In: Sustainable Design and Manufacturing. KES-SDM 2021. Smart Innovation, Systems and Technologies, Volume 262. Springer, Singapore
DOI:10.1007/978-981-16-6128-0_26

Designing a Research Tool for Sustainable Aquaculture Project

Miying Yang[1][0000-0002-8617-2115], Martino Luis[1][0000-0002-1368-8284], Dodi Hermawan[2], Lely Herlina[2], Rakesh Nayak[3][0000-0003-3630-9993], Jens Jensen[3][0000-0003-4714-184X], Sonal Choudhary[4][0000-0001-5232-6860], Peter Ball[5][0000-0002-1256-9339], and Steve Evans[6][0000-0003-1757-6842]

[1] Group of Sustainability, School of Management, Cranfield University, UK
[2] University of Sultan Ageng Tirtayasa, Indonesia
[3] Science and Technology Facilities Council, UK
[4] Management School, Sheffield University, UK
[5] The York Management School, University of York, UK
[6] Institute for Manufacturing, University of Cambridge, UK
miying.yang@cranfield.ac.uk

Abstract. Many research projects require strong interactions between academics and practitioners. Academics often face the challenges of collecting sufficient, high-quality research data, while achieving the project aim and producing practical impact to industrial partners. This paper presents the design of a research tool for data collection that increases industrial engagement in a sustainable aquaculture project. The project aim was to explore digital solutions for improving sustainability of shrimp aquaculture industry in Indonesia. To better facilitate the data collection and industrial engagement, we adapt the life cycle thinking and multi-stakeholder concepts from an existing tool, known as Sustainable Value Analysis Tool, redesign the rationale, and develop a new research tool to meet the specific purposes of this project. The research tool is composed of three parts: mapping and clustering challenges, assessing challenges, and co-designing digital solutions. The research tool was used in a workshop with 12 industrial partners from various organizations across the aquaculture supply chains in Indonesia in August 2019. The findings show that the empirical data collected through this tool is richer and more comprehensive compared to semi-structured interviews, and that the use of the tool greatly improved the industrial engagement. The feedback from the industrial partners shows that the tool has effectively helped them engage in the research process and improved the communication between themselves. This paper therefore suggests that designing and using such research tools is an effective way for data collection and industrial engagement.

Keywords: Research tool, sustainable aquaculture, sustainable value analysis tool, digital solutions.

1 Introduction

Many research projects require strong interactions between academics and practitioners. However, academics often face the challenges of collecting sufficient, high-quality research data, while achieving the project aim and producing practical impact to industrial partners. To better facilitate research data collection and industrial engagement, this paper presents the design of a research tool for a research project on sustainable shrimp aquaculture. This research tool adapts the key concepts and techniques from an existing tool, known as Sustainable Value Analysis Tool (SVAT) [1, 2], and redesigns the rationale to meet the specific purpose of this research project.

The SVAT was initially developed to help firms discover opportunities to create and capture sustainable value across the product life cycle [1]. It provides a structured approach for firms to analyze the value uncaptured [3] for key stakeholders across the entire product life cycle, and identify new opportunities for sustainable value creation. The tool has been effective in assisting firms in innovating their business models for sustainability and identifying new value opportunities for circular economy [2, 4, 5]. It has been used for consultancy, business training and university education in sustainable business model innovation. Later, the concepts of SVAT were embedded into roadmapping process [7, 8], and a new tool, i.e., Sustainable Value Roadmapping Tool (SVRT) [6], was developed to help managers develop sustainable business visions and build strategic pathway towards them. The tool has been used for sustainable strategic planning of adopting additive manufacturing in short-, medium- and long-term [9]. The SVAT has also been used in the combination with other tools to design new business models, such as Business Model Canvas [10], Value Mapping Tool [5, 11], and Sustainable Value Proposition Builder [12]. So far, the SVAT has been mostly used in manufacturing sectors and at firm level, and it is particularly effective to manufacturers transforming towards service-oriented business models, or towards circular economy through end-of-life value analysis.

In this paper, we explore how to design a research tool from SVAT and present a case of using it in a non-manufacturing sector (i.e., aquaculture) and at industry level. The paper will present the key concepts and the application of the SVAT, the design of the research tool and its application in a sustainable shrimp aquaculture project. The results show that the key concepts behind the SVAT can be adjusted flexibly for studying sustainability/circular economy research; and that the empirical data collected through this way seem to be richer and more comprehensive compared to semi-structured interviews. It has also effectively helped the industrial partners to engage in the research process and co-design the practical solutions together with the academics.

