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The usefulness of sustainable business models: Analysis from oil and gas industry

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Abstract

The management of offshore platforms at the end of their production phase is a complex issue for technological, socioeconomic, ecological and safety reasons. The decommissioning or reconversion of offshore platforms in the context of a circular economy (CE) will lead to new knowledge acquisition, changing values and changing behaviours towards sustainability consistent with the 'new' business objectives. Multiuse platforms at sea (MUPSs) represent an interesting solution for development of marine infrastructures, including areas in which to start and develop various creative economic activities that are in harmony with the needs of environmental protection including renewable energy, sea shellfish farming, decarbonisation plants, tourism, and recreation. Particularly, the research activity focused on a deep literature review of offshore platform decommissioning and sustainable business model (SBM) in a CE context. This allowed us to access the sustainable business model canvas (SBMC), a conceptual tool that represents a holistic view of the different managerial multiuse options and their social and environmental impacts. Besides, to test the SBMC, we adopt an empirical analysis by semi-structured questionnaires given to a sample of stakeholders in the decommissioning industry. The methodology was enriched by interviews with key informants to better investigate the business ecosystem and the feasibility of decommissioning applied to the case of an Italian offshore platform located in the Adriatic Sea. This article aims to contribute to supporting SBMs development following a holistic approach in relationship with all stakeholders and propose a multi-criteria decision-making analysis for evaluating and comparing alternative decommissioning options.

KEYWORDS
business model canvas, circular business model, corporate social responsibility, decommissionig, environmental management, multi-use platform, sustainable business model, sustainable development

1 | INTRODUCTION

The conversion of offshore platforms is a complex and risky activity that requires diverse skill and qualifications. It will also be a complex process since new business models (BMs) that are enhanced by transformative technologies and different infrastructures must be implemented and, above all, will be shared by several stakeholders. The design and implementation of an intervention of this type must find a balance point between safeguarding public health and environmental concerns with technical and economic feasibility. The decommissioning activities (Lakhal et al., 2009) could bring new opportunities for oil and gas companies (Patin, 1999). The issue is that when offshore oil and gas platforms end their operational phase, the environmental and economic impacts of the removal is of interest to the community. Full removal policies assume of 'leaving the seabed as it was found' and represent the seemingly most ecologically sustainable option. Therefore, abandoning the removal hypotheses for these structures represents the best practice from an environmental, ecological, and managerial point of view. This consideration has led some nations to leave obsolete structures as artificial reefs or to find alternative solutions for their sustainable reuse. This work stems from a basic question: 'What happens when an oil and gas platform end its life cycle and becomes obsolete and inactive?'. This research proposes the possibility of reusing offshore extraction platforms that are otherwise slated for total removal following the closure of their related hydrocarbon deposits. This phase, called decommissioning, is the conclusive natural act of a platform's life, usually due to the depletion of the reservoir. Following the need to dispose of a platform, as for civil works, different design solutions can be adopted, evaluating various factors, among which the economic one is undoubtedly one of the most relevant. In this paper, all the divestiture possibilities applicable to an offshore platform and the SBMs applicable to them will be analysed in a circular economy context. In the world, an increasing number of offshore platforms, subsea facilities and pipelines will need to be decommissioned. These assets represent 'end-of-life products'. Linear economic system thinking treats decommissioning as an offshore demolition activity, with waste to be disposed of. The CE approach[1] seeks to find new uses for assets and their components, consistent with commercial and sustainability objectives. Suppose the industry develops approaches to support ways of putting back components from those assets into the reuse-refurbish-recycle loop. In that case, the burden of decommissioning oil and gas assets will become more attractive in terms of sustainable business. The CE approach to decommissioning brings a new perspective that considers reuse and regeneration as critical aspects to be considered along with other matters from the earliest stages of decommissioning planning. Such thinking needs to be embedded in contracting strategy, decommissioning option development and commercial models. The approach also requires considerable cross-asset and cross-company development to maximise idea generation and learning and create new markets for regenerated products.

In this article, we pose the following research question: 'Is there a sustainable business model (SBM) in the literature that can be used for the conversion or decommissioning of oil and gas platforms?'

The article is structured in different sections. Section 2 presents the theoretical framework, Section 3 includes methodology used in the study, Section 4 shows the results of the analyses carried out and discussed the results. Finally, the last section concludes the paper with final remarks that includes managerial implications, limitations, and future research.

2 | LITERATURE REVIEW

Business model innovation (BMI) has seen a recent surge of interest from the fields of academic research and business practice. Changes to BMs are recognised as a fundamental approach to realise innovations for sustainability. However, little is known about the successful adoption of SBMs. The purpose of this theoretical framework is to develop a unified theoretical perspective for understanding BMI that led to better organisational, economic, environmental and social performance. The success or failure, and therefore the performance in terms of economic value created, of any company is a function of a firm's ability to create value for their customers. Therefore, it is necessary to define a BM from the customer's perspective and that of the company (in terms of the economic value to be generated). The BM concept was originally used to communicate complex business ideas to potential investors within a short time frame (Zott et al., 2011). Table A1 in the Appendix indicates the BM's main dimensions and BMI identified by the literature on this topic. It is important to emphasise that the customer-oriented approach asserts itself as the prevailing approach in the BM's configuration in any industry context (Osterwalder & Pigneur, 2010). Two different approaches emerge from the BM literature (Zott et al., 2011). The first is the static model, which aims to identify the elements that represent good performance in the company and underline the importance of consistency between the BM's basic components. In complete opposition, the second is dynamic and tries to identify how the BM changes over time. This approach is also called 'transformational' (Chesbrough, 2006) since the function of bringing change and innovation (Markides, 1997) is attributed to the BM in how the company creates value. An important feature of innovative BMs is the ability to 'unlock' the value present in new technologies and consequently transform it into economic value (Chesbrough & Rosenbloom, 2002). An important contribution to the BM is that of Björkdahl (2009), who considers the concept of the BM in the diversification or 'cross-fertilisation' phase. The study's central topic is that changing new technologies within an existing technological base can open new spaces and discover new application areas of the same, which, consequently, use a transformation of the BM itself if the new technologies have potential economic value to capture. The analysis of the impact on BMs of technological innovation can be deepened from the perspective of open innovation (Chesbrough, 2003, 2007, 2010). The basic idea of open innovation assumes that to innovate a company must refer to internal knowledge and to that existing within its borders to access sources of ideas available in their ecosystem and co-create innovation as well as an economic and social value. Of course, to do this, it is necessary to design new BM (open business models) tailor-made for sharing knowledge in the ecosystem in which the company operates. This perspective differs from that of Amit and Zott's (2001) and Johnson et al.'s (2008) suggestions that managers can identify the ideal BM, even if competitive adaptation conflicts hinder the implementation of the same model. Chesbrough's (2010) work highlights how often identifying the optimal BM is not so clear and obvious (Christensen, 2013, p. XXVI, introduction).

