

Berchin, Issa Ibrahim; Guerra, José Baltazar Salgueirinho Osório de Andrade

Article

GAIA 3.0: Effects of the Coronavirus Disease 2019 (COVID-19) outbreak on sustainable development and future perspectives

Research in Globalization

Provided in Cooperation with:

Elsevier

Suggested Citation: Berchin, Issa Ibrahim; Guerra, José Baltazar Salgueirinho Osório de Andrade (2020) : GAIA 3.0: Effects of the Coronavirus Disease 2019 (COVID-19) outbreak on sustainable development and future perspectives, Research in Globalization, ISSN 2590-051X, Elsevier, Amsterdam, Vol. 2, pp. 1-5,
<https://doi.org/10.1016/j.resglo.2020.100014>

This Version is available at:

<https://hdl.handle.net/10419/330948>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by-nc-nd/4.0/>



GAIA 3.0: Effects of the Coronavirus Disease 2019 (COVID-19) outbreak on sustainable development and future perspectives

Issa Ibrahim Berchin^{a,b}, José Baltazar Salgueirinho Osório de Andrade Guerra^{a,c,*}

^a Centre for Sustainable Development (GREENS) at the University of Southern Santa Catarina, 34 Adolfo Melo Street, Florianópolis 88015-090, Sant Catarina, Brazil

^b ANCLIVEPA Veterinary College, 285 Ulisses Cruz Street, Sao Paulo 03077-000, Sao Paulo, Brazil

^c Cambridge Centre for Environment, Energy and Natural Resource Governance, (CEENRG), University of Cambridge, Cambridge, UK.

ARTICLE INFO

Article history:

Received 11 May 2020

Received in revised form 8 June 2020

Accepted 10 June 2020

Available online 25 June 2020

Keywords:

COVID-19

Coronavirus

Sustainable development

Global change

Future perspectives

ABSTRACT

In the past decades, the frequency of epidemics with global importance has increased significantly. Only in the first two decades of the 21st Century, the world has witnessed the epidemics of Severe Acute Respiratory Syndromes, Zika virus, Ebola virus, Yellow Fever, the new COVID-19, besides the traditional influenza and other virus and bacteria. However, due to the high level of globalization, the large-scale population flow and the high reproductive rate of the virus, COVID-19 suddenly affected several countries, infecting hundreds of thousands of people and killing dozens of thousands in the fastest unprecedented crisis ever recorded, which also led to the fastest severe economic crisis on history. This perfect storm of social, economic and health catastrophes caused by the COVID-19 pandemics, directly threatens the world's livelihood and wellbeing and jeopardize the achievement of the United Nation's Sustainable Development Goals. Sustainable development is personified by Gaia's definition, implying limits for human activities and urging for a better use of technologies and resources. Although temporary, these changes in human actions set future trends for humanity, changing many aspects of our behavior, which include impacts in culture, technology, healthcare, economy, policy, education and the environment. Which may lead to a new enlightenment based on the need for global solidarity and an urge for the implementation of sustainable development pathways, finally creating a common agenda for the future of humanity as part of the Gaia, not above it.

1. Introduction

When Lovelock first published his book presenting his thoughts of Gaia¹ in 1979 (Lovelock, 1979), he argued that the Earth is one large living being sheltering and enabling life itself. This view, although criticized by scientists, offers a perfect panorama of the interdependence of our ecosystems on earth, space and in the ocean, which urges or a holistic and integrative approach for the planet.

In 2018, Lenton and Latour advanced the Lovelock's concept of Gai from the idea that all "living things are part of a planetary-scale self-regulating system that has maintained habitable conditions", to the consideration that human self-awareness can interfere in the Earth's self-regulation (Lenton & Latour, 2018; Lovelock, 2009).

Although the initial Lovelock's concerns were the nuclear race and the effects of its radiation on Gaia, global population growth represents a pressing issue to be addressed (Sobrosa Neto et al., 2018). The global population increased from three billion people in 1960 to almost eight billion in 2020 (The World Bank, 2019), which require an unprecedented use of natural

resources that pressures the earth's ecosystems and challenges sustainable development (Mercure et al., 2019).

Therefore, human activities are affecting the Earth system and threatening its resilience, pushing the limits of the planetary boundary² (Steffen et al., 2015). Following the uncontrolled population growth, global greenhouse gases emissions has increased in the same period (The World Bank, 2019): CO₂ emissions went from 9 to 36 million kt; Methane emissions went from about 5 to more than 8 million kt of CO₂ equivalent; Nitrous oxide emissions went from 2 to almost 4 thousand metric tons of CO₂ equivalent.

