

Measurement of Natural Capital in academic journals

Abstract

This article is based on the existing literature on the concept, categories, and natural variables of capital and aims to discuss natural capital, offering some points of view on the emerging rationality of specialized literature. In a preliminary stage, a systematic analysis and cumulative review were used to identify and select the variables to measure natural capital and, in this stage, 1856 articles were selected. The surveys were captured and the variables on the environmental resources used in the research were analyzed with the result of the reading concentrated on the variables. A content analysis was carried out to check the reading, consisted of (i) pre-analysis, (ii) analytical description and (iii) inferential interpretation, verification of the frequency of words per article. The concept of natural capital is necessary and acceptable, but it is not easy to understand it categorically or measure its value. It is an interdisciplinary issue and some schools of thinkers could be noticed. The messages about ecological characteristics are limited to the field of study mainly of qualitative water analysis. It was also possible to identify contents that conceptualize the Natural Capital based on sources of energy and agriculture. There is a search for indicators as ways to measure the environment that give rise the variables to Natural Capital to meet mainly the needs of the economy. The article highlights the probable performativity of the concept and, ultimately, how it can impact us and incorporates the discussion of Natural Capital in the accounting headings. This article is a cautionary note for those who use the concept of natural capital and offers considerations using examples in the literature. Based on the existing literature, the originality lies in the discussion that natural capital is not a neutral term and its framing is likely to have broader implications.

Keywords: content analysis, economic rationality point, interdisciplinary research, natural capital

Volume 6 Issue 2 - 2021

Lorena L Furtado, Luiz Panhoca

Doctoral Program in Accounting, Federal University of Paraná – UFPR, Brazil

Correspondence: Luiz Panhoca, Department of accounting, Social Applied Sector (PPGCONT/SCCA), Av. Prof. Lothario Meissner, 632 - Campus III - Botanical Garden, 1st floor, room #31, ZIP 80210-070. Curitiba/PR, Brazil, Tel +55 41 3360 4418, +55 41 98418 8160, Email panhoca.luiz@gmail.com

Received: March 27, 2021 | **Published:** April 22, 2021

Introduction

Sustainability has pillars interconnected to economic, social, and ecological areas. To be sustainable, it is necessary that natural resources are present over time in a way that does not compromise the survival of future generations, which includes the life of man and the permanence of the ecosystem. For this, the measurement of Natural Capital (NC) is relevant to such sustainability.¹

Throughout history, the NC stands out in economic discussions as it integrates models and the observation of production and work²⁻⁴ and its episteme comprises social and ecological aspects in its body of analysis.^{3,4}

In the academic environment, the NC is discussed and the interest in this reinforced subject in the economy is evidenced as information for investment decision⁵ and is explained in this article from the Theory of Capital which, throughout history, has placed as evidence of the need to measure environmental resources as it is part of production activities⁶⁻⁸ Callon⁹ says that an intrinsic value from the perspective of neoclassical anthropology. However, NC is a material issue for accounting bodies and companies.¹⁰ The term (NC) activates a specific frame of reference.¹¹ In the economically attributed interpretation, there is a separation of subjects and objects that perpetuates a fractured epistemology.¹²

Measuring the NC takes us to a specific unit of measurement of this capital^{13,14} and puts economic analyzes in a situation of doubt in relation to measurement since natural resources require a different treatment from other metrics that not only measure monetary policy to

be measured objectively.¹⁵ Measuring NC requires multidisciplinary quantitative and qualitative knowledge that embodies knowing the degree of importance for human life, society, ecosystem, and development of a region in determining variables and units of measurement.^{8,16-18} Knowing whether research on NC is advancing in this direction requires a detailed analysis, for this purpose, it aimed to deepen us in academic research to infer about the messages brought in the variables and their measurement regarding the measurement of NC.¹⁹⁻²¹

The purpose of this study is to evaluate the texts of the articles for presenting characteristics that represent the published research are important sources of analysis on a particular subject²² and the text is seen as an array of meanings that worked analytically presents meanings discovered by researchers.¹⁹ Observe the texts and then answer the following research question: what content is being investigated in academic research to conceptualize Natural Capital?

The objective of this study is to investigate the content of articles published in journals blind review on the variables that comprise the NC for measurement purposes through content analysis. The analysis will seek to identify patterns and frequencies in the body of the texts and infer about the evolution and contextualization of the metrics explored in the CN.

The structuring of this article describes previous understandings of the phenomena under study and in the topic of methodology summarizes the research project, including collection strategies and analytical strategy, and interpretative investigation approach.