2.1 | Business model innovation

BMI is defined as a novel way of creating, delivering, and capturing value, which is achieved through a change of one or multiple components in the business model (Osterwalder & Pigneur, 2010). It has been widely acknowledged as a key source of competitive advantage, either by changing the terms of competition or by supporting the strategic marketing of innovative processes, products, and services (Björkdahl & Holmén, 2013). Therefore, BMI is the art of enhancing advantage and value creation by making simultaneous and mutually supportive changes to an organisation's value proposition to customers and its underlying operating model. At the value proposition level, these changes can address the choice of the target segment, product or service offering and revenue model (Johnson et al., 2008). Recently, BMI has received increasing attention in specific areas (e.g., sustainability, CE, retailing and digitisation). Due to these concepts' importance in their individual investigation fields, different 'substreams' have since emerged (Foss & Saebi, 2017). BMI is recognised as a key to the creation of sustainable business (Boons & Lüdeke-Freund, 2013; Boons & Lüdeke-Freund, 2013; Carayannis et al., 2014; Girotra & Netessine, 2013). The BM concept provides a link between the individual firm and the larger production and consumption system in which they are part (Boons & Lüdeke-Freund, 2013). BMIs for sustainability create significant positive or significantly reduced negative impacts for the environment or society through changes in the way an organisation and its value network create, deliver and capture value or, alternately, change their value propositions (Bocken et al., 2014). As the CE and sustainability gain greater attention from governments, industry and academia, BMIs for circularity and sustainability is becoming fundamental to sustaining firms' competitive advantages. A variety of BMI approaches have been proposed to suit the CE and sustainability principles. Although they largely have been addressed independently as two separate knowledge areas, there is an opportunity to seize synergies from the intersection of both visions (Pieroni et al., 2019).

2.2 | A sustainable and circular business model

Sustainability has become one of the key factors for long-term business success. Recent research and practice show that BMI is a promising approach to improving sustainability in manufacturing firms. To date, BMs have been examined mostly from the perspectives of value proposition, value capture, value creation and delivery. There is a need for a more comprehensive understanding of value to promote sustainability. BMIs for sustainability are defined as 'innovations that create significant positive or significantly reduced negative impacts for the environment or society, through changes in the way the organisation and its value network create, deliver value and capture value (i.e., create economic value) or change their value propositions' (Nielsen, 2020, p. 105). SBMs archetypes are classified into higher-order groupings, which describe the main BMI: technologically, socially and organisationally oriented innovations. This builds on Boons and Lüdeke-Freund's (2013) categorisation, which was found to be the most helpful in defining descriptive groupings. The technical grouping includes archetypes with a dominant technical innovation component (e.g., manufacturing process and product redesign); the social grouping includes archetypes with a dominant social innovation component (e.g., innovations in consumer offerings and changing consumer behaviour), while archetypes in the organisational grouping have a dominant organisational innovation change component (e.g., changing the fiduciary responsibility of the firm). SBMs aims at benefitting society or the environment by also generating economic value (Schaltegger et al., 2015). The core of a SBM is a sustainable value proposition, namely, a value proposition that allows multiple-stakeholder value creation by considering the needs of customers, shareholders, suppliers, and partners as well as the environment and society (Bocken et al., 2013; Donaldson & Preston, 1995; Tyl et al., 2015). Conceptualising a sustainable value proposition is a critical task in SBMI because it requires understanding and managing several needs and objectives across a network of multiple stakeholders to create shared value (Allee, 2000; Bocken et al., 2013; Porter & Kramer, 2011). The criticality lies in the fact that sustainable development (SD; Tsalis et al., 2020), both in research and practice, has given limited attention to understanding customer needs and integrating them with technological innovations to generate value (Keskin et al., 2013). Furthermore, a holistic view of the value proposition is required, where the benefits and costs of the customers need to be combined not only with those of the firm but also with those of a broader range of stakeholders, including investors, shareholders, employees, suppliers, the environment, and society (Bocken et al., 2013). Ultimately, a sustainable value proposition results from combining three interrelated building blocks: generating shared value for a network of stakeholders, addressing a sustainability problem, and developing a product or service that tackles this problem by taking stakeholders into account. The CE can play a vital role in solving material scarcity and environmental and social problems, but it needs the vision of new BMs. However, the existing methods for BMI have not been successfully explored from that perspective. Thus, this literature research aims to improve the circular BMI method and process. The CBM is defined as 'the rationale of how an organisation creates, delivers, and captures value with and within closed material loops' (Mentink, 2014). CBM require collaboration, communication, and coordination within complex networks of stakeholders (Antikainen et al., 2013).

