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SUSTAINABLE AND RENEWABLE ENERGY (SE HOSSEINI, SECTION EDITOR)

A Review on Water-Energy-Greenhouse Gas Nexus of the Bioenergy Supply and Production System

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Abstract

Purpose of Review Tremendous global pressures like resource depletion and climate change urge us to deploy alternate energy sources and to integrate carbon capture and sequestration processes. Biomass can be considered as one of the alternate renewable carbon-based fuels that can decrease environmental footprints in different applications. There is currently a lack of systematic review of greenhouse gas (GHG) emissions and water-energy nexus (WEN) in the biomass supply chains' system (BSCs) system. Therefore, the present study aims to conduct a comprehensive review of the studies carried out into WEN and GHG emissions regarding the BSCs. The published papers investigated in this study were categorized and evaluated based on their objectives, methodologies, geographic scales, and environmental sustainability factors.

Recent Findings The review revealed that not only literatures lack enough research into WEN and GHG, but also the capacity for effectively assessing the relationships between water, energy, and the trend of GHG emissions at a higher resolution. In addition, it was found that most of the previous studies have mainly focused on the economic influences of BSCs and mathematical methods for the optimization of BSCs. There is a need for the development of a mathematical dynamic model considering uncertainties and the multi-objective approaches to evaluate the trend of WEN and GHG in the BSCs.

Summary To achieve a sustainable development of the BSCs, WEN and GHG emissions need to be effectively managed. The findings of the present paper will assist researchers who work on renewable energy issues and potential users of the bioenergy industry to obtain a deeper understanding of the current state of knowledge in terms of WEN and GHG emission.

Keywords Biomass and bioenergy · Water-energy nexus (WEN) · Greenhouse gas (GHG) · Sustainability · Supply chain (SC)

Abbreviations

GHG	Greenhouse gas
WEN	Water-energy nexus
SC	Supply chain
BSCs	Biomass supply chains
MILP	Mixed-integer linear programming
LCA	Life cycle analyses
CSP	Concentrated solar power

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Introduction

According to estimations indicated by [1], by 2050, 50% of the populations in most developing countries will be living in urban areas. Such a condition, together with the economic developments at a global level, will exert an intolerable pressure upon critical natural resources such as water, food, energy, ecosystem, and land. In particular, an increase in people's income and reduction of poverty have concurred with tremendous growth in demands for various services and products, e.g., energy and water, which has resulted in overexploitation and degradation of natural resources. Such a challenging dilemma has been added with climate change in a situation where different climate mitigation/adaptation measures (e.g., desalination, irrigation, or biofuels) are highly resource intensive [2]. The way resources are currently exploited is a significant threat to the sustainability of development.

All over human history, water and energy have shaped the development process [3]. These two conceptually differ from each other; however, water requires energy for different procedures that build the cycle [4]. In spite of such a firm union, for a long time, water and energy have been investigated separately, until Gleick [5] unveiled the intrinsic connection between them in the 1990s. This led to the appearance of a new concept called "water-energy nexus" [5]. With the developing technology and science, a stronger interrelation has been established between water and energy [6]. Such interdependence of these two concepts has resulted in critical challenges in the world. Based on predictions made by the United Nations, 9600 million people will be living on earth by 2050, which can lead to a dramatic surge in energy and water demands [7]. Furthermore, estimation indicates that, in 2040, the energy volume consumed in the water sector will be doubled than that of today [8].

There is a complex relationship between the WEN and the environment that is necessary to inform local and national policy makers regarding the management of water, energy, and the environment. This approach is particularly relevant for sustainable development and climate change where the connections between water and energy are strong [9]. The WEF nexus is concerned with the challenges surrounding the need to balance competing demands on the water to address water and energy security under a changing climate [10]. The WEF nexus promotes a systems perspective, emphasizing holistic and cross-sectoral approaches to decision-making and planning.

This discussion has been well supported by the Kyoto Protocol and by various international actions such as the 2020 European Union's Strategy that targets a 20% decline in GHG, a 20% decrease in primary energy, and a 20% increase of renewable energy uses [11]. It is to be noted that WEN and GHG have a close interdependency that can help decision-makers to control the problems that may appear in managing the regional resources. There is a need for more inclusive macro-level research that aims to grow the current knowledge base on the available ways to address this challenge.

The most critical concern of companies today is the rapid delivery of products or materials of good quality at low cost and risk [12]. The future of sustainable energy supply is moving toward the use of renewable sources like biomass. Many researchers who worked on BSCs have confirmed that biomass is of great viability to be used instead of conventional fossil fuels [13]. Numerous activities done in line with this chain may cause disruptions to the water-energy-greenhouse gas nexus since these resources are vitally interconnected with the tremendous growth of the world population and the increasing expansion of urban areas.

The literature lacks enough research exploring the synergy between BSCs, WEN, and GHG emissions. Therefore, this paper aims to provide a comprehensive literature survey of water-energy nexus and greenhouse gas emission investigations through the BSCs. The scope of the present study is to review various modeling methods proposed for WEN and GHG emissions for biomass and bioenergy studies. The methods that are currently implemented in modeling GHG emission and WEN systems at various geographical scales can take advantage of further classification based on the scope of additional "nexus" elements they involve. The objectives of the present study are as follow:

1) To analyze the development process of the comprehensive WEN and GHG nexus of BSCs
2) To review the existing WEN and GHG emissions instruments by investigating the feasibility, objectives, and requirements of different methods when being applied to various contexts of "nexus"
3) To provide some recommendations on the most significant gaps and required actions for future studies

Methodology

To accomplish the defined research objectives, papers published in the area of WEN and GHG emissions in the case of bioenergy and biomass supply and production systems were comprehensively reviewed. To this end, a general internet search was done, and databases like Web of Science, Scopus, and Google Scholar were used. Boolean searches of the following keywords were utilized in the search: "water-energy nexus," "carbon dioxide emissions," "bioenergy," "biomass sustainability," and "biomass supply chain." The search was limited to papers published in English, but no limitation was put on the year of publication and geographical distribution.

Literature Review

Water-Energy Nexus

Review of the recent literature shows that only a few reviews have been carried out so far on WEN [3, 14, 15]. Some study focuses on the classification of the method types like profit-cost assessment, physical model, and optimization management approach [16], while others focus on a single sector or only one task in an industry. Many of them have analyzed the water footprint and/or performed life cycle analyses (LCA) [17, 18], while few papers have focused only on integrated models at scales that are only applied to the WEN studies [19, 20]. Klein and Rubin [21] analyzed the life cycle assessment of concentrated solar power (CSP) by comparing the life cycle GHG emissions, water consumption, and direct, onsite land use associated with the electricity production from CSP plants.