References

This literature review consists of combining both summary and synthesis, often within trying to identify specific conceptual categories.²³⁻²⁵

Natural Capital (NC) and its economic foundation

NC, as a research field, brings two main approaches: (i) the conservationist, nature is something that must last over time and therefore must be preserved,^{26,27} and (ii) the approach the restoration of renewable natural resources, which treats the NC as an asset that generates “dividends” or “interest” for the use of services and goods captured from ecosystems.²⁸⁻³² Even so, there is a need to improve the information on natural resources used to analyze national wealth and its subsequent measurement.^{33,34}

Understanding NC involves many interdependencies.³⁵ Knowing its value, which directs the discussion to its importance, for the production of wealth through not only economic development.^{36,37} The value, in this case, is not only limited to what is paid for work³⁸ but also supported by issues related to its scarcity,³⁹ of the production that makes up the capital value, such as land use, biological factors of ecosystems and human needs when using natural resources.^{28,37,40}

Fisher⁴¹ states that there should be a rental fee for the use of the NC that should serve not only to guarantee wages but also to support the rent for the use of the land. Even with the incorporation of such rent, the fact is that there is no guarantee that production will meet future generations over time, since the NC may become scarce. Lo and Power⁴² based on the model proposed by Fisher⁴¹ affirm that additional factors may influence in determining the supply chain strategy.

Riha⁴³ stated that German economic science is the result of a development process for more than 400 years and that it is evolutionary and maintained its conscious respect for tradition allowing it to respond to changes in socioeconomic conditions, and its characteristic features that include a sense of social purpose where the economy can be consciously oriented to meet not only material needs and the role of the State.

Thus, the importance given to NC and human capital was to demonstrate that these are essential factors for production.⁴⁴⁻⁴⁶ These are capitals that should not be matched, for example, the machines used in production (means to obtain a product).⁴⁷

More specifically the NC, the fact that it is limited leads to concerns, such as the way it is being consumed by society and impacts future needs, both economic and human.^{48,49} Based on agriculture, these future concerns bring perspectives on soil conservation and depletion.^{50,51} The concept that the earth is a resource linked only to work, passes those associated with other factors that are present in its structure (mineral resources, oxygen, ecosystem) that generate food (solar energy, rain, nutrients, among others).⁵² Natural limitations start to be observed due to the risk of compromising quality due to use over time.⁵³

The flow of natural resources for future generations may not be possible.⁸ The value of the NC does not depend only on observing what it represents for the production, but also, to whom it affects in an intertemporal perspective and, what changes in the normal course of nature, then comes the approach on local sustainability and globally, seeking to identify policies that maintain NC levels over time.^{54,55}

Understanding the qualitative characteristics of the Natural Capital

For social sciences, natural resources are supported by the so-called Social Ecology. This aspect identifies the relationship between man and nature through a historical and cultural lens, stating that there are impacts to be considered that affect the way of living and environmental standards over time.^{49,56} Social Ecology is interdisciplinary, emphasizes identifying the characteristics of society and takes into account cultural and historical aspects, considers that there is a complex and autopoietic system in which living beings are not limited to issues related to groups and their symbols.⁵⁷⁻⁵⁹

One possibility of interpretation is that the symbols introduced and constructed in society over time give meaning to their existence and are in the environment to organize the physical structure, laws, way of life among other aspects, satisfying their demands and planning how nature will be treated by man.^{56,60} Man establishes, through their culture, how actions are practiced, identifies behaviors of a social system, what is the limit between beings and their way of living,^{61,62} defining how the social body will behave and fixing their form of housing, food, animal husbandry, among other characteristics that will be limited by legal and historical issues.^{57,63} Civilization itself identifies aspects that shape a particular society, language, knowledge about symbols, currency, among other characteristics, shape the way the social system came to be granted, in addition to characterizing the culture of a people.⁶⁴ Other needs in the personal sphere (freedom, self-development, recreation, psychophysical health, etc.) and in the collective levels (social contacts, norms and values, ideals, cultural identity, and others) provoke “questions about the results obtained and caused, positive or negative, over time and the impact they have on NC.”¹⁶

Another interpretation is the focus on ecology, metabolic changes are discussed to explain the motivation of problems involving sustainability. Krausmann et al.⁶⁵ argue that “maintain the functioning of society’s metabolism without destroying the resource base and without damaging the natural environment, exceeding its capacity to absorb the flow of our metabolism is a basic requirement for sustainability”. Physical changes in natural components cause social changes and impact man’s way of life.⁶⁶ Components of nature have biological, energetic, and environmental issues at their core, linked to population dynamics, making the characteristics of such resources worthy of attention.⁶⁶⁻⁶⁸

Analyzing these natural components makes it possible to establish local policies appropriate to economic and sustainable development.^{69,70} These changes also impact the political and economic issues of a locality.⁷¹ Ecology is in this sense because it considers the qualitative aspects of the environment with the biological, ecosystemic, chemical, and structural observation of natural resources.⁷² And this appreciation is in line with the social welfare presented by the Millennium Assessment of Ecosystems (AM) in 2005, which advocates an accurate survey of the various ecosystems (exploited or not) to guarantee basic services for man.