2 Sustainable Value Analysis Tool (SVAT)

2.1 Key Concepts

SVAT is built upon four key concepts: life cycle thinking, stakeholder, sustainable value, and multiple forms of value. It provides firms with a scheme to systematically map the stakeholders at each stage of product life cycle, look for value uncaptured, and with a method to design new opportunities [1, 2].

- Life cycle thinking. Product life cycle describes the life of a product from its design to production, usage and finally disposal. A product life cycle is normally divided into beginning of life (BOL), middle of life (MOL), and end of life (EOL). BOL is when product is designed and manufactured; MOL is when product leaves factories and is distributed and used; and EOL is when product is recycled, reused, remanufactured and disposed [13].
- Stakeholders. Stakeholders refer to the "groups and individuals who can affect or be affected" by the actions connected to value creation [14]. There are various stakeholders across the entire product life cycle. Companies need to consider the value creation for all these stakeholders rather than shareholders alone [15, 16].
- Sustainable value. Sustainable value include the value of all three dimensions of sustainability [17], i.e. economic, environmental and social value [18].
- Multiple forms of value. SVAT uses value uncaptured, i.e. the potential value that has not been captured, as a new perspective for business model innovation [3]. It follows a structured approach to identify four forms of value uncaptured, i.e., value surplus, value absence, value destroyed and value missed [2].

2.2 Application of SVAT

The SVAT (Figure 1, a) is composed of a poster and a set of cards with step-by-step guidance. The tool has been used by industrial practitioners from over 100 firms and the feedback has shown that the tool is effective in innovating their business models for sustainability and identifying new value opportunities for circular economy. In most cases, the SVAT was used for purposes related to 1) circular economy, 2) sustainability innovation, 3) business model innovation, and 4) product design and innovation.

To further explore the use case of the tool, Yang and Despeisse [6] developed a Sustainable Value Roadmapping Tool (Figure 1, b) to embed the sustainable value analysis into roadmapping process [7]. It combines the strengths of SVAT and Roadmapping, which has shown to be an effective approach to support managers to integrate sustainability into vision development and strategic planning process. Despeisse et al [9] further adapted it to help companies build sustainable visions and strategically develop a pathway of adopting additive manufacturing technologies towards the visions.

The SVAT has also been used in combination with other tools for sustainable business model innovation (see Figure 1, c). The Business Model Canvas [10] has been widely utilized to analyze the nine blocks of business models, including the value propositions, customer segment, customer relationships, channels, key partners, key activities, key resources, cost structure and revenue. The Cambridge Value Mapping Tool (CVMT) has been used to map the failed value exchanges (i.e., value missed and destroyed) among different stakeholders and identify the new value opportunities. The Sustainable Value Proposition Builder [12] has been created to help companies develop sustainable value proposition based on new value opportunities, and we found that it is particular effective when these opportunities were resulted from the value analysis supported by CVMT and SVAT.