Also, a few researchers have reviewed the macro-level studies and methods that have taken into consideration issues such as energy, water, environmental elements, food, and land at various sectors and various geographic scales [15, 22]. The studies, as mentioned earlier, have significantly contributed to the body of related knowledge, although WEN has not been adequately studied in respect to BSCs. For example, from a chemical engineering point of view, Shastri [23] conducted a review of the latest progress that has occurred in lignocellulosic and microalgal biofuels. His findings indicated that the WEN would be more and more discussed in the future in terms of sustainability aspects. Further, it was mentioned that there is a need for integrated system instruments to find out dynamics and sectoral interdependencies.

There are a few researches that focus on the WEN in biomass and bioenergy energy supply and production system. A mixed-integer linear fractional programming (MILFP) model of shale gas was developed by [24] to optimize the water SC network and economic performance. In their suggested model, freshwater consumption is minimized, and at the same time, profit is attempted to be maximized. In the same year, another study reviewed the ways biorefineries can be used to solve the issues related to WEN [25]. They emphasized the need for the development of process integration and optimization models that can effectively address the potential interactions with nexus elements. Additionally, they took into consideration the available opportunities for the process systems engineering methods at the entire BSCs for the effective use of food-energy-water resources. They tried to connect various phases of BSCs to the nexus in a complicated manner [25].

In another project, a MILP optimization framework was introduced by López Díaz et al. [26] to design a bio-refining system and, simultaneously, consider the interactions with the neighboring watershed. They adopted a material flow analysis method to construct an efficient SC for both producing and distributing raw material, grains, and biofuels for land and water needs. Yuan et al. [27] designed a life cycle-based framework with the use of spatial optimization approaches to evaluate the bioenergy feasibility in a specific area.

In our paper, VOSviewer software is used for the visualization of the aggregate level of the frequency of keywords like "WEN" and "biomass and bioenergy." The use of this software allows users to visualize, through infographics, the key topics or themes clusters, inter-relationships between the topics, and frequency of certain research areas [28]. This tool shows the density of interests, identification of areas in need of more attention, and trends in WEN of BSCs until 2020.

As shown by Fig. 1, five distinct clusters exist among which the yellow-red group is the most dominant one where researchers have paid attention to bioenergy, biomass, and climate changes. As explained earlier, WEN, GHG emission, environmental impacts, and life cycle evaluation have not been addressed sufficiently (red and blue clusters). Furthermore, bioenergy and optimization methods have received much more attention from the academic community (green and blue clusters). In Fig. 2, the cluster density of co-occurrences is depicted, which shows words employed to address the gaps in WEN in BSC-related studies. This review showed that WEN, GHG emission, and carbon footprint had received less attention from researchers working in this field of study. In Fig. 3, all papers released were categorized based on their publication year during the last 5 years. Only a few studies have cited the papers published between 2015 and 2017. In Fig. 4, the recently published articles are separated based on their geographical scope and affiliations. Findings showed that just a few countries, e.g., the USA, England, and China, have focused upon this important issue.

Greenhouse Gas Emissions

The studies already carried out on the air pollution footprints of supply chains are typically confined to analyzing only a single country, or in case of international research, the research is generally confined to the resolution of nations or global regions. For example, Wang et al. [29] attempted to analyze issues at a worldwide level in a way to find out the way methane (CH_4) emission in the international trade and final consumption has evolved in huge economies from 2000 to 2012. Their findings confirmed that the USA, European Union, India, Brazil, and China accounted for most of CH_4 emitted from production processes from 2000 to 2012. The authors in [30] carried out in-depth analyses upon the demand-driven energy, land, and water resources consumed by the vast Chinese economy during 2012.

In case BSCs are taken into consideration either to maximize the profit or to minimize the cost, decision-makers need to consider the sustainability-related issues [31]. In this regard, only a small number of studies have defined the environmental, social, and economic goals in optimization processes of the BSCs to generate bioenergy and bio-products with the adoption of multi-objective approaches. Environmental criteria in terms of GHG emissions and carbon footprint have received less attention in BSC modeling and optimization in the past. Still, there is a growing recognition in the recent years. In a recent study, a dynamic simulation model was developed to assess the effects of changes in the production technology (PT) and transportation technology (TT) on the BSC environmental sustainability during 50 years (between 2000 and 2050) regarding three key biomass suppliers in Malaysia [32]. Table 1 summarizes some recent studies that have been conducted in the past 10 years (2009–2019).

In order to highlight the environmental gap in BSCs, we categorized the investigations that have been done for the last 10 years in terms of their sustainability objectives (Fig. 5). The

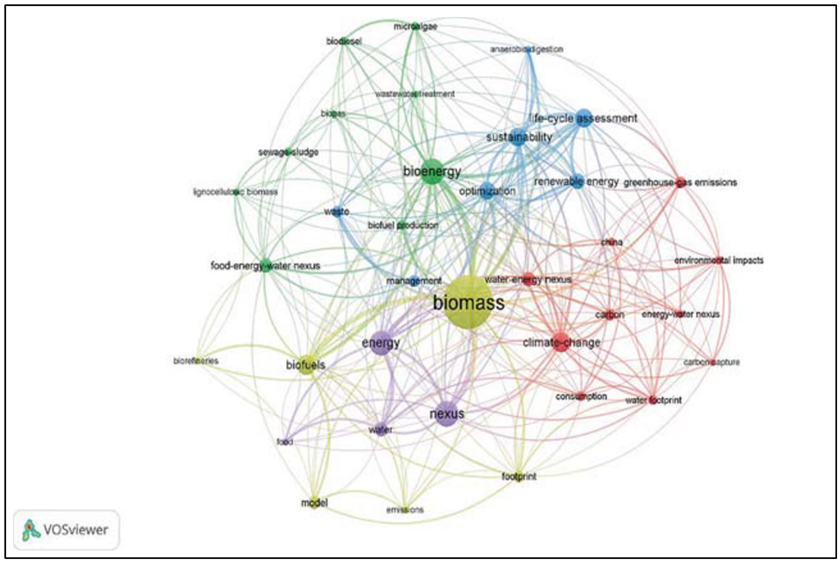

Fig. 1 Network visualization of keywords theme occurrences

number of studies that have taken into consideration the environmental, social, and economic issues when designing models has been comparatively stable between 2009 and 2017; however, an abrupt rise can be observed in this regard in 2018. It shows an increased interest of scholars in designing and optimizing BSC models with the integration of the three main sustainability elements. Especially, the environmental and social objectives need more attention. Also, during the past decade, only a few researchers have considered all three aspects of sustainability, as mentioned above (i.e., social, environmental, and economic) at a single research.