The literature describes different subcategories, archetypes, or generic strategies for SBMs, such as product-service systems, bases of the pyramid, or circular business models (Bocken et al., 2014). These types have common characteristics and strive for innovative solutions to redesign their BM, as illustrated in Figure 1. For example, CBMs create sustainable value, employ proactive multistakeholder management, and have a long-term perspective with closing, slowing, intensifying, dematerialising, and narrowing resource loops (Bocken et al., 2016; Geissdoerfer et al., 2017). The MacArthur Foundation (2013) offers a schematic overview of CE activities and their impact on BMI. Figure 2, referred to as the 'butterfly diagram', illustrates a CE. Several archetypes of closed material loops are visible, such as

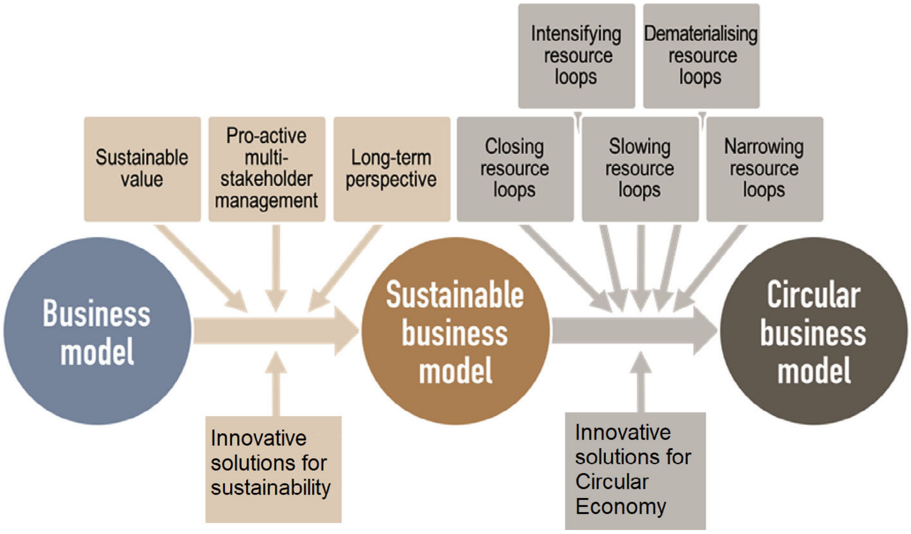

FIGURE 1 The forces involved in the transition to sustainable and circular business models.
Source: adapted from Geissdoerfer et al. (2017)

reuse, recycling, and soil restoration (fertilising the soil with organic waste). The material loops should be closed literally because materials and components must return to the original parts or product manufacturer. However, another manufacturer can use the material as long as the materials can flow back in the original material pool. In that case, the original manufacturer can use the material again, and downcycling is prevented. This is called open-loop recycling. The Ellen MacArthur Foundation (2013) presents five CE principles (pp. 26–28) to operationalise the concept of CE: (a) Design out waste; (b) Build resilience through diversity (balance efficiency with adaptability); (c) Shift to renewable energy sources; (d) Think in systems; and (e) Think in cascades.

CBMs reduce the extraction and use of natural resources and the generation of industrial and consumer wastes. They represent the key activities required to transition to a more resource-efficient and CE. CBMs already use existing materials and products as inputs, and therefore, their environmental footprint tends to be considerably smaller than that for traditional BMs:

1. *Maintenance*,[2] extends the product's lifetime by preventing faults or breakdown.
2. *Repair* extends the product's lifetime after a fault or breakdown and restores the original (or lesser) performance of the use state (Parlikad et al., 2003).
3. *Redistribution* (or reuse without treatments) can be done when a product reaches an end-of-need phase.
4. *Upgrading*, replaces outdated modules or components with technologically superior modules or components (Parlikad et al., 2003).
5. *Remanufacturing* replaces or repairs broken or outdated components of a product. Remanufactured products have equal or higher performance than the same original warranty, and therefore, customers can consider them the same as new products (Bakker & Hollander, 2013).
6. *Recycling* wins back base materials from used products but loses much of the added (or embodied) value (energy, labour, and the use of capital).
7. *Energy recovery* wins back part of the energy content of used products in the form of heat, electricity, or fuel before disposal.
8. *Disposal* must be regarded as the last resort for a material flow. It is recommended to have considered all other CE loops for possibilities to capture value.

In brief, CBMs modify the pattern of product and material flows through the economy. By doing so, they can reduce the adverse environmental side effects resulting from the extraction, use and eventual disposal of natural resources and materials. This results from facility-level improvements in material productivity and more fundamental changes in production and consumption patterns (Labuschagne, 2005).

2.3 | Offshore oil and gas platform decommissioning

In the last 20 years, there has been a great intensification of contributions both in the academic literature (see Table A3 in the Appendix) and among consultancy companies on the issue of decommissioning offshore platforms. More than 7500 oil and gas platforms are in offshore waters, 85% of which will become obsolete and require decommissioning within the next decade (Parente et al., 2006). Oil and gas offshore platforms and installations have a limited life of the operation. When the oil runs out, many terms describe the situation: abandonment, removal, disposal, and decommissioning. The decommissioning issue is now at the forefront of deep-water oil drilling for many reasons (the enormous costs required for disposal, the increasing number of rigs that require removal, the need to protect the marine environment and legal frameworks). Furthermore, it must be said that there are very few published researchers studying the problem according to its different facets (legal, environmental, and economic) in terms of the SBM. Several nations require complete removal of obsolete structures, which presents substantial engineering challenges and is estimated to cost the oil and gas industry more than USD 40 billion annually (Salcido, 2005). A large proportion of this