These pressures on Gaia are leading to many global changes, such as climate change that threatens the life on earth and promote large scale human migration (Berchin, Valduga, Garcia, & de Andrade Guerra, 2017; McNamara & Gibson, 2009), extreme weather events, the sixth mass extinction of species (Ceballos, Ehrlich, & Dirzo, 2017; Slaughter, 2012), among many other environmental effects that pressures social and economic systems in a symbiotic relationship (see Fig. 1). (See Fig. 2.)

* Corresponding author.

E-mail address: baltazar.guerra@unisul.br. (J.B.S.O. de Andrade Guerra).

¹ For the purpose of this article, Gaia is described as the integration of the global environment/ecosystems, which influence and are influenced by economic and social activities.

² Planetary boundaries "defines a safe operating space for humanity based on the intrinsic biophysical processes that regulate the stability of the Earth system" (Steffen et al., 2015).

This relationship was recently explored by economists defending the theory of the Water-Energy-Food (WEF) Nexus (Mercure et al., 2019; Sobrosa Neto et al., 2018). The WEF Nexus “represents the complex interrelations and interdependencies among water, energy and food systems”, which are influenced by global economic (industrialization, international trade, production and consumption patterns, technologies), social (population growth, large-scale migration, land use, urbanization, consumers behaviors, technologies, ageing) and environmental (extreme weather events, land degradation, ocean acidification, change in precipitation patterns, global warming, sea level rise, floods, droughts) changes that creates challenges for governance and requires a holistic approach (de Andrade Guerra, Berchin, Garcia, et al., 2020).

For instance, food systems are among the most susceptible sectors to the effects of the Coronavirus Disease 2019 (COVID-19) outbreak, since (1) demand for healthier food products is increasing, (2) food safety methods and technologies are required at all levels (producers, retailers and consumers) to avoid the spreading of the virus, (3) food security is threatened by the quarantine holding about a billion people in lockdown, although governments are flexing measures, and (4) food systems have to meet long term sustainability standards (Galanakis, 2020). These considerations should be addressed by all stakeholders, supported by public policies to ensure food security for all (Berchin et al., 2019).

The Food and Agriculture Organization of the United Nations estimates that around one third of the world's food are lost or wasted every year (FAO, 2019). Most of food wasted in developing countries are generated during agricultural production and postharvest handling or storage, whilst food losses in developed countries are generated during agricultural and consumption stages (Galanakis, 2012; Galanakis, 2013). The valorization of food waste contributes to enhance the sustainability of food systems by generating multiple by-products with high added value and functional ingredients; thus, reducing the amount of food waste disposed, which is a serious challenge in urban areas (Bursać Kovačević et al., 2018; Galanakis, 2018; Galanakis, Tsatalas, & Galanakis, 2018).

Using this integrative perspective of the synergies between environmental, economic, and social systems, this article aims to elucidate what are the effects of the COVID-19 outbreak on sustainable development and explore some future perspectives, advancing the Gaia's concept.

2. Effects of the COVID-19 outbreak on sustainable development

In the past decades, the frequency of epidemics with global importance has increased significantly. Only in the first two decades of the 21st Century, the world has witnessed the epidemics of Severe Acute Respiratory Syndromes (SARS), Middle East Respiratory Syndrome (MERS), Zika virus, Ebola virus, Yellow Fever, the new COVID-19, besides the traditional influenza and other virus and bacteria (Buckee, 2020; World Health Organization, 2019).

From this shortlist, three are variations of the coronavirus (SARS, MERS, COVID-19), which are zoonotic diseases emerging in highly populated regions (Poland, 2020). COVID-19, for instance, has a high reproductive rate and, therefore, it spreads faster than the others. Due to the high level of globalization and large-scale population flow, the virus suddenly affected several countries, infecting hundreds of thousands of people and killing dozens of thousands in the fastest unprecedented crisis ever recorded, which also lead to the fastest severe economic crisis in history (Poland, 2020; World Health Organization, 2020; Zhou et al., 2020).