Method

This phase of the work as recommended by Fink²⁴ presents how the content of the selected literature was treated and how the analysis was conducted. The exploratory study is based on content analysis²⁰ to check the attributes of the messages in context articles that form the basis for analysis.

In a preliminary stage, a Systematic analysis and cumulative review were used to consider and select the variables to measure NC (Attachment 1) The Scopus database (chosen for convenience) was consulted. The initial sample in the analysis of those keywords, in combination with the terms “biology,” “chemistry,” “ecology,” and “human and social” (1856 articles) was identified. The abstracts (904) and the variables emerged from the analysis to investigate the existence of a relationship of measurement with the environment, natural resources, environmental sustainability issues, and NC. Six articles that were not available for reading were excluded. Then the surveys were captured and the variables on environmental resources used in the research were analyzed, as a result of the concentrated reading about the variables, the focus of the present work was on the analysis of 17 sustainability measurement surveys and five NC measurement surveys, with the available sample consisting of 22 articles. A list of the 22 articles can be seen in Annex 2 of Furtado and Panhoca 2020.⁷³

The content analysis was conducted to examine whether there is stability in the texts produced during the reading important for the inductive technique.^{20,74} As written messages are means of communication, they make it possible to extract objective structured information, grouping topics about a social context through systematic procedures, with a pragmatic structure enabling replication.^{74,75}

The content analysis process consists of (i) pre-analysis, observation of the word frequencies present in the 22 articles (ii) analytical description, indication of the word frequencies present in the articles that will be grouped by year, and (iii) inferential interpretation, verification of the frequency of words per article.

The pre-analysis consists of making an organized arrangement of the material by readings and investigations. The analytical description allows you to code, classify terms, and perform further categorizations. Inferential interpretation consists of reflecting on theoretical grounds to draw conclusions about the findings already codified and grouped.⁷⁶

In a first step (pre-analysis), contextual terms and standards become objects of analysis in order to describe and understand the meaning of the metrics described for the measurement of NC. After all, “... texts are always the observable parts of a chosen context”.¹⁹ It is expected an understanding of the research environment related to NC measurement.

Analysis

First, the global analysis was carried out, and then the cross-sectional analysis.

Global analysis

The analyzes were performed using version 7.5 of ATLAS.ti. Before placing the 22 texts in the system, the structure was organized into new files, excluding bibliographic references and figures. Subsequently, the texts were converted to PDF and transferred to the ATLAS.ti system. When performing word frequency analysis, the system itself tends to exclude characters such as commas, periods, asterisks, among others. Thus, after such exclusion, the words and their frequencies are extracted and compressed in an excel spreadsheet. The content analyzes were separated into three stages: (i) Frequency of the words contained in the 22 articles; (ii) Frequencies of words present in the articles that will be grouped by year, and; (iii) Frequency of words per article.

To optimize this step, those words that contained only 4 syllables and limited to pronouns were excluded, mainly. Words were excluded

with a frequency of 100 to 299 words, and the presence of pronouns and adjectives used to make sense of the sentences and not to contextualize them was also observed. The analyzed interval was the one with a frequency of at least 300 and at most 1300 times in the analyzed texts.

The term “Sustainability” with 1328 repetitions is present in all articles. Subsequently, the word “Capital” occurred 834 repetitions in a total of 14 articles. The word “Natural” in 20 articles, identified 635 times in the texts.

The words “Economic” (frequency of 560 words), “Indicators” (frequency of 533 words), “Sustainable” (frequency of 436 words), and “Social” (frequency of 427 words), were also highlighted. Present in all analyzed articles.

Cross-sectional analysis

The temporal distribution of words by the articles was observed to verify if there was a focus of study per year. The articles were grouped by year to then perform the word frequency analysis. The results are identified where the number of times it was repeated is broken down beyond the word:

The articles were published in the years 2009, 2011, 2014, 2015, 2016, 2017, 2018, and 2019. The term sustainability was present in the 6 years analyzed.