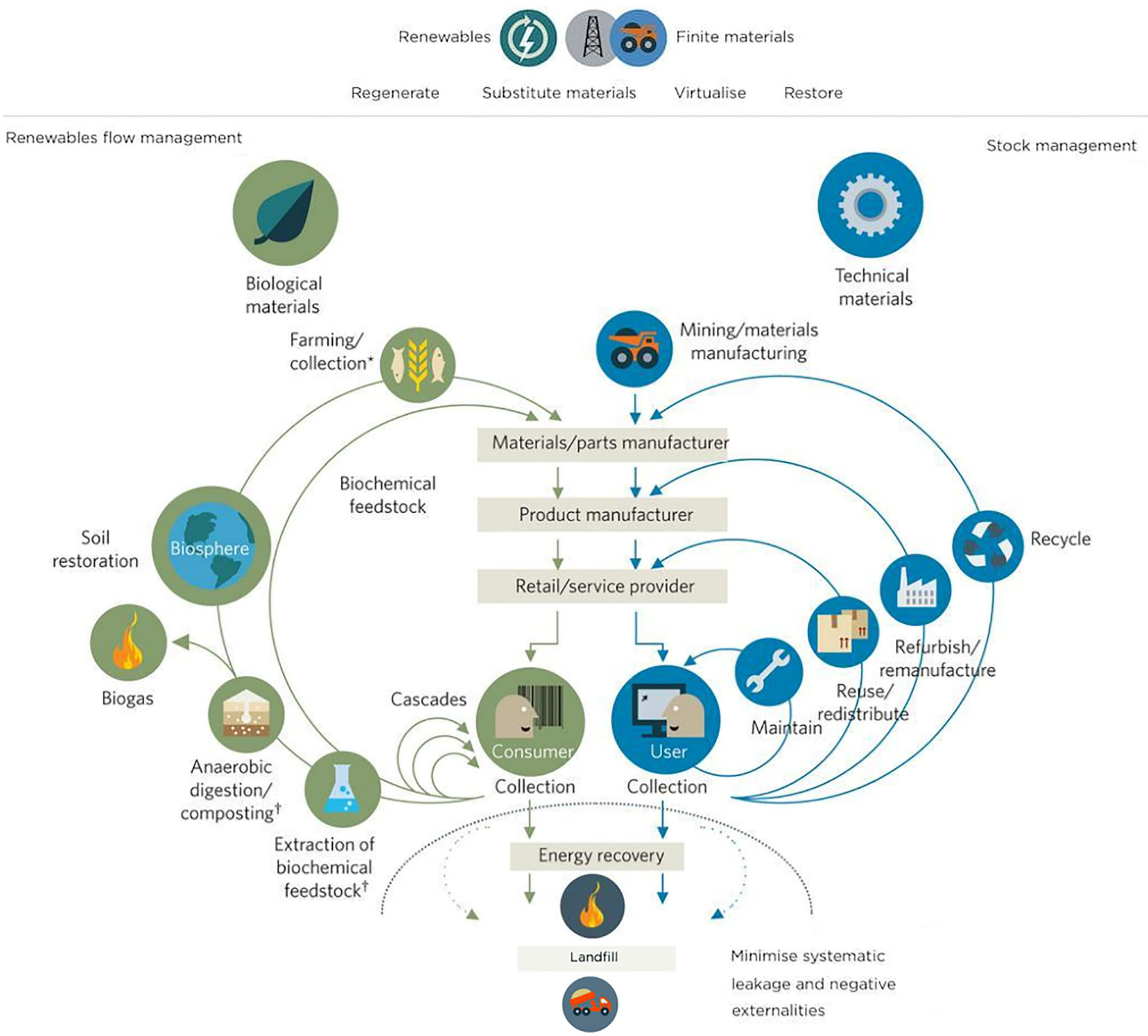

FIGURE 2 The circular economy framework.
Source: adapted from MacArthur (2013)

cost will be passed on to the public through tax concessions afforded to industry (Ekins et al., 2006). These costs are likely to have wider socioeconomic impacts owing to effects on local and regional economies. Policies of complete removal assume that leaving the seabed unaltered represents the most environmentally sound decommissioning option. However, we now know that oil structures can develop diverse marine communities during their production lives, with some structures supporting communities of regional significance (Macreadie et al., 2011). Examples include oil platforms in the northern Gulf of Mexico that support a commercially and recreationally important red snapper fishery (Gallaway et al., 2009) and platforms off southern California that support substantial juvenile populations of a declining rockfish species (Love et al., 2006). In other cases, oil structures may provide important habitats to ensure populations' connectivity, as has been speculated for cold-water coral in the North Atlantic (Bell & Smith, 1999). Removal of such structures is unlikely to represent the best environmental practice, and recognition of this has resulted in some nations leaving obsolete structures in place as artificial reefs. Rigs-to-reefs programmes are extremely controversial, and debates regarding their validity are ongoing in most regions (Jørgensen, 2012; Macreadie et al., 2012). Lakhal et al. (2009) detailed the phases of offshore operations. This flowchart shows the different components of decommissioning. Figure 3 below shows that the oil and gas processing equipment and piping are completely removed. The decommissioning process considers the total amount of pipeline running from all platforms either to shore or to other platforms that collect the oil or gas; these are generally shipped to shore for disposal. The deck and jacket of a rig are the most concerning parts for

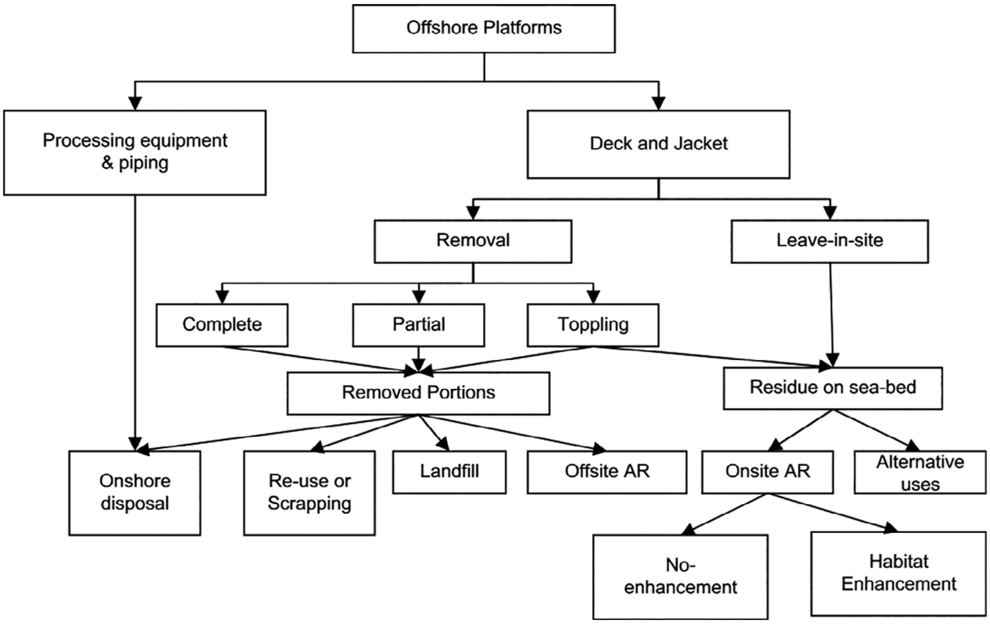

FIGURE 3 Oil and gas platform decommissioning options.
Source: Schroeder and Love (2004)

disposal. The removed portions are reused for platforms or disposed of onshore. At present, a more flexible and phased approach is used. This suggests immediate and total removal of offshore structures (mainly platforms) weighing up to 4000 tonnes in areas with depths less than 75 m and after 1998 at depths less than 100 m. Partial removal, known as toppling, is allowed for very large and heavy steel or concrete installations, which comprise the remaining 10% of offshore structures. In deeper waters, removing only the upper parts from above the sea's surface to 55 m deep and leaving the remaining structure in place is allowed. The removed fragments can be either transported to the shore or buried at sea. This approach considers the possible secondary use of abandoned offshore platforms for other purposes. At present, platform decommissioning alternatives fall into four general categories: complete removal, partial removal, toppling and leave-in-place. Schroeder and Love (2004) propose that decommissioning alternatives leave partial platforms onsite to develop artificial reefs, which provide substrates for marine organisms (see Figure 3 below).