Only in the first three months of 2020, due to the COVID-19 Pandemics, the United Nations (2020) estimates that 5 to 25 million jobs were lost, US\$ 860 billion to US\$ 3.4 trillion losses in labor income, 30% to 40% downward pressure on global foreign direct investment flows, 20% to 30% decline in international arrivals, 1.5 billion students out of school at the primary to upper-secondary classes, 3.6 billion people offline. This statement only exacerbates the already foreseen socioeconomic impacts of this Pandemic, particularly affecting the most vulnerable groups are already at risk - women, youth, low-wage workers, small and medium enterprises, and the informal sector.

This crisis requires further global cooperation, bigdata technologies and networks for decision-making, transparency for data disclosure, responsibility of decision-makers, businesspersons and the civil society, high investments in healthcare services and economic intentions from governments, aiming to decrease the COVID-19's health and economic toll (Poland, 2020; Zhou et al., 2020).

This perfect storm of social, economic and health disasters caused by the COVID-19 pandemics, directly threatens the world's livelihood and wellbeing and jeopardize the achievement of the United Nations Sustainable Development Goals (SDGs) (Zhou et al., 2020). The 17 SDGs and its 169 targets aims to promote a global agenda for sustainable development to be achieved by 2030. Specifically, SDG 3 aims to “ensure healthy lives and promote well-being for all at all ages” (United Nations, 2015).

Sustainable development is covers social, environmental and economic aspects to sustain life on Earth, respecting the planetary boundaries for the present and future generations Pirouz, Haghshenas, Haghshenas, & Piro, 2020). Sustainable development is personified by Gaia's definition, implying limits for human activities and urging for a better use of technologies and resources. However, the COVID-19 outbreak jeopardizes sustainable development by affecting the economy and the society and, although it is a transitory challenge “it has the potential to disrupt the process, which can have years of adverse effects” (Pirouz, Haghshenas, Haghshenas, and Piro, 2020). Gaia also reflects on the interdependent and interconnection among all living beings on Planet Earth, urging for an integrative single approach to counterbalance the social, economic and environmental effects of the COVID-19 Pandemic.

The United Nations' Secretary-General, António Guterres, stated that COVID-19 is the greatest challenge for humanity since the formation of

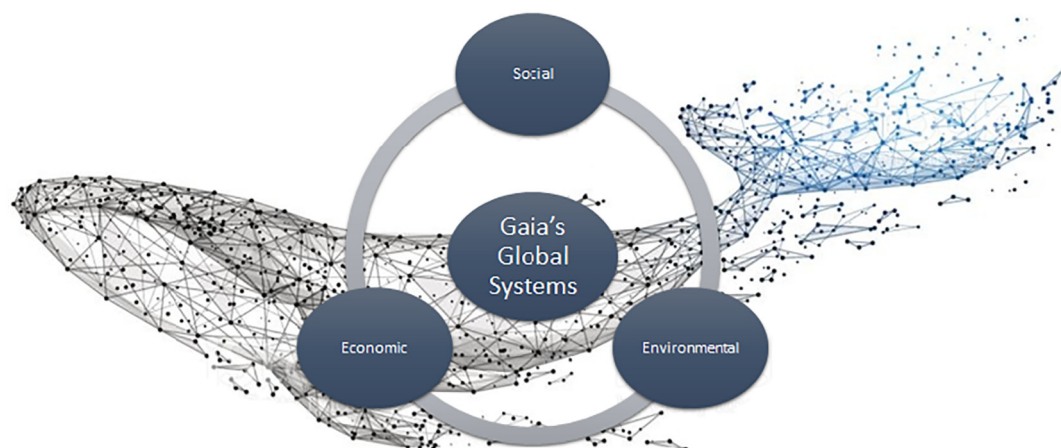


Fig. 1. Gaia's global systems.



Fig. 2. COVID-19 pandemic on the SDGs.

Source: United Nations (2020)

the United Nations (United Nations, 2020). And this test requires global solidarity, good governance and a sense of shared responsibility. António Guterres continues, arguing that “this human crisis demands coordinated, decisive, inclusive and innovative policy action from the world's leading economies – and maximum financial and technical support for the poorest and most vulnerable people and countries” (United Nations, 2020).

3. Addressing future perspectives

Transitory environmental improvements promoted by the reduction of human activities, include a higher air quality due to the reduction of industrial production and travels, reduction of traffic in cities, a

cleanup of the Venice canals, among others. However, these are temporary conditions and do not reflect a significant lasting change in human activities. This is also valid for the social distancing and the economic crisis.