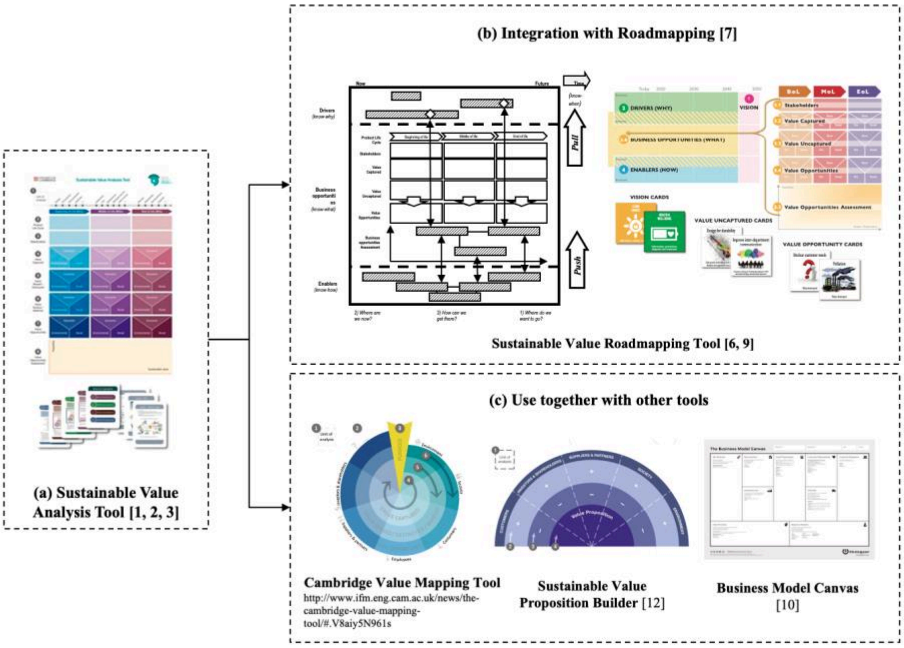


Fig. 1. Application of Sustainable Value Analysis Tool

3 Design of the Research Tool

3.1 Background of the Research Project

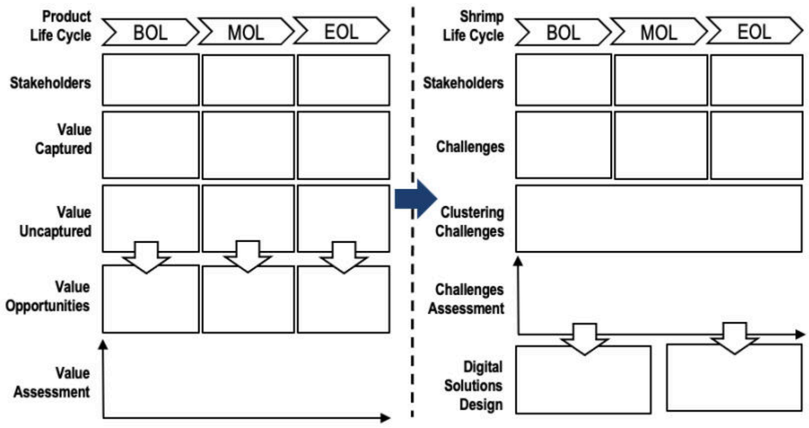
UK is a large shrimp consumption country, importing around US$ 850 million shrimp products every year, with around 53.2% from Southeast Asia, such as Indonesia, India, Vietnam, Bangladesh and Thailand [19]. According to the FAO (2019), Indonesia is the fourth largest shrimp producer in the world. However, Indonesian Directorate General of Aquaculture reports that around 40% of shrimps in Indonesia are lost during the cultivation, production and logistics due to changing water quality, diseases and shrimp cannibalism. This has resulted in significant waste and affected food safety, e.g., due to bacteria in shrimps and the use of banned antibiotics. This research project aims to design digital solutions for improving the productivity, food safety and sustainability of shrimp industry in Indonesia. The specific purposes are to 1) identify the key challenges of productivity, food safety and sustainability in shrimp aquaculture industry in Indonesia, and 2) explore the applications of digital technologies (e.g., Internet of Things, big data, artificial intelligence, blockchain) to address these challenges.

In order to achieve the purposes of the research project, the team needs to collect empirical data from industrial partners in Indonesia, and co-design digital solutions for a more sustainable shrimp industry. Our research team consists of academics from interdisciplinary backgrounds in the UK, such as sustainability innovation, circular economy, operations/supply chain management, data science and aquaculture science. The industrial partners include various stakeholders from the Indonesian shrimp industry, including shrimp farmers, shrimp product manufacturer, middlemen, shrimp associations and government. The project requires strong engagement between the academics and industrial partners at the early stage. Due to the physical distance and different time zones between the two countries, it is challenging to have regular communication between the researchers and practitioners, which means there is limited time for data collection and engagement. Therefore, we realized that there is a strong need for an effective and efficient method for research data collection and industrial engagement.

3.2 Designing the Rationale

Since SVAT has been used for sustainability innovation in various research projects, we explored whether or not the concepts and rationale of SVAT could be adjusted and used for this research project. The general rationale of SVAT is that "*mapping the value uncaptured for all key stakeholders across the product life cycle can help organizations discover new opportunities for sustainable value creation*" (Figure 2, a). The requirement of this research tool is to co-design digital solutions for a more sustainable shrimp aquaculture industry in Indonesia. We adapted the life cycle thinking and stakeholder concepts from SVAT and adjusted the value logic to meet the specific requirement of this research project.

Combining the project requirement and the key concepts taken from SVAT, the rationale of this research tool is that "*mapping the challenges for all key stakeholders across the shrimp life cycle can help organizations design digital solutions to address these challenges*" (Figure 2, b). Some techniques, such as clustering, ranking and assessment, were also adjusted to design the detailed data collection process.