In summary, the most common decommissioning options are the following: (a) *Disposing on land* (bringing the installation onshore, cleaning it, breaking it up into scrap for recycling in the steel industry or disposal at licenced sites); (b) *Toppling on-site* (cleaning the installation, placing or toppling the cut section on the seabed); (c) *Placing in deep water* (cleaning the installation, and then towing it and placing it a deep water site); (d) *Leaving on-site* (making the installation safe and leaving in situ); (e) *Artificial reef* (cleaning the installation and using it to form an artificial reef to improve local marine life); (f). *Reuse in another location* (cleaning the installation, carrying out non-destructive tests, removing and transporting it to another site suitable for the platform's characteristics, then installing it at the new site; and (g). *Reuse for another scope* (making the installation safe and transferring its use or purpose and potential ownership).

3 | METHOD

A design science approach (Holmström et al., 2009) is used to derive the conceptual framework based on a critical literature review (Grant & Booth, 2009). Multiple-choice questionnaires and in-depth interviews are used as well. To pursue this paper's objective, the authors also provide an analysis based on a case study (Italian platforms) that allowed an in-depth exploration of the phenomenon by utilising a range of data sources. Specifically, the study was carried out from June 2019 to July 2020. A literature review was implemented to select the main managerial tool for the sustainable reconversion of offshore platforms (see Tables A1 and A2 in the Appendix). The model proposed, which emerged from the literature, was the SBMC. Furthermore, to test and adopt the SBMC in the decommissioning industry, an empirical analysis was conducted on several stakeholders by semi-structured questionnaires. The collection data process was performed in three phases. In the initial phase, the questionnaires were distributed to stakeholders in the decommissioning industry during a study meeting organised at the Chieti-Pescara Chamber of Commerce (24 January 2020) by partners of the offshore platform conversion for eco-sustainable multiples use (PLACE) project. The latter was used by the University of Naples Federico II group and for the parties of interest of University of Bologna and Polytechnic University of Marche as a support tool for the hypotheses of sustainable conversion of offshore platforms and related BMs. Subsequently, during the data entry processing, both the number and the exploratory contributions of the research were expanded thanks to the contribution of other questionnaires completed by scholars from international universities such as Harvard (Belfer Center for Science and International Affairs) and the University of California. Furthermore, scholars of issues related to decommissioning and environmental sustainability from the North Atlantic area (project partner of Innovative exploitation of Adriatic

Reefs to strengthen Blue Economy - ADRIREEF) were added to the questionnaires' collection, to whom the questionnaire was sent in English. At an interval of approximately 6 months, a data set consisting of 43 total responses was obtained. The case study provides a description and shows an illustrative application of the framework for extrapolating further insights (Eisenhardt, 1989). The case study represents a strategy for doing research, which involves an empirical investigation of a particular contemporary phenomenon within its real-life context (Yin, 2003). The Italian context of offshore platforms has been selected for the analysis. In Italy, there are 136 platforms (of which 13 are within 12 miles of shore), among which 16 (of which 10 are within 12 miles of shore) are nearing the end of their production cycle and will thus have to be dismantled. Regarding the case study, the research question was: 'How can the emerged managerial model be applied to the case of an Italian oil and gas platform?'. The case study approach was useful in forming a holistic view of context-specific and complicated situations (Halinen & Gornroos, 2005; Yin, 2003). The case study approach is the most suitable in situations where the main research questions are depictive (Yin, 2014). During the second phase, the authors selected experts who represented different areas of business in the conversion off offshore platforms: (a) Tourism and recreational activities with high experiential content; (b) Productive activities in support of the CE and Blue Growth; and (c) Scientific and ecological application activities. Three semi-structured interviews were conducted in February and April 2020 and lasted an average of 90 min. However, the authors conducted semi-structured interviews to avoid limiting the interviewees and the possible serendipity of any additional evidence that might be used to revise or strengthen our research. In particular, the authors interviewed: (a) *Umberto Pellizari*, founder of Apnea Academy freediving school; (b) *Luca Intermesoli*, founder of Scuba Diving Centre; and (c) *Matteo Stante*, process development engineer at Alma CIS (a company working in the renewable energy industry). The in-depth interviews (Legard et al., 2003) concerned questions on the sustainability and recovery of offshore platforms in business terms (the questionnaire can be found in the Supporting Information). The objective was to shed more light on the role of business in enhancing sustainable development, the enablers and barriers to SBMI and the visions of an ideal SBM to focus on the important issues and form interesting statements. The interview protocol framework comprised of four stages: (a) ensuring interview questions align with research questions; (b) constructing an inquiry-based conversation; (c) receiving feedback on interview protocols; (d) piloting the interview protocol (the interview protocol can be found in the Supporting Information). The authors preserved the conversational and inquiry goals of the research act by including open-ended questions and discussions diverged from the interview guide, the experts were encouraged to interact. The authors collected data through interview notes, and tape recordings were utilised to allow for more consistent transcription (Creswell, 2012).The authors adopted the two-pass process for data verification, notated the interview comparisons with audio files, and received written approval of the transcripts by the participants. Finally, after the validation and testing of the SBMC model by the stakeholders and the questionnaire, the model was applied to a case study regarding an Italian offshore platform. The offshore facilities are in the Adriatic Sea and has characteristics such as seen when implementing a total reconversion of a MUPSs.