The United Nations (2020), has recommended that countries cope with the impacts of COVID-19 by promoting:

- **Global measures to match the magnitude of the crisis.** Focusing on a human-centered, innovative and coordinated stimulus package; avoiding protectionist measures; and boosting economic support to developing countries.
- **Regional mobilization.** Guarantee trade policies for global connectivity and coordination; engage with private financial sector to support

businesses; and address structural challenges and strengthen normative frameworks to deal with transboundary risks.

- **National solidarity is crucial to leave no one behind.** Undertake fiscal stimulus and support for the most vulnerable; protect Human Rights and focus on inclusion; support to Small and Medium sized Enterprises; support decent work; Support education; and Prioritize social cohesion measures.

Although temporary, these changes set future trends for humanity, changing many aspects of our behavior, which include impacts in culture, technology, healthcare, economy, policy, education and the environment.

- **Culture:** Increase of global solidarity and cooperation;

The COVID-19 Pandemic requires more solidarity among human beings and countries, dividing communities, businesspersons and governments between (1) the need for social distancing to flatten the curve of contamination and avoid the exhaustion of healthcare systems and (2) the need to continue economic activities to avoid further depression that affects people's lives, jobs and access to food, and recover the economy. Although some cultural aspects of societies, such as the wet markets in China, will maintain their traditional course, with some small changes. For instance, the most likely source of COVID-19, the wet markets in China, already opened for the public.

- **Technology:** Acceleration of information and communication technologies in the societies' core activities;

This crisis demands high levels of creativity and technology to maintain the main activities of our society (education, labor, politics, health), which will lead to a definitive inclusion of information and communication technologies in the societies' core activities, social behavior and industry sectors.

- **Healthcare:** Demonstration of the vulnerability of healthcare systems throughout the globe.

The inefficiency and vulnerability of governments, economies and healthcare systems throughout the globe demonstrates the urgent need for better governance and more just/inclusive economies that support the basic needs of the people. Technology might also support this sector by using telemedicine and other resources for basic needs.

- **Economy:** Demonstration of the vulnerability of the global economy;

The high sensitivity of economies and the financial sector to the COVID-19 even before its classification as a Pandemic, demonstrates the high vulnerability of the global economy. Which requires a more intensive role of governments as last resort and moral risk administrator, also operating with a Keynesian economic approach of government's interventions to stimulate economic activities and safeguard its people. This crisis also incentive the acceleration of the Industry 4.0, speeding the rates of informatization of the production, communication and services.

- **Policy:** Increase of the government's power, in municipal, state and federal level. And, the increase of pressures on the governments by the people via social media;

The higher use of social media as a political tool is determining the *modus operandi* of governments according to the people's demands. There is also a dispute between the municipal, state and federal governments over the response to the COVID-19. Thus, this crisis enabled a stronger social control by the state and a higher use of multiple sources of information for big data technologies that helps to control the virus. To support this big data network, a multi-stakeholder and multi-sectoral collaboration is necessary, sharing data and increasing transparency.

- **Education:** Increased used of technologies and distance learning;

As more than 2 billion students in all level of education is out of their schools, many educational institutions are adopting distance learning practices in many innovative ways, which is accelerating the amplitude of the

use of technologies to better prepare future leaders for Industry 4.0. The higher use of technology for multiple sectors and social needs, particularly in learning and engagement on politics via social media, requires that people educate themselves to self-organize their agendas and learn to investigate whether an information is true or fake news.

- **Environment:** Sudden improvement of overall environmental quality due to the reduction of human activities.

The rapidly social distancing of people and the closure of national, state and municipal borders slowed people's travel and industrial production, which promoted a transitory and sudden improvement of overall environmental quality due to the reduction of human activities. These improvements are reflected in air and water quality, reducing pollution. The question is whether this crisis can promote a sense of awareness and responsibility over the current production patterns and human behavior, which should have lasting effects; or this is indeed a transitory effect, which will fade as the Pandemic outbreak lose forces.

4. Conclusions

In the Anthropocene, humans occupy a critical role in the Gaia's balance, requiring that humanity accelerate its paths towards the SDGs. Reviewing the societies' production and consumption behaviors and increasing the resilience of global systems with a deeper care for people.

Humankind is facing an unprecedented crisis that should make us better, improving global solidarity and the concern for others wellbeing, highlighting the importance of the social dimension of the SDGs and reshaping our relationship with the natural environment. Which may lead to a new enlightenment based on the need for global solidarity and an urge for the implementation of sustainable development pathways, finally creating a common agenda for the future of humanity as part of the Gaia, not above it.