In 2009 (02 articles), there were 218 repetitions of the term “NC” being a relevant factor for the analysis of research related to the accounting of environmental resources. The presence of the word “capital” was present in 2011 (03 articles). In 2014 (01 article) the term “Welfare” was mentioned 71 times in the article. For the year 2015 (02 articles) “analysis” and “urban” are present in the articles and aligned with the theme of sustainability and the urban environment. In 2016 (02 articles), the presence of the word “management” presents the core of sustainable management.

The years 2017 (05 articles) and 2018 (05 articles) were the years with the highest number of articles. The focus of the articles for the year 2017 was sustainability and water. For the year 2018, the articles presented a frequency in relation to the word “indicators”. Finally, in 2019 the detail is in the word “economic” in which the studies are aligned with the theme corporate development of companies.

Analysis by article

As an analysis of the content of the texts individually, the words with the highest frequencies in each article were selected. Subsequently, one more reading of each article was performed to identify the focus of the selected words. Table 1 shows the results ordered by year:

Table 1

Content analysis by article

Observing the table above, there is an emphasis on corporate sustainability by organizations.⁷⁷⁻⁸²

It is also possible to observe evaluations about the term NC as the focus of 6 types of research.^{44,83-87} Furthermore, in the research by Zijp et al.⁸⁸ and Mondelaers, van Huylensbroeck and Lauwers,⁸⁹ and Kelly et al.⁹⁰ the theme of sustainability related to the agricultural process had an emphasis. Furthermore, water analysis was observed as an important research factor by Ren and Liang,⁹¹ Hai et al.,⁹² and Zijp et al.⁹³ These surveys emphasize sustainability with an aspect focused on environmental management.

Sustainable development has gained greater relevance in the research by Husgafvel et al.,⁸¹ Lior, Radovanovic, and Filipovic,⁹⁴ and Van Beynen et al.⁷⁹ On social welfare, such term called attention to the research Kaivo-oja et al.⁹⁵ and Engelbrecht.⁵⁵

Finally, urban metabolism became a prominent content in the research by Zhang, Yang and Yu.⁹⁶ It is worth mentioning that the researches listed here have the characteristic of bringing the theme of sustainability as a point of study for the development of its analysis objectives.

Conclusion

In the analyzed texts, sustainability has its prominence, which would be expected since the 22 articles were selected using the keyword “environmental sustainability”. It is now necessary to identify what such Sustainability refers to.

Two strands of studies were observed in the texts on the theme of sustainability: one to address corporate aspects to identify a balance between economy, society, and the environment, and the other directed to environmental aspects to manage natural resources in order to meet human demands. Corporate sustainability goes against the studies invoked in the economic area^{7,8,45} rooted in the observation of production and its nuances in the discussion of the relationship between capital and labor. Sustainability, which places the environment as an object of study, seeks to improve research practices beyond economics, invoking attributes such as forests, agriculture, and water as centers of analysis.^{66,67}

Regarding social emblems in the texts, the focus is on social well-being^{55,95} necessary for man’s life in the present and in the future and which is related to the NC offered by the environment. This focus is absorbed by Strong Sustainability⁵⁴ in which the NC must be studied for the purpose of meeting human life in the present and in the future. Kurniawan and Managi⁸⁷ emphasized the use of NC as a source of analysis and regional efficiency.

Regarding ecological attributes, the center of the analysis is in the environment, especially with regard to water quality,^{80,84,86,91–93,96} against what was presented as relevant in terms of biological analysis.^{67,69} These items are contextualized as variables that are part of the NC.

It was also possible to identify in one of the works an analysis of energy sources, which includes non-renewable resources discussed in the work of Zhang et al.⁹⁶ Policies aimed at discussing best practices in the use of environmental resources are also featured in the works by Zijp et al.,⁹³ Kelly et al.,⁹⁰ and Van Beynen et al.⁷⁹

The purpose of this work was to identify the content of the research being carried out by the academic community on the measurement of NC, so as to understand the concept of NC. Through an analysis of the contents of academic texts, it was possible to identify which economic, social, and ecological attributes have been used to contextualize the NC and its subsequent measurement and are placed as structures for discussions in the academic environment.

On economic issues, the NC study highlights corporate sustainability, that is, that which prioritizes production geared to economic growth, highlighting the discussion of the relationship between capital and labor. Notes that the NC is part of the productive activity and therefore needs to be measured.