Figures 6 and 7 show the distribution of articles in terms of biomass, bioenergy products, supply chain system, and environmental objectives. It can be seen that different bioenergy production such as wood was considered in the investigation, but less attention was paid to environmental factors such as GHG emissions in terms of multi-objective optimization approaches and source of uncertainties in BSCs. Besides, most of the studies are conducted in some specific regions such as the USA and some European countries. Having said that, there are some studies on biomass and bioenergy products conducted in other different regions like Africa, Malaysia, Australia, and Indonesia (Fig. 8).

Discussion and Future Directions

Many countries have focused on taking effective measures to alleviate climate change, especially with the current increased public awareness on unwanted costs of climate change. Most

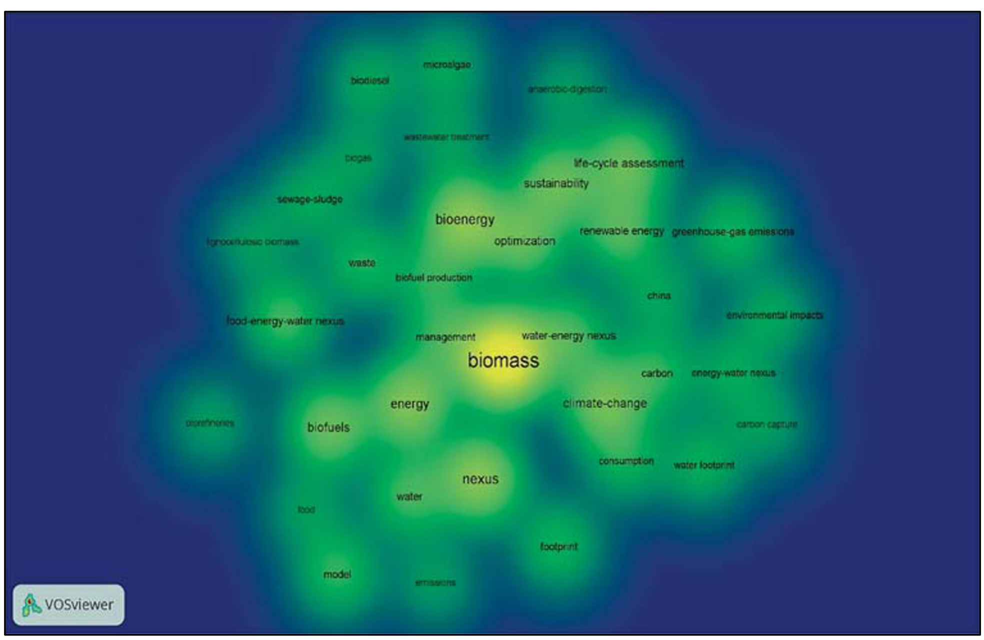

Fig. 2 Density visualization of key theme occurrences

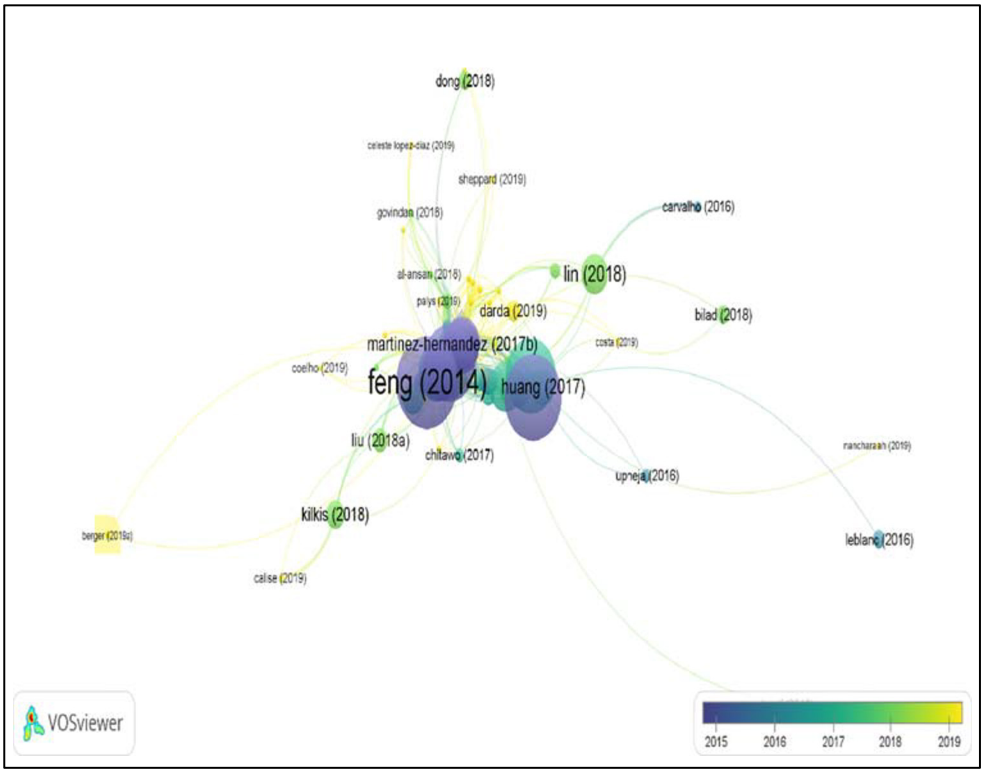

Fig. 3 Network visualization of author theme occurrences

of the current air pollution is due to GHG emissions that can threaten public health. A new challenge for the biomass and bioenergy industry is how to achieve low or zero GHG emission, optimal WEN, and a properly protected environment. However, current literature lacks a comprehensive investigation specifically on these issues. Only a few approaches have been proposed in literature specifically to support the supremacy and application of technical solutions. This issue can offer a challenging area for researchers working in this area of study if they are aimed at having a more considerable influence on resource-related policy-making processes and management.

Appropriately, analyzing GHG emissions, water usage, and energy consumption regarding BSCs can provide a great aid to the decision-makers and policy makers to utilize the resources in the most effective way with less risk. However, only limited research has been carried out to investigate such significant issues of environmental sustainability in the context of the biomass industry.