4 | RESULTS AND DISCUSSION

The dimensions of SBMC cover the three conceptual pillars of the BM definition: (a) *creation of value* (key partners, key activities and key resources); (b) *delivery of value* (channels, customer segment and customer relationships); and (c) *the capture of value* (cost structure and revenue structure). The newly developed SBMC includes both the nine dimensions of the BM and sustainability-specific issues (cost and profit of eco-reconversion) that impact all BM elements. Furthermore, much in the same way that the original BMC is used to understand revenues and costs, the main objective of SBMC is to appraise how the organisation generates environmental benefits and environmental impacts. In this case study, the authors concentrate on creating value for a broader range of stakeholders and consider the benefits from societal and environmental perspectives. In line with CE and Blue Growth strategies, an SBMC approach provides a series of potential advantages. According to a series of in-depth interviews conducted with key informants and other data collection sources, the current study investigated how reconversion of offshore platforms can create value to support sustainable growth. Figure 4 contains an SBMC-based illustration of the results.

4.1 | Key partners

Key partners are of paramount importance for the development of strategies for the SBMC. When considering a partnership, several factors need to be considered, such as a link to the value proposition, selection criteria, partnership agreements, development of a win-win relationship and defining terms and service levels. *Region and municipality* partners and *research centres* are strategically important partners for technological and operational challenges in an Italian offshore platform's conversion process. *Port authorities*, *universities*, *associations to protect the environment* and *engineering companies* play a proactive role in facilitating the development of an entrepreneurial project to convert a platform. Partnerships with *industrial federations*, *zoo prophylactic institutes*, *ship owners and naval cooperatives support* the development of activities. *Logistical and technical partners* are considered key partners because they provide support for determining activities. During the interviews, two levels of partnership emerged. First, the recreational-level partnership allows the *diving club and sports federation* to carry out training and recreational activities. Second, technical partners carry out training and the *professional activities for diving instructors* (e.g., Professional Association of Diving Instructors, International Association of Nitrox and Technical Divers and Technical Diving International). However, to support the sustainable management of offshore platforms, it is necessary to involve a series of public-private partners who structure a fully connected network to

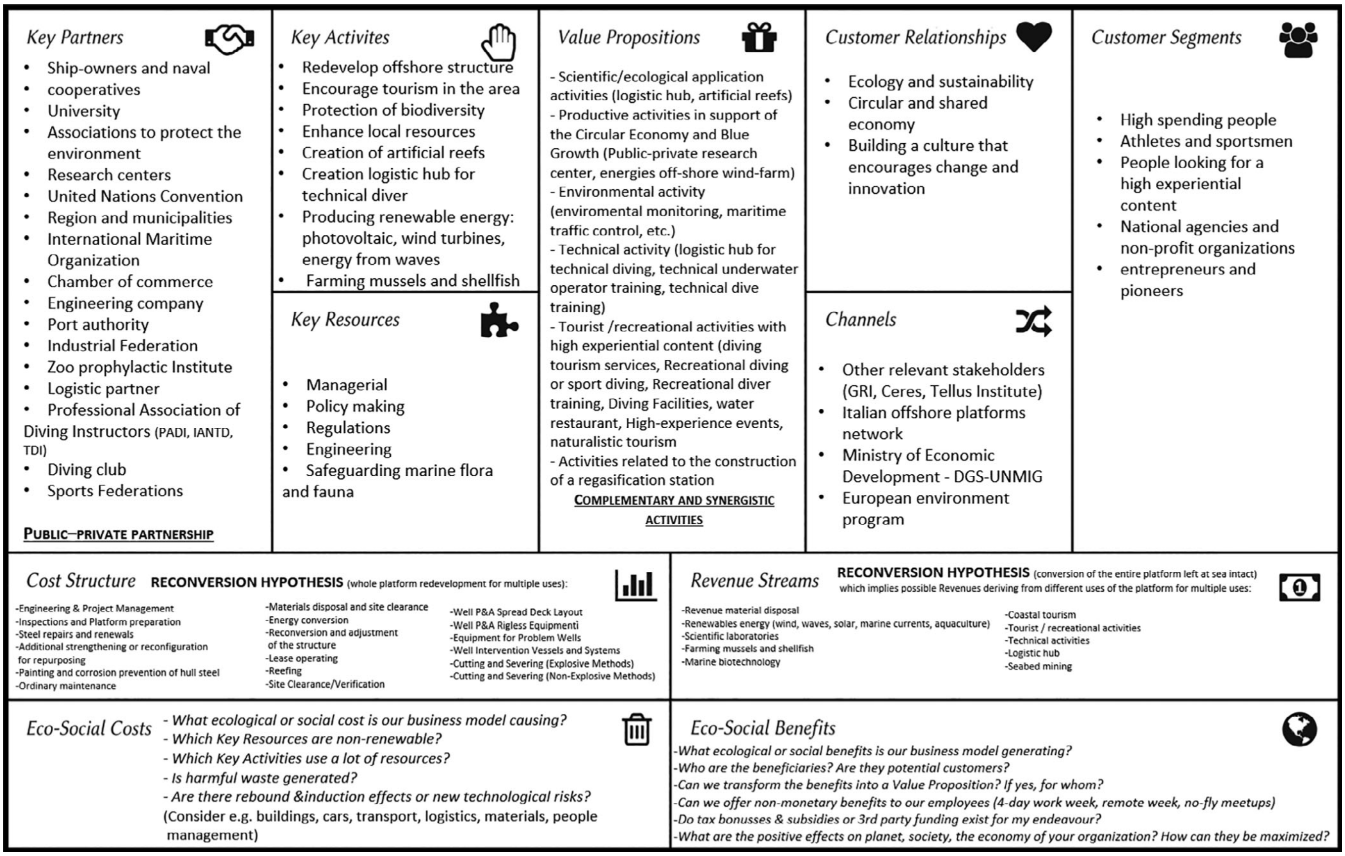

FIGURE 4 Sustainable business model canvas for offshore platforms.
Source: adapted from Osterwalder and Pigneur (2010)

develop and gain scalability. The partnership includes the idea of continuous vision and value iteration.