Regarding social issues, research brings guided content on social welfare,^{55,95} meeting the study Sustainability Strong presenting the

search for environmental resources that occur over time.⁵⁴ NC must be identified for the purpose of meeting social welfare. The messages about ecological characteristics are limited to the field of study mainly of qualitative water analysis. It was also possible to identify contents that conceptualize the NC based on sources of energy and agriculture.

In the texts, there is a search for indicators as ways to measure the environment.^{77,78,80,81–83,90,94,97} These indicators give rise to the variables related to NC to meet, mainly, the needs of the economy.

With the conclusions of the work, to expand the content for the construction of the variables of natural capital, it is proposed: i) interdisciplinary analysis on natural capital; ii) survey of social and ecological factors present in natural capital; iii) proposing indicators measuring bases consistent with its social and ecological factors.

There is a limitation of the sample placed here in the work, since there may be other researchers with prominence in such an area of study. Furthermore, it is worth making a more critical observation of the speech of such authors to learn about intertextual aspects, that is, dialogues that are being constructed based on other texts present in the literature on the measurement of NC. For future research, it is proposed to identify the qualitative characteristics in more detail involving mainly the social and ecological fields, improving thus the attributes of nature that are essential for man and that need to be inserted in the context of inferences about the NC for measurement purposes.

Acknowledgments

The authors express appreciation of the critical review made by the Editors and anonymous reviewers, which considerably improved the clarity and quality of the report, and thank Mr. Pedro Canto for help with the English translation.

Funding

This work was supported by the Coordination for Improvement of Higher Education Personnel [CAPES – Coordenação de Aperfeiçoamento de Pessoal de Nível Superior]; and the National Council of Technological and Scientific Development [Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq [grant number 402940/2016-4].

Conflicts of interest

We have no conflicts of interest to disclose.

References

1. Elkington J. *Green swans: the coming boom in regenerative capitalism*. Austin: Fast Company Press; 2020.
2. Callon M. Civilizing markets: Carbon trading between in vitro and in vivo experiments. *Accounting, Organizations and Society*. 2009;(34)3–4:535–548.
3. Morales J, Sponem S. You too can have a critical perspective! 25 years of critical perspectives on accounting. *Critical Perspectives on Accounting*. 2017;(43):149–166.
4. Russell S, Milne MJ, Dey C. Accounts of nature and the nature of accounts: critical reflections on environmental accounting and propositions for ecologically informed accounting. *Accounting, Auditing and Accountability Journal*. 2017;(30)7:1426–1458.
5. Dierkes M, Preston LE. Corporate social accounting reporting for the physical environment: a critical review and implementation proposal. *Accounting, Organizations and Society*. 1977;1(2):3–22.