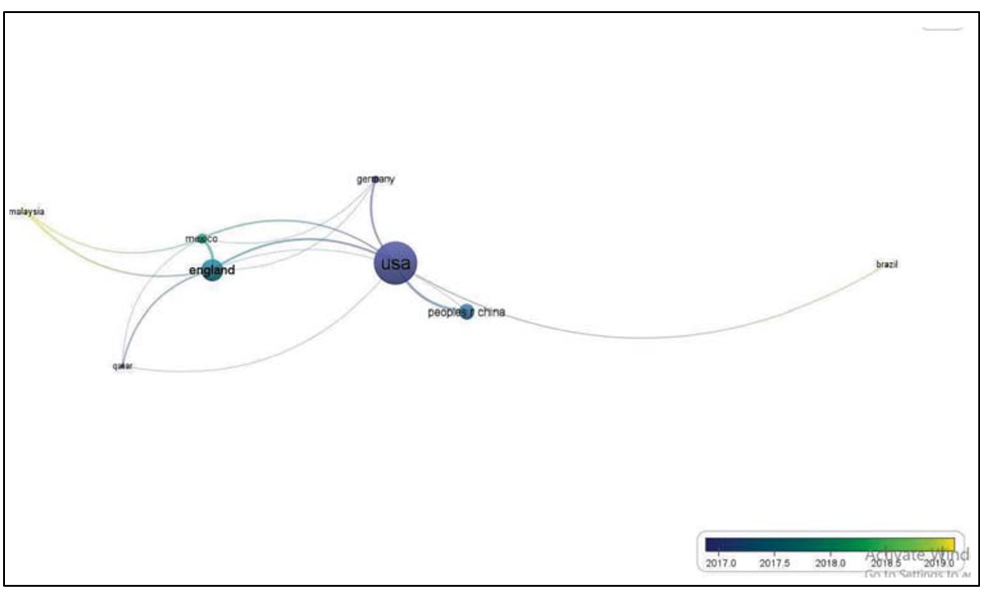

Fig. 4 Network visualization of organization theme occurrences

Table 1 Economic, environmental, and social classification of the BSCs

Author	Sustainability			Method	Objective	Region
	Economic	Environmental	Social			
Ayoub et al. [33]	✓	✓	✗	Meta-heuristic (GA)	To consider each stakeholder in biomass supply chains such as supplier of biomass resources, transportation, conversion, and electricity suppliers	Japan
Leduc et al. [34]	✓	✗	✗	MILP	To estimate the optimum number and geographic locations of biodiesel plants based on cost minimization of supply chain	India
Zamboni et al. [35]	✓	✓	✗	MILP (multi-objective)	To minimize the operation cost of SC and environmental effects based on greenhouse gas (GHG) emissions	Italy
Zamboni et al. [36]	✓	✓	✗	MILP (multi-objective)	To contribute for designing process of biofuel systems, by considering the economic effect of the supply as a criterion	Italy
Cucek et al. [37]	✓	✗	✗	MILP (multi-objective)	To optimize the economically potential application of resources, accounting for the competition between energy and food production	Central of Europe
Mele et al. [38]	✓	✓	✗	MILP	To use a decision-making tool to determine the optimal design of SC for the combined production of sugar and ethanol	Argentina
You and Wang [39]	✓	✗	✗	MILP (multi-objective)	To determine optimum design and planning of biomass-to-liquids (BTL) supply chains under economic and environmental criteria	USA
Giarola et al. [40]	✓	✓	✗	MILP (multi-objective)	To design bioethanol supply chains by considering environmental and financial performance design drivers and alternative process design	Italy
You et al. [41]	✓	✓	✓	MILP (multi-objective)	To assess the main characteristics of cellulosic ethanol supply chains, such as supply seasonality and geographical diversity	USA
Cucek et al. [42]	✓	✓	✓	MINLP (multi-objective)	To maximize economic performance and minimize the environmental and social FPs (footprints)	Europe
Yue et al. [43]	✓	✓	✓	MILFP (multi-objective)	To address the cradle-to-gate life cycle of bioelectricity involving biomass cultivation and harvesting, raw material pre-treatment, energy conversion, and biopower production, as well as transportation and storage	Numerical example
Bairamzadeh et al. [44]	✓	✓	✓	MILP (multi-objective)	To determine the optimal design and planning of a lignocellulosic bioethanol SC to optimize sustainable supply chain framework	Iran
Roni et al. [45]	✓	✓	✓	MILP	To optimizes the CO^2-CO^2 emissions because of transportation-related activities in the SC as well as to optimize the social effects of biofuels by creating the number of jobs	USA
Santibañez-Aguilar et al. [46]	✓	✓	✗	MILP (multi-objective)	To show a novel method for the optimum planning based on uncertainty for a biomass conversion system considering simultaneously economic and environmental objectives	Mexico
Azadeh and Arani [47]	✓	✗	✗	System dynamics/stochastic mixed-integer programming	To plan and design a biodiesel SC from biomass fields to consumption markets	Numerical example
Miret et al. [48]	✓	✓	✓	MILP (multi-objective)	To concentrate on multi-objective optimization involving all the aspects of the sustainable issue, called economic, environmental, and social	France
Cambero and Sowlati [49]	✓	✓	✓	MILP (multi-objective)	To optimize the social benefit and net present value, as well as minimize greenhouse gas emission of a forest-based biorefinery SC	Canada
Fattahi and Govindan [50]	✓	✓	✓	Multi-stage stochastic programming	To design and planning of a biofuel SC network from biomass to demand centers where biomass supply is stochastic	Iran
Chavez et al. [51]	✓	✓	✓	MILP (multi-objective)	To design of a sustainable supply chain using multiple agricultural coffee crop residues	Colombia
Galanopoulos et al. [52]	✓	✓	✗	MILP/Advanced Interactive Multidimensional Modeling (AIMMS) software	To study the logistics, network optimization, transportation and inventory management, and the resulting environmental and economic impacts	Germany

Table 1 (continued)

Author	Sustainability			Method	Objective	Region
	Economic	Environmental	Social			
Tsao et al. [53]	✓	✓	✓	Stochastic programming and fuzzy probabilistic multi-objective programming	To design of a sustainable supply chain network for maximizing social benefits while minimizing economic costs and environmental impacts	Numerical example
Roni et al. [54]	✓	✗	✓	MILP	To simultaneously optimize feedstock sourcing decisions, and optimal pre-processing depot locations and size	US

A large number of studies have been conducted to develop innovative methods and frameworks for systematically evaluating the interrelationships between energy, water, and other key elements. A singular framework for conducting a "nexus research," however, is missing in the literature. Based on the papers and approaches reviewed in the present research, numerous studies are at the "understanding" stage focusing on analyzing the trend of WEN in a quantitative manner. Only a small number of researchers have comprehensively analyzed the water-energy-greenhouse gas nexus at a relevant geographic scale like the city, national, or regional level. Some model frameworks have been introduced in literature with the aim of better understanding WEN in their defined scope. A number of these studies have investigated the WEN-related research together with the corresponding models. Most of these studies are carried out in the USA and Australia [14, 55]. It is not easy to evaluate the comparative benefits of duplicating or adapting those methods/models for various contexts or in different geographic regions.