Therefore, international networks forged by globalization and strengthened by the technological advances enables greater knowledge transfer, which emphasize the importance of maintaining these networks active to share good practices and experiences.

Future studies must keep the track on the virus social impacts, observing its trends and long-term effects on our society. Also using big data technologies to map initiatives and good practices to improve the resilience of human socioeconomic systems and its relations with the environment.

CRedit authorship contribution statement

Issa Ibrahim Berchin: Conceptualization, Methodology, Formal analysis, Validation, Investigation, Writing - review & editing, Supervision, Project administration, Funding acquisition. **José Baltazar Salgueirinho Osório de Andrade Guerra:** Conceptualization, Methodology, Formal analysis, Validation, Investigation, Writing - review & editing, Supervision, Project administration, Funding acquisition.

Declaration of competing interest

The authors declare that there are no conflicts of interest.

Acknowledgment

This study was conducted by the Centre for Sustainable Development (Greens), from the University of Southern Santa Catarina (Unisul), in the context of the project BRIDGE - Building Resilience in a Dynamic Global Economy: Complexity across scales in the Brazilian Food-Water-Energy Nexus; funded by the Newton Fund, Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina (FAPESC), Coordenação de Aperfeiçoamento de Pessoal de Nível superior (CAPES), National Council for Scientific and Technological Development (CNPq) and the Research Councils United Kingdom (RCUK).