4.2 | Key activities

Key activities describe the actions performed to create, market and deliver value propositions to customers and make profits from them. Not all activities can be categorised into key activities but only activities that truly support the organisation's success in delivering value propositions to its customers. This represents the key activities for (economic) value creation within the offshore platform from an economic standpoint. The *protection of biodiversity* represents one of the most important activities in the conversion scenario, followed by *producing energy from renewable sources* and *redeveloping the offshore structure*. Other key activities that emerged are creating artificial reefs, enhancing local resources, encouraging tourism in the area and the *residential conversion of platforms*. According to interviewees, the *creation of logistic hubs for divers* and *farming mussels and shellfish* can be relevant key activities for value creation in converting an offshore platform. These activities are applied under environmentally friendly conditions since sustainability is one of the worries for actors involved in the conversion scenario.

4.3 | Key resources

Key resources represent the most important for the success of an SBMC. During data collection, a growing sensitivity to sustainability aspects (economic, environmental and social) and safety emerges in the broader sense. The results show that many interviewees have considered the application of blue economy principles (The EU Blue Economy Report, 2020). *Safeguarding marine flora and fauna* represents a principal key resource. According to the data collected, to maintain or even restore the good conservation status of natural habitats and wild fauna and flora, it is important to prevent activities that could harm them. Engineering resources operate during the life cycle of a platform. Furthermore, *regulations* have an imposing role on key resources. Over the last decades, international and national regulatory frameworks, as well as technological and ideological frameworks, have changed significantly. The perception of the conversion of offshore facilities in *policymaking* has changed over the years. Indeed, growing attention has been given to projections, environmental impact assessments and public awareness. According to interviews, a policymaker's role is central in the decision process; they gather information through consultation and research and reduce and extract from the information a policy, or a set of policies, that promote the preferred course of action. In addition, *managerial* resources are no less important; these play a key role in converting an offshore platform.

4.4 | Value proposition

Value propositions has a central place in the SBMC concept, value capture is about considering how to earn revenues (i.e., capture value) from the provision of goods, services or information to users and customers (Teece, 2010). In the process of converting an offshore platform, *productive activities in support of the CE and Blue Growth* (e.g., marine culture or exploitation of renewable energies, such as offshore wind farms) play a central role in creating and offering a value proposition. *Scientific and ecological application activities* such as artificial reefs, biodiversity hotspots and fish restocking sheltered from fishermen's nets and an underwater paradise for underwater, naturalistic and sports tourism are considered relevant by key informants. An important role is played by *environmental activity* (e.g., environmental monitoring and maritime traffic control). The data analysis shows that activities related to the construction of a *regasification station* are of low importance within Italian platforms. According to an interviewee, *technical activities* (e.g., a logistics hub for diving, technical underwater operator training and technical dive training), and *tourism and recreational activities* (e.g., diving tourism services, recreational diving or sport diving, recreational diver training, diving facilities, water restaurant, high-experience events and naturalistic tourism) represent important elements of value creation, particularly when they have experiential content. These types of activities would exponentially increase the customer base and turnover, and they can represent business opportunities. In a MUPS perspective, these activities must be considered complementary and synergistic.

4.5 | Customers relationship

Customer relationships refer to the relationship built and maintained with customers. This can be considered the lifeblood of business activity. The relationships established with customers are crucial to the survival and success of the business. This dimension includes all the people and organisations for which the business creates value. Building an effective SBMC depends on the identification of the customers that the business tries to serve. According to the data collected, in an offshore platform conversion scenario, the primary aim to be pursued from a customer relations standpoint is *ecology and sustainability*. The *circular and sharing economies* are increasingly gaining traction with academia, industry and policymakers and have become elements on which to build relationships. According to interviews, even within customer relations, *building a culture that encourages change and innovation* will be the foundation upon which a successful innovation BM must be built.

4.6 | Channels

Channels describe how potential customers become aware of the products and services, how they evaluate value propositions, how they purchase, how their value propositions are delivered to the customers and how they receive support. Effective channels distribute the business's value propositions fast, broadly and efficiently. It is the element that communicates with the customer segment and conveys the value propositions. From the data collected, the *Ministry of Economic Development*, in particular Directorate General for safety of mining and energy activity (DGS-UNMIG), has emerged as the principal channel from the MUPSs perspective. Additionally, the *offshore platform network* represents substantial support for emerging activities, even opportunities to ramp up offshore renewable investment and to develop new operations and BMs. The data collected highlights that *European environmental programmes* and *other relevant stakeholders* represent a channel for improving the possibility of funding and supporting all activities. Promotion of energy transitions in European programmes aims to create new opportunities for industry, generate green jobs across the continent and strengthen the EU's global leadership in offshore energy technologies.

4.7 | Customer segment

The customer segment dimension includes all the people and organisations for which the business creates value. Building effective SBMCs depends on the identification of the customers to serve. The growing awareness and extensive media coverage on environmental issues, such as sustainability, the CE and Blue Growth, as well as increases in customer consciousness, are the growing forces that encourage a form of sustainable entrepreneurship, sustainable non-profit organisational initiative and sports and sustainable recreational activities. In the decommissioning programme, it is important to establish a mechanism to involve *national agencies* and *non-profit organisations* in reviewing, accepting and managing the conversion process. *Entrepreneurs* and *pioneers* are considered relevant customers in the hypothesis of platform conversion. Combining the classic entrepreneurial process with sustainability concepts can generate supporting ecological system stability and contribute to the vitality of local communities. According to interviews with *athletes* and *sportspeople*, *consumers looking for high experiential content* as well as *high-spending consumers* are considered the most important customers in the areas of technical, tourism and recreational activities. The results show that interconnection across sustainability, innovation and entrepreneurship are relevant.

4.8 | Cost structure

The cost structure describes the costs incurred for delivering value propositions to customers and performing all business activities. Each offshore platform is unique in terms of structure and site characteristics, equipment used, market conditions, contract terms, time of operation and operator preferences. In oil and gas platforms, decisions about when and how an offshore structure is decommissioned involve issues of environmental protection, safety, costs and strategic opportunity. Estimating the cost of activities and resources needed for the operation of the conversion hypothesis is a major step. The cost of conversion depends on several factors such as the site, the size of the project, the regulations applicable, the power price, operating costs, the extent of reusable infrastructures and the expected profitability of the repowered project compared to the actual market. According to different engineering studies, the authors estimate these main category costs associated in a conversion scenario will be: engineering and project management, inspections and platform preparation, steel repairs and renewals, additional strengthening or reconfiguration for repurposing, painting and corrosion prevention of hull steel, ordinary maintenance, materials disposal and site clearance, energy conversion, reconversion and adjustment of the structure, lease operating, site clearance and verification, well P&A spread deck layout, well P&A rigless equipment, equipment for problem wells, well intervention vessels and systems, and cutting and severing.