Likewise, dynamic problems have been even less investigated. Dynamic simulation approaches, for instance, the use of AnyLogic software, combined with life cycle assessment model such as GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation), can be of great usefulness in the analysis of the dynamic nature of BSCs and environmental effects (e.g., WEN and carbon footprint that cannot be examined independently for each phase of BSCs). Researchers can utilize dynamic system modeling when designing models consisting of one or multiple values that vary over time. Besides, through this approach, complex environments can be graphically displayed, which facilitates the investigation and exploration of various potential scenarios and makes it easy to detect the system's behavior at particular times with any necessary details. Moreover, there is a need to understand the complex relations in the BSC processes with various "what-if" scenarios when the system consists of uncertainties.

In an integrated model, one of the most critical functions is a long-term scenario analysis. Such scenario analysis would need a long-term study of historical data about energy and water. However, our review of the literature revealed that only a small number of researchers, such as [56], had conducted historical analysis on WEN. In some countries such as Malaysia and Australia, WEN has remained unstudied, and enough research has not been conducted on how urban growth affects the availability and consumption of water and energy. Therefore, there is still room to research these topics. The WEN historical variation can be well considered to find out the interconnections among elements in the past and to determine the most effective parameters on changes that may occur in water and energy dynamics. Historical data analysis also helps to predict more effectively the prevailing risks, available options, and current trade-offs between strategies and planning opportunities.

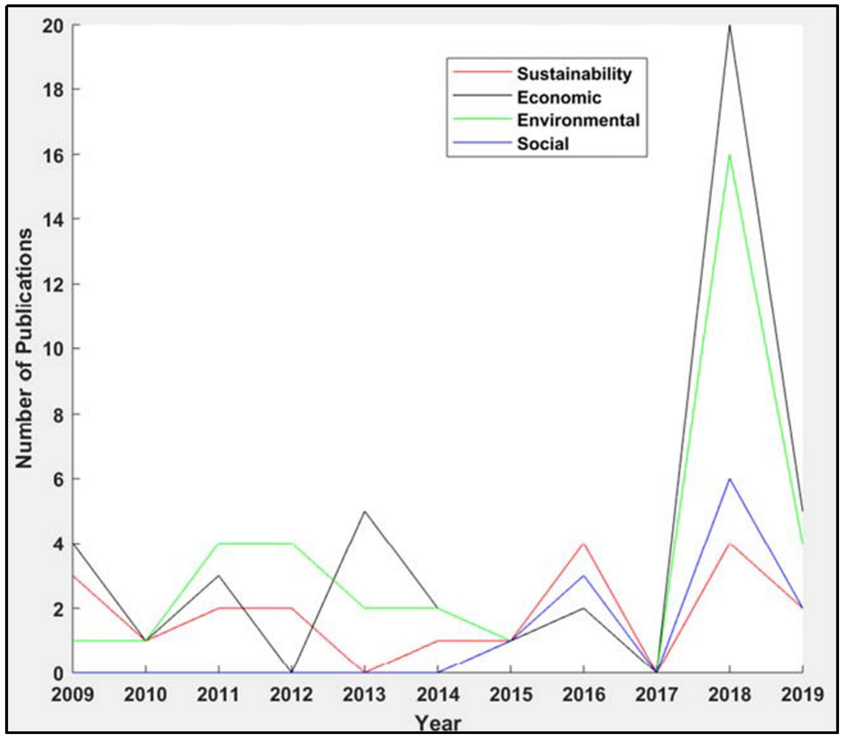

Fig. 5 Biomass supply chain articles in terms of sustainability objectives

The literature lacks a mathematical framework applying the WEN concept to BSC modeling. To explore how various environmental aspects like energy consumption, GHG emission, and water usage interact with each other is of great importance to BSCs. In the future, the researchers working in this area of study need to focus on how to make a balance among all the three