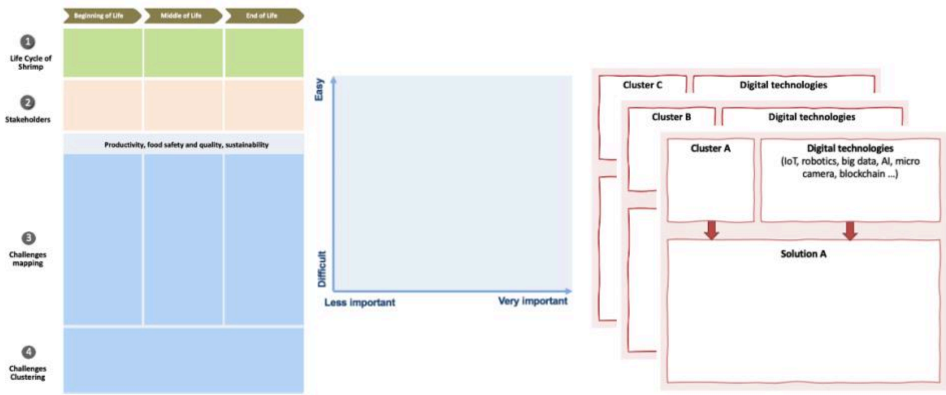


(a) Rationale of Sustainable Value Analysis Tool Adapted from [2]   **(b) Design the rationale for the research tool**

Fig. 2. Designing the Rationale of the Research Tool

3.3 Designing the Research Tool

Based on the rationale, the research tool for this project is developed. The tool is composed of three parts, as is shown in Figure 3: (a) mapping and clustering challenges, (b) assessing challenges, and (c) designing digital solutions. Design thinking techniques, such as clustering, dot-voting and 2x2 matrix, are used for these purposes.



(a) Map and cluster challenges   **(b) Assess challenges**   **(c) Design digital solutions**

Fig. 3. The Research Tool for the Sustainable Aquaculture Project

The research tool is designed to be used in interactive workshops with industrial partners across aquaculture supply chains. Participants are guided to follow four steps to map the challenges on the first poster (Figure 3, a): 1) map the life cycle of shrimp, 2) map the stakeholders in each stage of shrimp life cycle, 3) map the key challenges for these stakeholders across the entire shrimp life cycle, considering the productivity, food safety and sustainability dimensions, and 4) cluster the identified challenges. The participants are guided to discuss and write ideas on post-it-notes and put them onto the related places of the posters. The facilitator plays an important role especially during the challenge clustering process.

The clustered challenges will be placed onto an empty poster. The participants will then be given dot labels with different colors representing the importance and easiness. Each participant needs to select three most important challenges and three most difficult challenges by placing different-colored dot labels in the relevant clusters. Then the clustered challenges will be placed in the second poster (Figure 3, b) for assessment. The most important challenge clusters (according to their easiness) will be moved to the digital solutions design posters (Figure 3, c), in which the data scientist takes a lead to co-design the digital solutions to address this challenge cluster.

3.4 Using the Research Tool

This research tool was used in a multi-stakeholder workshop in Sidoajo, Indonesia in August 2019. Participants include 12 industrial partners from Indonesia shrimp industry, including the governmental representatives from the Ministry of Marine Affairs and Fisheries Republic of Indonesia, shrimp farmers, processors, shrimp and fishery associations, and fishery aquaculture researchers. The participants were divided into three groups with at least one facilitator or translator in each group. Each group followed the step-by-step process of the research tool within the group first, and then shared the data after each step, facilitated and coordinated by the lead researchers of the project. The industrial participants come from various stages of the shrimp life cycle, and they bring valuable, complementary expertise and knowledge to each process. Each group's data was shared and integrated after each step. Figure 4 shows the data collection through this research tool.

(1) Mapping the life cycle of shrimp

The participants mapped the entire life cycle of shrimp, from the brood stock, hatchery, post larva, cultivation, harvest; to shrimp processing, retailing, exporting, consumption; and to disposal.

(2) Mapping the key stakeholders across the entire shrimp life cycle

The participants mapped the key stakeholders involved in each stage of the shrimp life cycle. A large number of stakeholders were identified, among which the main stakeholders include: government (local, EU/US, Japan), fishery department, ministry of trade, brood stock feeder, hatchery business entity, farmers, feed companies, artificial additive providers, middleman, shrimp and fishery association, shrimp processors, ice companies, shrimp processing equipment providers, international accrediting bodies, retailer, local market, logistic companies, end consumers, restaurant owners, shrimp shell recyclers, food waste collectors.