References

- Berchin, I. I., Nunes, N. A., de Amorim, W. S., Alves Zimmer, G. A., da Silva, F. R., Fornasari, V. H., ... de Andrade Guerra, J. B. S. O. (2019). The contributions of public policies for strengthening family farming and increasing food security: The case of Brazil. *Land Use Policy*, 82, 573–584. <https://doi.org/10.1016/j.landusepol.2018.12.043>.
- Berchin, I. I., Valduga, I. B., Garcia, J., & de Andrade Guerra, J. B. S. O. (2017). Climate change and forced migrations: An effort towards recognizing climate refugees. *Geoforum*, 84, 147–150. <https://doi.org/10.1016/j.geoforum.2017.06.022>.
- Buckee, C. (2020). Improving epidemic surveillance and response: Big data is dead, long live big data. *The Lancet Digital Health*. [https://doi.org/10.1016/s2589-7500\(20\)30059-5](https://doi.org/10.1016/s2589-7500(20)30059-5).
- Bursać Kovačević, D., Barba, F. J., Granato, D., Galanakis, C. M., Herceg, Z., Dragović-Uzelac, V., & Putnik, P. (2018). Pressurized hot water extraction (PHWE) for the green recovery of bioactive compounds and steviol glycosides from *Stevia rebaudiana* Bertoni leaves. *Food Chemistry*, 254, 150–157. <https://doi.org/10.1016/j.foodchem.2018.01.192>.
- Ceballos, G., Ehrlich, P. R., & Dirzo, R. (2017). Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. *Proceedings of the National Academy of Sciences*, 114(30), E6089–E6096. <https://doi.org/10.1073/pnas.1704949114>.
- de Andrade Guerra, J. B. S. O., Berchin, I. I., Garcia, J., ... Ribeiro, J. M. P. (2020). A literature-based study on the water–energy–food nexus for sustainable development. *Stochastic Environmental Research & Risk Assessment*. <https://doi.org/10.1007/s00477-020-01772-6>.
- Food and Agriculture Organization of the United Nations [FAO] (2019). The State of Food and Agriculture 2019. Moving forward on food loss and waste reduction. Rome. Licence: CC BY-NC-SA 3.0 IGO. <http://www.fao.org/3/ca6030en/ca6030en.pdf> (Accessed 8 June 2020).
- Galanakis, C. M. (2012). Recovery of high added-value components from food wastes: Conventional, emerging technologies and commercialized applications. *Trends in Food Science & Technology*, 26(2), 68–87. <https://doi.org/10.1016/j.tifs.2012.03.003>.
- Galanakis, C. M. (2013). Emerging technologies for the production of nutraceuticals from agricultural by-products: A viewpoint of opportunities and challenges. *Food and Bioprocess Technology*, 91(4), 575–579. <https://doi.org/10.1016/j.fbp.2013.01.004>.
- Galanakis, C. M. (2018). Phenols recovered from olive mill wastewater as additives in meat products. *Trends in Food Science & Technology*, 79, 98–105. <https://doi.org/10.1016/j.tifs.2018.07.010>.
- Galanakis, C. M. (2020). The food systems in the era of the coronavirus (COVID-19) pandemic crisis. *Foods*, 9(4), 523. <https://doi.org/10.3390/foods9040523>.
- Galanakis, C. M., Tsatalas, P., & Galanakis, I. M. (2018). Implementation of phenols recovered from olive mill wastewater as UV booster in cosmetics. *Industrial Crops and Products*, 111, 30–37. <https://doi.org/10.1016/j.indcrop.2017.09.058>.
- Lenton, T. M., & Latour, B. (2018). Gaia 2.0. *Science*, 361(6407), 1066–1068. <https://doi.org/10.1126/science.aau0427>.
- Lovelock, J. (1979). *Gaia: A new look at life on earth*. Oxford: Oxford University Press, 169.
- Lovelock, J. (2009). *The vanishing face of Gaia: A final warning*. New York: Basic Books, 289.
- McNamara, K., & Gibson, C. (2009). 'We do not want to leave our land': Pacific ambassadors at the United Nations resist the category of 'climate refugees. *Geoforum*, 40, 475–483. <https://doi.org/10.1016/j.geoforum.2009.03.006>.
- Mercure, J.-F., Paim, M. A., Bocquillon, P., Lindner, S., Salas, P., Martinelli, P., ... Vinales, J. E. (2019). System complexity and policy integration challenges: The Brazilian energy-water-food Nexus. *Renewable and Sustainable Energy Reviews*, 105, 230–243. <https://doi.org/10.1016/j.rser.2019.01.045>.
- Pirouz, B., Haghshenas, S. S., Haghshenas, S. S., & Piro, P. (2020). Investigating a serious challenge in the sustainable development process: Analysis of confirmed cases of COVID-19 (new type of coronavirus) through a binary classification using artificial intelligence and regression analysis. *Sustainability*, 12(6), 2427. <https://doi.org/10.3390/su12062427>.
- Poland, G. A. (2020). Another coronavirus, another epidemic, another warning. *Vaccine*, 38(10), v–vi. <https://doi.org/10.1016/j.vaccine.2020.02.039>.
- Slaughter, R. A. (2012). Welcome to the Anthropocene. *Futures*, 44(2), 119–126. <https://doi.org/10.1016/j.futures.2011.09.004>.
- Sobrosa Neto, R. C., Berchin, I. I., Magtoto, M., Berchin, S., Xavier, W. G., & Guerra, J. B. S. O. A. (2018). An integrative approach for the water-energy-food nexus in beef cattle production: A simulation of the proposed model to Brazil. *Journal of Cleaner Production*, 204, 1108–1123. <https://doi.org/10.1016/j.jclepro.2018.08.200>.
- Steffen, W., Richardson, K., Rockstrom, J., Cornell, S. E., Fetzer, I., Bennett, E. M., ... Sorlin, S. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, 347(6223), 12598550–1–1259855-10. <https://doi.org/10.1126/science.1259855>.
- The World Bank (2019). Indicators. <https://data.worldbank.org/indicator> (Accessed 29 March 2020).
- United Nations (2015). Transforming our world: the 2030 Agenda for Sustainable Development. https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A.RES.70.1_E.pdf (Accessed 30 March 2020).
- United Nations (2020). Shared responsibility, global solidarity: Responding to the socio-economic impacts of COVID-19. <https://unsdg.un.org/sites/default/files/2020-03/SG-Report-Socio-Economic-Impact-of-Covid19.pdf> (Accessed 1 April 2020).
- World Health Organization (2019). A world at risk: annual report on global preparedness for health emergencies. https://apps.who.int/gpmb/assets/annual_report/GPMB_annualreport_2019.pdf (Accessed 29 March 2020).
- World Health Organization (2020). COVID-19 situation. <https://experience.arcgis.com/experience/685d0ace521648f8a5beee1b9125cd> (Accessed 30 March 2020).
- Zhou, C., Su, F., Pei, T., Zhang, A., Du, Y., Luo, B., ... Xiao, H. (2020). COVID-19: Challenges to GIS with big data. *Geography and Sustainability*. <https://doi.org/10.1016/j.geosus.2020.03.005>.