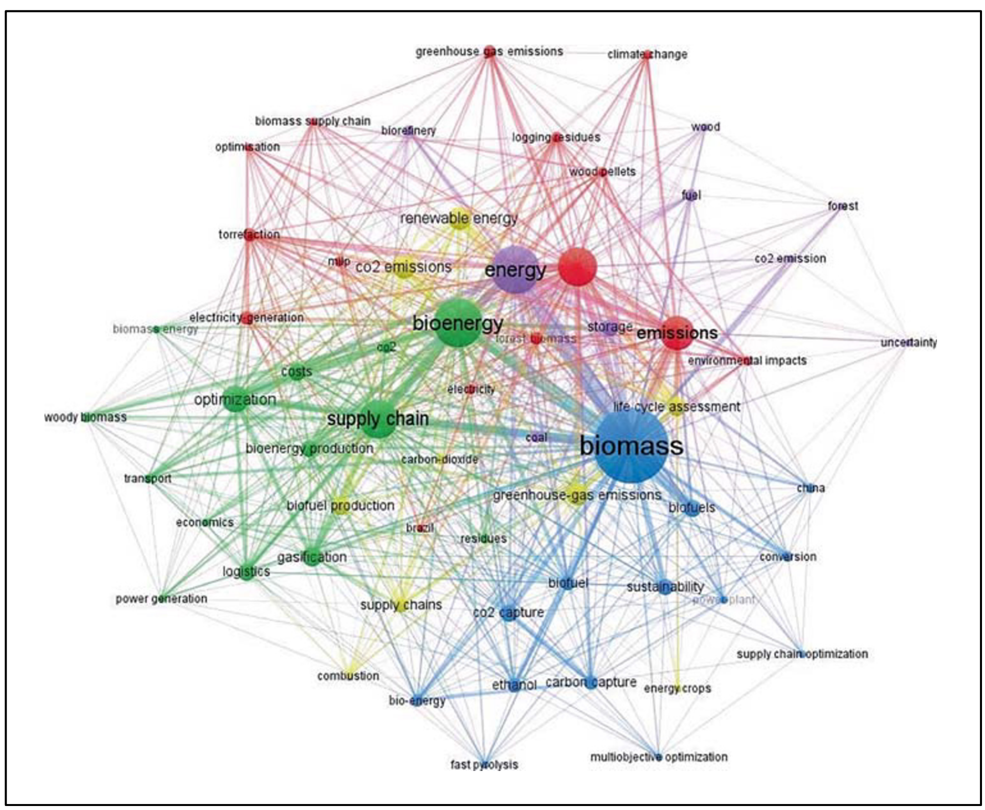

Fig. 6 Network visualization of keywords theme occurrences

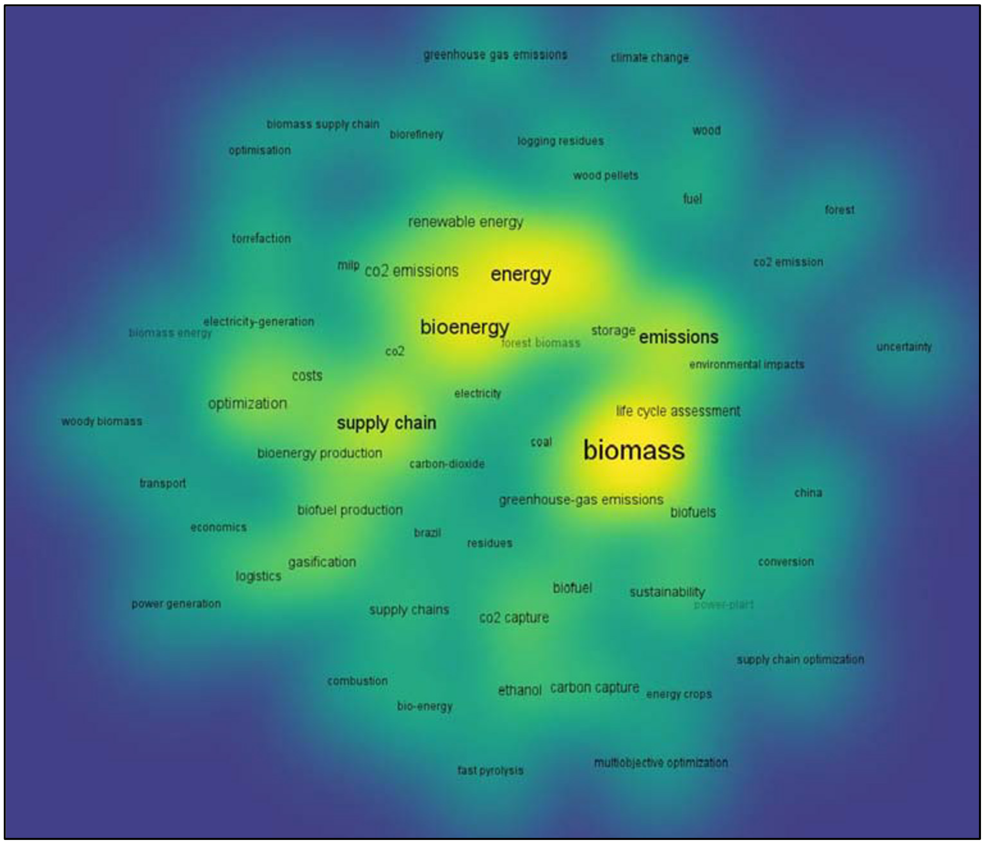

Fig. 7 Density visualization of principle theme occurrences

sustainability pillars, namely, social, economic, and environmental factors. Most of the existing research is centered around the BSC economic effects; though, mathematical tools can be of high usefulness to address significant issues related to environmental sustainability in BSCs. Besides, a multi-objective approach can be developed to analyze the existing options for

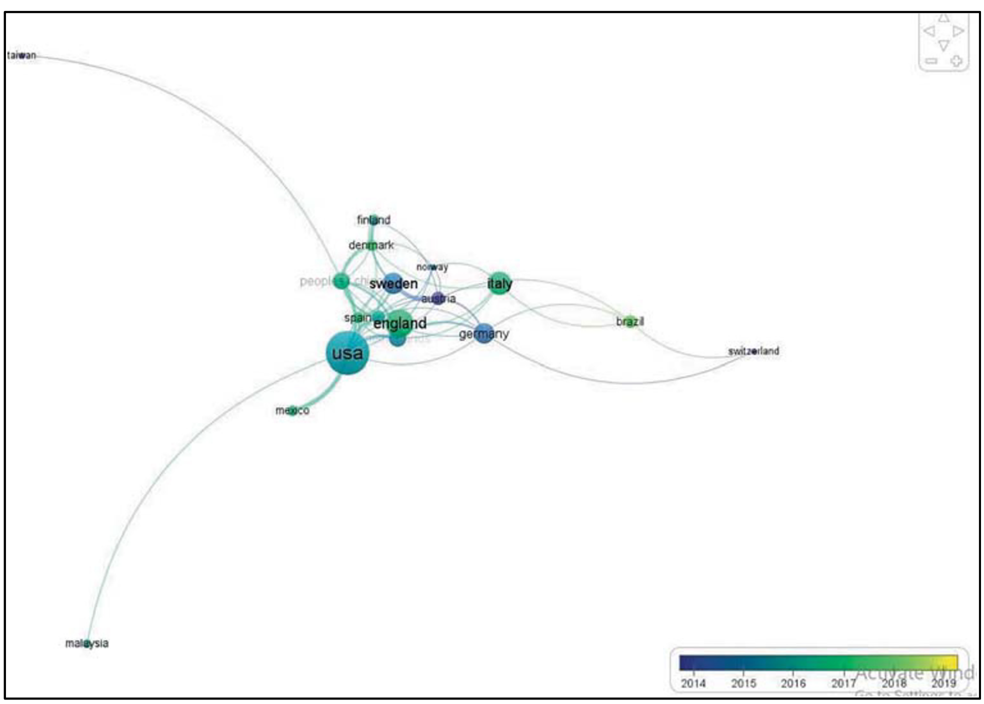

Fig. 8 Network visualization of organization theme occurrences

synergistic interactions between water-energy-greenhouse gas nexus for the biomass and bioenergy supply and production system.

Research into biomass generation and processing has been often confined to specific countries possessing certain biomass types, raw materials, climate, and political/economic conditions. Thus, this market requires approaches with the capacity of capturing the significant impacts at local scales in a way to provide solutions better adapted to local circumstances and also facilitate synergistic interactions. Nonetheless, the approaches proposed for these purposes need to have enough flexibility for adjusting the study level to a scale that can be appropriately used by policymakers. Mainly, there is a need for approaches capable of modeling the way local decisions influence national development and vice versa. To this end, case studies are required to be carried out on BSCs in countries with different climates to average geographical biases.

It is necessary to enhance the capacity of classifying and comparing the capabilities, strengths, and weaknesses in currently used approaches. It will help stakeholders to effectively make use of existing knowledge to enhance the quality of water/energy resources management. Also, it helps the academic community to be more focused on the effective improvement of the existing knowledge and even on governance and implementation of WEN.