6. Böhm-Bawerk EV. *Positive Theory of Capital*. New York: G. E. Stechert and Co; 1930.
7. Usher D. Traditional capital theory. *The Review of Economic Studies*. 1965;(32)2:169–186.
8. Brand F. Critical natural capital revisited: Ecological resilience and sustainable development. *Ecological Economics*. 2008;(68)3:605–612.
9. Callon M. What does it mean to say that economics is performative? In: MacKenzie D, Muniesa F, Siu L, editors. *Do economists make markets? On the performative of economics*. Princeton, New Jersey: Princeton University Press; 2007:311–357.
10. ACCA (Association of Chartered Accountants and Fauna and Flora International) KPMG. Is natural capital a material issue? An evaluation of the relevance of biodiversity and ecosystem services to accountancy professionals and the private sector. 2013.
11. Lakoff G. Why it matters how we frame the environment. *Environmental Communication*. 2010;(4)1:70–81.
12. Castree N. Commodifying what nature? *Progress in Human Geography*. 2003;3(27):273–297.
13. Ijiri Y. A framework for triple-entry bookkeeping. *The Accounting Review*. 1986;4(61):745–759.
14. Robinson J. Capital theory up to date: A reply. *The Canadian Journal of Economics*. 1971;(4)2:254–256.
15. Clayton TD, Collison S, Gallhofer S. et al. University of Dundee. *Accounting Organizations and Society*. 1992;17(5):399–425.
16. Chiesura A, Groot RD. Critical natural capital: a socio-cultural perspective. *Ecological Economics*. 2003;(44):219–231.
17. Daily GC, Söderqvist T, Aniyar S, et al. The value of nature and the nature of value. *American Association for the Advancement of Science*. 2000;5478(289):395–396.
18. Gómez-Baggethun E, Barton DN. Classifying and valuing ecosystem services for urban planning. *Ecological Economics*. 2013;(86):235–245.
19. Krippendorff K. *Content analysis: an introduction to its methodology*. 2nd edn. London: Sage Publications Inc; 2004.
20. Neuendorf KA. *The content Analysis - guidebook*. London: Sage Publications; 2002.
21. Proctor EH, Silmere R, Raghavan P, et al. Outcomes for implementation research: conceptual distinctions, measurement challenges, and research agenda. *Administration and Policy in Mental Health and Mental Health Services Research*. 2010;2(38):65–76.
22. Creswell JW. *Qualitative inquiry and research design: choosing among five approaches*. 2nd edn. London: Sage Publications Inc; 2007.
23. Cook KE, Murowchick E. Do literature review skills transfer from one course to another? *Psychology Learning and Teaching*. 2014;(13):3–11.
24. Fink A. *Conducting research literature reviews: From the internet to paper*. 5th edn. New York: Sage Pub; 2020.
25. Ridley D. *The literature review: A step-by-step guide for students*, 2nd edn. London: Sage Publications; 2012.
26. Ehrlich PR, Tobiasm MC. *Hope on earth: a conversation*. Chicago, IL: University of Chicago Press; 2014.
27. Pieck SK. What stories should a national nature monument tell? Lessons from the german green belt. *Cultural Geographies*. 2018;(26)2:195–210.
28. Bartelmus P. *Sustaining prosperity, nature and wellbeing: what do the indicators tell us?* London: Routledge; 2018.
29. Gray M. The confused position of the geosciences within the natural capital and ecosystem services approaches. *Ecosystem Services*. 2018;(34) Part A:106–112.
30. Norton LR, Smart SM, Maskell LC, et al. Identifying effective approaches for monitoring national natural capital for policy use. *Ecosystem Services*. 2018;(30):98–106.
31. Turner RK, Daily GC. The ecosystem services framework and natural capital conservation. *Environmental and Resource Economics*. 2007;(39)1:25–35.
32. Woodworth P. *Our once and future planet: Restoring the WORLD in the climate change century*. University of Chicago Press; 2013.
33. Flores JA, Konrad O, Flores CR, et al. Inventory data on Brazilian Amazon's non-wood native biomass sources for bioenergy production. *Data in Brief*. 2018;(21):1935–1941.
34. Maldonado TV, Panhoca L, Allievi F. MuSIASEM analysis structure proposal for micronarratives on extractive productive chains in the Amazon context. *Ecological Indicators*. 2019;(106):1–10.
35. Bodin ÖSM, Alexander J, Baggio ML, et al. Improving network approaches to the study of complex social-ecological interdependencies. *Nature Sustainability*. 2019;(2):551–559.
36. Alvim RG, Oliveira MM, Castellanos HG. Global social change: human ecology from an eco-ethical perspective. In: Valera L, Castilla J, editors. *Global changes: ethics of science and technology assessment*. 2020;46:121–130.
37. Stenmark M. *Environmental ethics and policy-making*. Routledge, London; 2017.
38. Ricardo D. The principles of political economy and taxation. *History of Economic Thought Books*, Batoche Books, Kitchener, Ontario. (Original work published 1821); 2001.
39. Faber M, Proops JLR. Natural resource rents, economic dynamics and structural change: a capital theoretic approach. *Ecological Economics*. 1993;1(8):17–44.
40. Leff H. Political ecology: A Latin American perspective. *Desenvolvimento e Meio Ambiente*. 2015;(35):29–64.
41. Fisher AC. Measures of natural resource scarcity. In: Smith VK, editors. *Scarcity and Growth Reconsidered*. 1977;(8):248–275.
42. Lo SM, Power D. An empirical investigation of the relationship between product nature and supply chain strategy. *Supply Chain Management*. 2010;(15)2:139–153.
43. Riha T. German political economy: the history of an alternative economics. *International Journal of Social Economics*. 1985;(12)3/4/5:2–248.
44. Kurniawan RS, Managi S. Linking wealth and productivity of natural capital for 140 countries between 1990 and 2014. *Social Indicators Research*. 2019;(141):443–462.
45. Robinson J. Capital theory up to date. *The Canadian Journal of Economics*. 1970;(3)2:309–317.
46. Teachman JD, Paasch K, Carver K. Social capital and the generation of human capital. *Social Forces*. 1997;(75)4:1343–1359.
47. ISSC, IDS, UNESCO. *World social science report 2016, challenging inequalities: pathways to a just World*. Paris: UNESCO Publishing; 2016.
48. Scott A. Conservation and capital theory: Rejoinder. *The Canadian Journal on Economics and Political Science*. 1956;(22)1:99–101.
49. Barbier EB. The concept of natural capital. *Oxford Review of Economic Policy*. 2019;1(35):14–36.
50. Clark JS, Furtan WH. An economic model of soil conservation/depletion. *Journal of Environmental Economics and Management*. 1983;4(10):356–370.
51. Dazzi CW, Cornelis EAC, Costantini M, et al. The contribution of the European Society for Soil Conservation (ESSC) to scientific knowledge, education and sustainability. *International Soil and Water Conservation Research*. 2019;(7)1:102–107.