(3) Mapping and clustering life cycle challenges

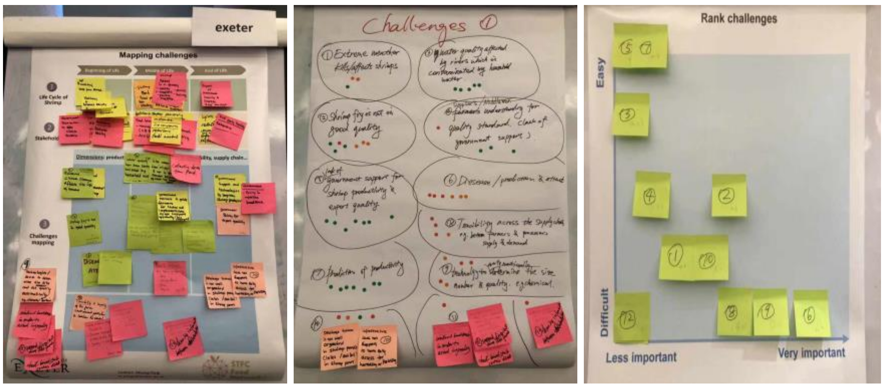
The participants identified over 70 challenges across the entire shrimp life cycle from multiple stakeholders' perspectives (Figure 4, a), and clustered them into the following 12 types of challenges (Figure 4, b):

- Shrimp death due to extreme weather

- Low quality of shrimp fry
- Water quality affected by rivers and household waste and pollution
- Shrimp farmers and manufacturers' lack of understand quality standards
- Lack of government support for shrimp productivity and export quality
- Disease prevention/prediction
- Prediction of productivity
- Traceability across supply chain
- Lack of technology to automatically determine the shrimp size, quantality and quality
- Lack of infrastructure for shrimp pond (e.g., draining system)
- Spread and distribute the brood stock (e.g., to avoid inbreeding)
- Lack of information sharing and coordination among supply chain actors

(4) Assessing challenges

The challenges were assessed according to the importance and easiness, and we identified the six most important challenges (based on the result of dot voting) that can be taken into the next step. We analyzed the root causes of the challenges and found that they share some common patterns, that is, they have the potential to be solved by a similar set of technologies. We then further grouped these challenges into two clusters (A and B). This clustering is based on whether or not these challenges could be solved by a similar set of technologies. Cluster A is that the lack of control of farming water quality causes the shrimp death and disease; and that the lack of technology to determine the shrimp size, number and quality causes the feeding problems, and therefore cannibalism. Cluster B is that the lack of the communication, collaboration, and support of the stakeholders across the entire shrimp supply chain.



(a) Mapping challenges (b) Clustering challenges (c) Assessing challenges

Fig. 4. Use of the Research Tool in the Sustainable Aquaculture Project

(5) Co-design of the digital solutions for sustainable aquaculture

We further analyzed the Cluster A and Cluster B, and designed the conceptual solutions of using digital technologies (e.g. IoT, robotics, big data, AI, micro camera, blockchain) to address these challenges. The digital solution for Cluster A is to develop smart sensors and camera to monitor and predict the changes of water environment through real-time data collection and analysis. This can help shrimp farmers to prevent shrimp death from water changes or extreme weather, and provide them scientific feeding plans to reduce cannibalism. The digital solution for Cluster B is to develop a system which can improve the transparency and traceability of the entire shrimp supply chain, to improve the effectiveness and efficiency of communication among supply chain actors, and to reduce unnecessary costs and improve food safety. In particular, it is identified that the application of non-invasive sensor technologies and space geospatial data analytics can be used to monitor, predict the real-time environmental change of shrimp cultivation and production in Indonesian shrimp farming firms. Such applications can prevent the potential shrimp disease and death, improve food safety, maximize the shrimp quality and productivity, and reduce waste. These conceptual solutions provide the initial ideas of the prototype development in the later stages of the research project.

3.5 Feedback and Observation of Using the Research Tool

The 8-hour workshop was recorded, and relevant data was transcribed and analyzed. The use of the research tool for industrial engagement received positive feedback from the industrial participants. First, all participants commented that the life cycle thinking of the research tool provided them a systematic, structured way to map and analyze the challenges across the entire life cycle of shrimp. The visualization of the tool helped them identify more challenges and see the connections between the challenges which were previously ignored. Second, the multi-stakeholder concept helped them better understand their stakeholders' challenges, which were not fully considered previously. Several industrial participants, for instance, mentioned that it is important to use the tool together with other supply chain partners, as the tool facilitates the communication that help them understand each other’s challenges and concerns. An interesting observation is that they identified many stakeholders due to the life cycle thinking. They also found some common challenges between different stakeholders and the mutual interests in solving these challenges. Third, many participants mentioned that they were more willing to share their challenges and knowledge when using this visualized tool.