In the following, some priority elements are provided to improve the management of WEN and GHG emission of BSCs:

- Combining available guidelines, standards, and funding to enhance the WEN efficiency
- Developing educational programs at different levels
- Designing effective methods applicable to quantifying and tracking WEN and GHG emissions

Conclusion

To achieve a sustainable development at all scales, water-energy nexus (WEN) and GHG emissions need to be effectively managed. Inclusive analysis of WEN and the GHG emission trends can provide a deeper understanding of the quantitative interconnections between energy and water. Also, it can direct the related actions and policies toward optimization of outcomes and minimization of environmental risks.

During the last decade, issues related to the “water-energy-GHG nexus” have received increasing attention from both academic and policy-making communities. For the present study, recently published academic literature pertaining to WEN and GHG emission for biomass and bioenergy energy and production system was comprehensively surveyed. This paper not only summarized various existing approaches to analyzing WEN and GHG emissions but also discussed these approaches in terms of their key purposes. As findings indicated, the research into WEN has grown substantially in recent times, in terms of the number of papers and the capability of the academic groups.

The findings of the present paper will help researchers who work on renewable energy issues and potential users of the bioenergy industry to obtain a deeper understanding of the current state of knowledge in terms of WEN and GHG emission. In the future, researchers need to capture the details of WEN and GHG trends with respect to BSCs in addition to developing more conscious approaches with numerous objectives, stages, and scales, based on all probable uncertainties.

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References

1. Unicef D. Annual report 2012: United Nations Children’s Fund, The (UNICEF); 2013.
2. Zahraee SM, Khalaji Assadi M, Saidur R. Application of artificial intelligence methods for hybrid energy system optimization. Renew Sust Energ Rev. 2016;66:617–30. https://doi.org/10.1016/j.rser.2016.08.028.
3. Hamiche AM, Stambouli AB, Flazi S. A review of the water-energy nexus. Renew Sust Energ Rev. 2016;65:319–31.
4. Hardy L, Garrido A, Juana L. Evaluation of Spain’s water-energy nexus. Int J Water Resourc Dev. 2012;28(1):151–70.
5. Gleick PH. Water and energy. Annu Rev Energy Environ. 1994;19(1):267–99.
6. Tan C, Zhi Q. The energy-water nexus: a literature review of the dependence of energy on water. Energy Procedia. 2016;88:277–84.
7. Connor, R. (2015). The United Nations world water development report 2015: water for a sustainable world (Vol. 1). UNESCO publishing.
8. Conti J, Holtberg P, Diefenderfer J, LaRose A, Turnure JT, Westfall L. International energy outlook 2016 with projections to 2040: USDOE Energy Information Administration (EIA). Washington DC: United States; 2016.
9. Pardoe J, Conway D, Namaganda E, Vincent K, Dougill AJ, Kashaigili JJJCP. Climate change and the water–energy–food nexus: insights from policy and practice in Tanzania. Clim Pol. 2018;18(7):863–77.
10. Mdee AJWA. Disaggregating orders of water scarcity-the politics of nexus in the Wami-Ruvu River Basin. Tanzania. 2017;10(1):100.
11. Amanatidis G. European policies on climate and energy towards 2020, 2030 and 2050. 2019. https://www.europarl.europa.eu/.
12. Bargshady G, Zahraee SM, Ahmadi M, Parto A. The effect of information technology on the agility of the supply chain in the Iranian power plant industry. J Manuf Technol Manag. 2016;27(3):427–42. https://doi.org/10.1108/JMTM-11-2015-0093.
13. Zahraee SM, Mokhtar AA, Tolooie A, Asri NAM. Performance evaluation of EFB biomass supply chain for electricity power generation based on computer simulation: Malaysia case study. Adv Mater Sci Eng Springer. 2020:363–75.
14. Nair S, George B, Malano HM, Arora M, Nawarathna B. Water–energy–greenhouse gas nexus of urban water systems: review of concepts, state-of-art and methods. Resour Conserv Recycl. 2014;89:1–10.