52. Gaffney MM. Soil depletion and land rent. *Natural Resource Journal*. 1965;(4)3:537–557.
53. Collins RA, Headley JC. Optimal investment to reduce the decay rate of an income stream: The case of soil conservation. *Journal of Environmental Economics and Management*. 1983;1(10):60–71.
54. Arrow K, Dasgupta JP, Mäler KG. Evaluating projects and assessing sustainable development in imperfect economies. *Environmental and Resource Economics*. 2003;26(4):647–685.
55. Engelbrecht H. Natural capital, subjective well-being, and the new welfare economics of sustainability: Some evidence from cross-country regressions. *Ecological Economics*. 2009;2(69):380–388.
56. Fischer-Kowalski M, Weisz H. The archipelago of social ecology and the island of the Vienna school. In: Haberl H, Fischer-Kowalski M, Krausmann F, editors. *Social Ecology. Human-Environment Interactions*. 2016;(5):3–28.
57. Haberl H, Fischer-Kowalski M, Krausmann F. Of birds and bees: Biodiversity and the colonization of ecosystems. *Social ecology: Society-nature relations across time and space*; 2016:375–388.
58. Hausknost D, Gaube V, Haas W, et al. Society can't move so much as a chair - systems, structures and actors. In: H Haberl, Fischer-Kowalski M, Krausmann F, editors. *Social ecology: Society-nature relations across time and space*. 2016:375–388.
59. Parboteeah P, Jackson TW. Expert evaluation study of an autopoietic model of knowledge. *Journal of Knowledge Management*. 2011;(15)4:688–699.
60. Luhmann N, Barrett R. Society as a social system. *Choice Reviews Online*. 2012;(1):1–12.
61. Orlove BS. Ecological Anthropology. *Ecological Anthropology*. 1980;(9):235–273.
62. Sieferle RP. Cultural evolution and social metabolism. *Geografiska Annaler, Series B: Human Geography*. 2011;(93)4:315–324.
63. Erb KH, Haberl H, Jepsen MR, et al. A conceptual framework for analysing and measuring land-use intensity. *Current Opinion in Environmental Sustainability*. 2013;5(5):464–470.
64. Wiedenhofer D, Haas W, Neudinger M, et al. Material stocks and sustainable development. In: Haberl H, editor. *Social ecology social ecology: society-nature relations across time and space*. Part of the Human-Environment Interactions book series, Huen; 2016:277–291.
65. Krausmann F, Weisz H, Eisenmenger N. Transitions in sociometabolic regimes throughout human history. In: Haberl H, Fischer-Kowalski M, Krausmann F, editors. *Social ecology: Society-nature relations across time and space*. Springer Nature Switzerland AG; 2016:63–92.
66. White B. A review of the economics of biological natural resources. *Journal of Agricultural Economics*. 2000;3(51):419–462.
67. Huffaker RG, Wilen JE. Animal stocking under conditions of declining forage nutrients. *American Journal of Agricultural Economics*. 1991;4(73):1213–1223.
68. Tisdell C. Local communities, conservation and sustainability: Institutional change, altered governance and Kant's social philosophy. *International Journal of Social Economics*. 1997;(24)12:1361–1375.
69. Dasgupta P. The welfare economic theory of green national. *Environmental Resource Economic*. 2009;(42):3–38.
70. Swallow SK. Resource capital theory and ecosystem economics: Developing nonrenewable habitats with heterogeneous quality. *Southern Economic Journal*. 1996;(63)1:106–123.
71. Victor PA. Indicators of sustainable development: some lessons from capital theory. *Ecological Economics*. 1991;(4)3:191–213.
72. Chapin FS, Matson PA, Vitousek PM. *Principles of terrestrial ecosystem ecology*. New York: Springer-Verlag; 2011.
73. Furtado LL, Panhoca L. How are the variables for the measurement of natural capital being elaborated? *Journal of Environmental Management*. 2020;(262):1–6.
74. Triviños A. Introduction to social science research: qualitative research in education - positivism, phenomenology, marxism. *Formação* (1). Atlas, São Paulo; 1987.
75. Kronberger N, Wagner W. Keywords in context: statistical analysis of texts. In: Bauer MW, Gaskell G, editors. *Qualitative research with text, image and sound: a practical manual*. Brazil: Vozes, Petrópolis, RJ; 2002.