From the research perspective, we found that the research data collected through this tool is richer, more visual and comprehensive compared to the traditional semi-structured interviews especially when multiple stakeholders are engaged in the process.

4 Conclusion

This paper presents the design of a research tool for data collection and industrial engagement in a research project on sustainable shrimp aquaculture. This research project aims to explore digital solutions for improving sustainability of shrimp aquaculture industry in Indonesia. The project requires strong engagement with the industrial partners in Indonesia, including shrimp farmers, processors, middlemen and government. To better facilitate the research data collection and industrial engagement, the paper takes the concepts and techniques from the Sustainable Value Analysis Tool, and develop a new research tool for this project. The research tool was used in the workshop with industrial partners from various aquaculture organizations in Indonesia. The key challenges for different stakeholders across the shrimp life cycle were identified, clustered and assessed, based on which two digital solutions were co-designed to address these challenges. The results show that the empirical data collected through this way seem to be richer and more comprehensive compared to semi-structured interviews. It has also effectively helped the industrial partners to engage in the research process and co-design the practical solutions together with the academics.

Acknowledgements

This research project is supported by the Science and Technology Facilities Council (STFC) Food Network Plus and the Engineering and Physical Sciences Research Council (EPSRC) Internet of Food Things Network Plus.

References

1. Yang M (2015) Sustainable value analysis for product-service systems. PhD thesis, University of Cambridge
2. Yang M, Vladimirova D, Evans S (2017) Creating and Capturing Value Through Sustainability. Res Manag 603:30–39
3. Yang M, Evans S, Vladimirova D, Rana P (2017) Value uncaptured perspective for sustainable business model innovation. J Clean Prod 140:1794–1804.
4. Zacho KO, Mosgaard M, Riisgaarrd H (2018) Capturing uncaptured values — A Danish case study on municipal preparation for reuse and recycling of waste. Resour Conserv Recycl 136:297–305
5. Evans S, Fernando L, Yang M (2017) Sustainable value creation - frrom concept to implementation. In: Sustainable Manufacturing. Springer, pp 203–220
6. Yang M, Despeisse M (2016) Sustainable Value Roadmapping Tool. In: R&D Management Conference. Cambridge, UK
7. Phaal R, Farrukh CJP, Probert DR (2007) Strategic roadmapping: a workshop-based approach for identifying and exploring strategic issues and opportunities. Eng Manag J 19:3–12
8. Dissel MC, Phaal R, Farrukh CJ, Probert D (2006) Value roadmapping: a structured approach for early stage technology investment decisions. In: 2006 Technology Management for the Global Future - PICMET 2006 Conference. Ieee, pp 1488–1495
9. Despeisse M, Yang M, Evans S, et al (2017) Sustainable Value Roadmapping Framework for Additive Manufacturing. In: Procedia CIRP
10. Osterwalder A, Pigneur Y (2005) Clarifying business models: origins, present, and future of the concept. Commun Assoc Inf Syst 15:1–25.
11. Bocken NMP, Short SW, Rana P, Evans S (2013) A value mapping tool for sustainable business modelling. Corp Gov 13:482–497
12. Vladimirova D (2019) Building sustainable value propositions for multiple stakeholders: a practical tool. J Bus Model 7:1–8
13. Jun H, Kiritsis D, Xirouchakis P (2007) Research issues on closed-loop PLM. Comput Ind 58:855–868

14. Freeman RE (1984) Strategic management: A stakeholder approach. Pitman, Boston, MA
15. Freeman E (2007) Managing for stakeholders: survival reputation and success. Yale University Press
16. Argandoña A (2011) Stakeholder theory and value creation
17. Elkington J (1998) Cannibals with forks: the triple bottom line of 21st century business
18. Rana P, Short S, Evans S (2012) D2.1 State-of-practice in business modelling and value-networks, emphasising potential future models that could deliver sustainable value
19. Pegg S (2019) Market insight factsheet: prawn and shrimp
20. FAO (2019) The state of food and agriculture: moving foward on food loss and waste reduction