15. Endo A, Tsurita I, Burnett K, Orencio PM. A review of the current state of research on the water, energy, and food nexus. J Hydrol. 2017;11:20–30.
16. Endo A, Burnett K, Orencio PM, Kumazawa T, Wada CA, Ishii A, et al. Methods of the water-energy-food nexus. Water. 2015;7(10): 5806–30.
17. Keairns DL, Darton RC, Irabien A. The energy-water-food nexus. Ann Rev Chem Biomole Eng. 2016;7(1):239–62. https://doi.org/10.1146/annurev-chembioeng-080615-033539.
18. Kucukvar M, Cansev B, Egilmez G, Onat NC, Samadi H. Energy-climate-manufacturing nexus: new insights from the regional and global supply chains of manufacturing industries. Appl Energy. 2016;184:889–904.
19. Granit JJ, King RM, Noël R. Strategic environmental assessment as a tool to develop power in transboundary water basin settings. Int J Soc Ecol Sustain Dev (IJSESD). 2011;2(4):1–11.
20. Weitz N, Strambo C, Kemp-Benedict E, Nilsson M. Closing the governance gaps in the water-energy-food nexus: insights from integrative governance. Glob Environ Chang. 2017;45:165–73.
21. Klein SJ, Rubin ES. Life cycle assessment of greenhouse gas emissions, water and land use for concentrated solar power plants with different energy backup systems. Energy Policy. 2013;63:935–50.
22. Bieber N, Ker JH, Wang X, Triantafyllidis C, van Dam KH, Koppelaar RH, et al. Sustainable planning of the energy-water-food nexus using decision making tools. Energy Policy. 2018;113:584–607.
23. Shastri Y. Renewable energy, bioenergy. Curr Opinion Chem Eng. 2017;17:42–7.
24. Gao J, You F. Optimal design and operations of supply chain networks for water management in shale gas production: MILFP model and algorithms for the water-energy nexus. AICHE J. 2015;61(4):1184–208.
25. Martinez-Hernandez E, Samsatli S. Biorefineries and the food, energy, water nexus—towards a whole systems approach to design and planning. Curr Opinion Chem Eng. 2017;18:16–22.
26. López PR, Galán SG, Reyes NR, Jurado F. A method for particle swarm optimization and its application in location of biomass power plants. Int J Green Energy. 2008;5(3):199–211.
27. Yuan K-Y, Lin Y-C, Chiueh P-T, Lo S-L. Spatial optimization of the food, energy, and water nexus: a life cycle assessment-based approach. Energy Policy. 2018;119:502–14.
28. Shaharudin MS, Fernando Y, Jabbour CJC, Sroufe R, Jasmi MFA. Past, present, and future low carbon supply chain management: a content review using social network analysis. J Clean Prod. 2019;218:629–43.
29. Wang Y, Chen B, Guan C, Zhang B. Evolution of methane emissions in global supply chains during 2000–2012. Resour Conserv Recycl. 2019;150:104414.
30. Guan S, Han M, Wu X, Guan C, Zhang B. Exploring energy-water-land nexus in national supply chains: China 2012. Energy. 2019;185:1225–34.
31. Zahraee SM, Mamizadeh F, Vafaei SA. Greening assessment of suppliers in automotive supply chain: an empirical survey of the automotive industry in Iran. Glob J Flex Syst Manag. 2018;19(3): 225–38. https://doi.org/10.1007/s40171-018-0189-5.
32. Zahraee SM, Golroudbary SR, Shiwakoti N, Kraslawski A, Stasinopoulos P. An investigation of the environmental sustainability of palm biomass supply chains via dynamic simulation modeling: a case of Malaysia. J Clean Prod. 2019;237:117740.
33. Ayoub N, Elmoshi E, Seki H, Naka Y. Evolutionary algorithms approach for integrated bioenergy supply chains optimization. Energy Convers Manag. 2009;50(12):2944–55. https://doi.org/10.1016/j.enconman.2009.07.010.
34. Leduc S, Natarajan K, Dotzauer E, McCallum I, Obersteiner M. Optimizing biodiesel production in India. Appl Energy. 2009;86(Supplement 1):S125–S31. https://doi.org/10.1016/j.apenergy.2009.05.024.
35. Zamboni A, Bezzo F, Shah N. Spatially explicit static model for the strategic design of future bioethanol production systems. 2. multi-objective environmental optimization. Energy Fuel. 2009;23(10): 5134–43. https://doi.org/10.1021/ef9004779.
36. Zamboni A, Shah N, Bezzo F. Spatially explicit static model for the strategic design of future bioethanol production systems. 1. cost minimization. Energy Fuel. 2009;23(10):5121–33.
37. Čuček L, Lam HL, Klemeš JJ, Varbanov PS, Kravanja Z. Synthesis of regional networks for the supply of energy and bioproducts. Clean Techn Environ Policy. 2010;12(6):635–45. https://doi.org/10.1007/s10098-010-0312-6.
38. Mele FD, Kostin AM, Guillén-Gosálbez G, Jiménez L. Multiobjective model for more sustainable fuel supply chains. a case study of the sugar cane industry in Argentina. Ind Eng Chem Res. 2011;50(9):4939–58. https://doi.org/10.1021/ie101400g.
39. You F, Wang B. Life cycle optimization of biomass-to-liquid supply chains with distributed–centralized processing networks. Ind Eng Chem Res. 2011;50(17):10102–27. https://doi.org/10.1021/ie200850t.
40. Giarola S, Zamboni A, Bezzo F. Supply chain design and capacity planning: from first to second generation biofuel systems. Chem Eng Transact. 2011;24:253–8.
41. You F, Tao L, Graziano DJ, Snyder SW. Optimal design of sustainable cellulosic biofuel supply chains: multiobjective optimization coupled with life cycle assessment and input–output analysis. AICHE J. 2012;58(4):1157–80.
42. Čuček L, Varbanov PS, Klemeš JJ, Kravanja Z. Total footprints-based multi-criteria optimisation of regional biomass energy supply chains. Energy. 2012;44(1):135–45. https://doi.org/10.1016/j.energy.2012.01.040.
43. Yue D, Slivinsky M, Sumpter J, You F. Sustainable design and operation of cellulosic bioelectricity supply chain networks with life cycle economic, environmental, and social optimization. Ind Eng Chem Res. 2014;53(10):4008–29. https://doi.org/10.1021/ie403882v.
44. Bairamzadeh S, Pishvaee MS, Saidi-Mehrabad M. Multiobjective robust possibilistic programming approach to sustainable bioethanol supply chain design under multiple uncertainties. Ind Eng Chem Res. 2015;55(1):237–56.
45. Roni MS, Eksioglu SD, Cafferty KG, Jacobson JJ. A multi-objective, hub-and-spoke model to design and manage biofuel supply chains. Ann Oper Res. 2017;249(1–2):351–80.
46. Santibañez-Aguilar JE, Morales-Rodriguez R, González-Campos JB, Ponce-Ortega JM. Stochastic design of biorefinery supply chains considering economic and environmental objectives. J Clean Prod. 2016;136(Part B):224–45. https://doi.org/10.1016/j.jclepro.2016.03.168.
47. Azadeh A, Vafa AH. Biodiesel supply chain optimization via a hybrid system dynamics-mathematical programming approach. Renew Energy. 2016;93:383–403. https://doi.org/10.1016/j.renene.2016.02.070.
48. Miret C, Chazara P, Montastruc L, Negny S, Domenech S. Design of bioethanol green supply chain: comparison between first and second generation biomass concerning economic, environmental and social criteria. Comput Chem Eng. 2016;85:16–35. https://doi.org/10.1016/j.compchemeng.2015.10.008.
49. Cambero C, Sowlati T. Incorporating social benefits in multi-objective optimization of forest-based bioenergy and biofuel supply chains. Appl Energy. 2016;178:721–35. https://doi.org/10.1016/j.apenergy.2016.06.079.
50. Fattahi M, Govindan K. A multi-stage stochastic program for the sustainable design of biofuel supply chain networks under biomass

supply uncertainty and disruption risk: a real-life case study. Transport Res Part E. 2018;118:534–67.

51. Chávez MMM, Sarache W, Costa Y. Towards a comprehensive model of a biofuel supply chain optimization from coffee crop residues. Transport Res Part E. 2018;116:136–62.
52. Galanopoulos C, Barletta D, Zondervan E. A decision support platform for a bio-based supply chain: application to the region of Lower Saxony and Bremen (Germany). Comput Chem Eng. 2018;115:233–42.
53. Tsao Y-C, Thanh V-V, Lu J-C, Yu V. Designing sustainable supply chain networks under uncertain environments: fuzzy multi-objective programming. J Clean Prod. 2018;174:1550–65.
54. Roni MS, Thompson DN, Hartley DS. Distributed biomass supply chain cost optimization to evaluate multiple feedstocks for a biorefinery. Appl Energy. 2019;254:113660.
55. Radcliffe JC. The water energy nexus in Australia–the outcome of two crises. Water-Energy Nexus. 2018;1(1):66–85.
56. Zhuang Y. A system dynamics approach to integrated water and energy resources management. 2014.