76. Bardin L. Content analysis. Edições 70, Lisboa; 1977.
77. Moldavska A, Welo T. Testing and verification of a new corporate sustainability assessment method for manufacturing: A multiple case research study. *Sustainability*. 2018;(10)11:2–40.
78. Nikolaou IE, Tsalis TA, Evangelinos KI. A framework to measure corporate sustainability performance: A strong sustainability-based view of firm', *Sustainable Production and Consumption*. 2019;(18):1–18.
79. Van Beynen P, Akiwumi FA, Van Beynen K. A sustainability index for small island developing states. *International Journal of Sustainable Development and World Ecology*. 2018;(25)2:99–116.
80. Delai ITS. Sustainability measurement system: A reference model proposal. *Social Responsibility Journal*. 2011;3(7):438–471.
81. Husgafvel RK, Poikela J, Honkatukia, et al. Development and piloting of sustainability assessment metrics for arctic process industry in finland — the biorefinery investment and slag processing service cases. *Sustainability*. 2017;(9)1693.
82. Dočekalová MP, Kocmanová A. Comparison of sustainable environmental, social, and corporate governance value added models for investors decision making. *Sustainability*. 2018;10(649):1–13.
83. Fenichel EP, Hashida Y. Choices and the value of natural capital. *Oxford Review of Economic Policy*. 2019;1(35):120–137.
84. Fenichel EP, Abbott JK, Bayham J, et al. Measuring the value of groundwater and other forms of natural capital, *PNAS*. 2016;9(113):2382–2387.
85. Couharde C, Géronimi VD, Hotel EM, et al. Measuring natural capital: the challenges lie donie the example of nouvelle-cale. *European Journal of Development Research*. 2011;(23):151–173.
86. Ruggeri J. Government investment in natural capital. *Ecological Economics*. 2009;(68)6:1723–1739.
87. Kurniawan R, Managi S. Sustainable development and performance measurement: global productivity decomposition. *Sustainable Development*. 2017;(654):639–654.
88. Zijp M, Posthuma CL, Wintersen A, et al. Definition and use of solution-focused sustainability assessment: a novel approach to generate, explore and decide on sustainable solutions for wicked problems. *Environment International*. 2016;(91):319–331.
89. Mondelaers KGV, Huylenbroeck, Lauwers L. Sustainable value analysis: sustainability in a new light: results of the EU SVAPPAS Project. *Euro Choices*. 2012;2(10):9–15.
90. Kelly E, Latru L, Desjeux YM, et al. Diazabakana et al. Sustainability indicators for improved assessment of the effects of agricultural policy across the EU : Is FADN the answer? *Ecological Indicators*. 2018;(89):903–911.
91. Ren J, Liang H. Multi-criteria group decision-making based sustainability measurement of wastewater treatment processes. *Environmental Impact Assessment Review*. 2017;(65):91–99.
92. Hai R, Shi H, Zhang B, et al. An ecological information analysis-based approach for assessing the sustainability of water use systems : a case study of the Huaihe River Basin, China. *Clean Technologies and Environmental Policy*. 2015;17(1):2197–2211.

93. Zijp MC, Der Loop SLW, Heijungs R, et al. Method selection for sustainability assessments: The case of recovery of resources from waste water. *Journal of Environmental Management*. 2017;(197):221–230.
94. Lior N, Radovanović M, Filipović S. Comparing sustainable development measurement based on different priorities: Sustainable development goals, economics, and human well-being - Southeast Europe case. *Sustainability Science*. 2018;(13)4:973–1000.
95. Kaivo-oja JJ, Panula-ontto J, Vehmas, et al. Relationships of the dimensions of sustainability as measured by the sustainable society index framework. *International Journal of Sustainable Development and World Ecology*. 2014;1(21):39–45.
96. Zhang Y, Yang Z, Yu X. Urban metabolism: A review of current knowledge and directions for future study. *Environmental Science and Technology*. 2015;(49)19:11247–11263.
97. Rodrigo P, Muñoz P, Wright A. Transitions dynamics in context: Key factors and alternative paths in the sustainable development of nations. *Journal of Cleaner Production*. 2015;(94):221–234.