trends to preserve the environment.

References

- [1] H. Nautiyal and Varun Goel, "Sustainability assessment: Metrics and methods," *Methods in Sustainability Science*, 2021.
- [2] M. Wackernagel, "Ecological Footprint," *Encyclopedia of Ecology (Second Edition)*, pp. Pages 270-282, 2019.
- [3] M. Gavrilescu, "Engineering Perspectives in Biotechnology," *sciencedirect*, pp. Pages 974-993, 2021.
- [4] PrमितVerma, Rishikesh Singh, Pardeep Singh and A.S. Raghubanshi, "Urban ecology – current state of research and concepts," *Urban Ecology*, pp. Pages 3-16, 2020.
- [5] C. Garrett, "Ecological footprint: definition, meaning and calculator," *climate consulting selectra*, 2022. . Available: <https://climate.selectra.com/en/environment/ecological-footprint>.
- [6] A. Lim, "What Is Ecological Footprint? Definition and How to Calculate It," 2022. Available: <https://www.treehugger.com/what-is-ecological-footprint-4580244>.
- [7] WWF Japan, "Japan Ecological Footprint report," WWF Japan, Tokyo, 2010.
- [8] Florian Schaefer, Ute Luksch, Nancy Steinbach, Julio Cabeça and Jörg Hanauer, "Ecological Footprint and Biocapacity," *European Commission*, 2006.
- [9] K. M. Ghanim, "Ecological Footprint," *Academy of Scientific Research and Technology*, 2021.
- [10] M. A. Moros-Ochoa, G. Y. C.-N. Anderson Quintero-Español and Carolina Llorente-Portillo, "Forecasting Biocapacity and Ecological Footprint at a Worldwide Level to 2030 Using Neural Networks," *mdpi*, 2022.
- [11] European commission, "Environmental footprint methods," *European commission site*, 2021. Available: https://environment.ec.europa.eu/news/environmental-footprint-methods-2021-12-16_en.

- [12] A. Galli, J. Kitzes, P. Wermer, M. Wackernagel, V. Niccolucci and E. Tiezzi, "An exploration of the mathematics behind the Ecological Footprint.," *International Journal of Ecodynamics*, p. 250–257, 2007.
- [13] Global footprint network, "Ecological Footprint," Global footprint network, 2022. Available: https://www.footprintnetwork.org/our-work/ecological-footprint/?_ga=2.17310705.972054640.1672448103-1450927185.1629675482.
- [14] ECOTEC - U.K, "ECOLOGICAL FOOTPRINTING," European Parliament, Directorate General for Research, Directorate A, The STOA Programme, Luxembourg, 2001.
- [15] I. S. Martin, "The Role of the Ecological Footprint Assessment in Guiding Sustainable Metropolitan Growth," Research Fellow College of Design, University of Minnesota, 2010.
- [16] Global footprint network, "National footprints and biolocapacity accounts," 2022. Available: <https://data.footprintnetwork.org/#/countryTrends?cn=59&type=BCpc,EFCpc>.
- [17] GOPP, "Environmental perspective of Alexandria region," General Organization for Urban Planning, Cairo, 2010.
- [18] GOPP, "Preparing the strategic plan for the urban development of Buhaira governorate and the developmental features of its centers project," General Organization for Urban Planning, Cairo, 2020.
- [19] A. A. Qutb, W. A. Ezzat and A. M. Al-Hindi, "A comparative economic study of the efficiency of mixed cow fattening farms in the centers of Buhaira governorate: using random spatial functions," *The Egyptian Journal of Agricultural Research*, pp. 435-454, 2016.
- [20] Directorate of Agriculture in Buhaira Governorate, "fisheries," Directorate of Agriculture in Buhaira Governorate, 2022. Available: <http://www.vercon.sci.eg/INSYS/Moderates/AlBehra/Centraldata.html>.