4.9 | Revenue streams

The revenue streams dimension describes how a business generates revenue from each customer segment by offering value propositions. In a MUPSs concept, it is possible to combine different activities in a CE and Blue Growth prospective, such as production, scientific, ecological, environmental, tourism and recreational activities. In addition, MUPS allows sharing financial as well as other market and nonmarket costs of installation and management (e.g., locally using the produced energy for different functionalities and optimising marine spatial planning). The design of these solutions is a complex interdisciplinary challenge involving scientists and technical experts with different backgrounds. Defining a platform decommissioning's social and ecological goals is critical in evaluating the efficacy and future performance of conversion scenarios. The conversion of the entire platform left at sea implies possible revenues derived from different uses of the platform, including: revenue material disposal, renewable energy (wind, waves, solar, marine currents and aquaculture), activities related to the blue and green economy, coastal tourism, marine biotechnology, sealed mining, energy from tides (tidal energy) and underwater currents, magnesium production factories, mini regasification plants, tourism or recreation islands, scientific laboratories, and as a hub for decarbonisation and hydrogen storage.

4.10 | Ecosocial costs

Ecosocial costs can greatly aid the decision-making process if management goals are specified within a local or regional context. Oil and gas exploration and production operations have the potential for various impacts on the environment, depending upon the stage of the process, the nature and sensitivity of the surrounding environment, pollution prevention and mitigation and control techniques. However, concerning the aquatic environment, the principal problems are linked to offshore structures and then to waste streams of drilling fluids, cuttings, well-treated chemicals and by-products. In the conversion hypothesis, it is not very easy to quantify the effects on ecosystem value and larger regional ecosystems. Of course, stakeholders may be influenced by more than one social value, and others may use arguments from multiple categories to promote a desired decommissioning outcome. A traditional BM often summarises organisational impacts primarily as financial costs; from an ecosocial perspective, the organisation's ecological costs are included. To identify the ecosocial costs, it is necessary to answer specific questions reported in the SBMC developed by the authors (Figure 4). In general, in this case study, ecosocial costs may be related to bio-physical measures such as CO_2e emissions, ecosystem impacts, natural resource depletion, human health, political perspectives, non-developmental areas, regional impacts of decommissioning alternatives for marine populations, determination of biological effects of any residual contaminants on local marine populations, and failure to dispose of pollution materials.

4.11 | Ecosocial benefits

Ecosocial benefits allows to better understand where the organisation's biggest environmental impacts lie within the BM and provides insights for where the organisation may focus on creating environmentally oriented innovations. Data collection highlighted that engagement with customers and stakeholders is critical in the SBMC approach to improve an ecosocial benefit. A major challenge in estimating socioeconomic impacts on these user groups and on the ecosystem itself is that most such impacts are second-order, that is, their magnitude and even their direction result from changes in other factors such as the location of the platforms (e.g., platforms near cities, major arterials or harbours will likely be visited more frequently than those far away), access to fishing grounds, the biomass of fish, the demand for tourism-related and recreational activities, the availability of substitute sites, weather and currents, and other resources. As with social costs, to identify the ecosocial benefit, it is necessary to answer specific questions reported in the SBMC developed by the authors (Figure 4). In the sustainable management of offshore platforms, principal benefits are connected to support the ecological, sustainability and economic effects, such as significantly positive effects from reduced CO_2 (Jensen et al., 2020), safeguarding marine flora and fauna, understanding and engaging the local context and supporting local culture and community social impacts associated with conversion project employment.

5 | FINAL REMARKS

We propose a flexible model that allows decommissioning options to be selected from the full range of alternatives (including rigs-to-reefs options) on a case-by-case basis. We outline a multicriteria decision-making analysis (multicriteria approach) for evaluating and comparing alternative decommissioning options across key selection criteria, including environmental, financial, socioeconomic, and health and safety considerations. Furthermore, the applicability of the business models can be expanded or tested to other industries, for example to the sustainable decommissioning of an offshore wind farm (Topham & Mcmillan, 2017); or in other countries, for example the decision framework for platform decommissioning in California (Bernstein, 2015). The SBMC develops the idea of a viable BM, following a holistic approach in relationship with all stakeholders. In addition to economic criteria, it focuses on the ecological and social consequences of the activity. It aims at maximising positive and avoiding negative impacts on society and nature. Therefore, sustainability is integrated into the core business. The visualisation on the canvas fosters coherence of the concept and clarification among the team members. It further supports communication with third parties and prepares for a solid business plan by evaluating potential costs and revenues from the business.

The main research limitations are related to the case study approach (Eisenhardt, 1989; Feagin et al. 2001; Yin 2013) and qualitative methods used during the empirical steps (semi-structured questionnaire). More replications in other industries are needed to enhance our findings' generalisability, from decommissioning to other linked industries. Moreover, the SBMC model has a conceptual nature (Maxwell, 2012; Flick, 2014; Taylor et al., 2015) and has been empirically supported by an analysis of only single case studies, although a wide informative contribution offered by several contexts in different countries could be useful.

Energy industry policies have historically focused on the planning, design and construction of energy infrastructures while typically overlooking the processes required to manage their end-of-life, particularly their decommissioning (Invernizzi et al., 2020). However, decommissioning of existing and future energy infrastructures is constrained by a plethora of technical, economic, social and environmental challenges that must be understood and addressed if such infrastructures are to make a net-positive contribution over their whole lives. Decommissioning represents an important opportunity to change the approach to the sea, and the exploitation of its 'business as usual' resources will contribute to the Blue Growth of the sectors involved, promoting diversification and synergies and improving the attractiveness, competitiveness and innovation at the regional and national levels. There is currently a lack of frameworks for supporting BMI in companies in the context of a CE. The current tools do not offer the needed understanding of the changing business environment and breakup of current value chains. Furthermore, the impact of CE models and sustainability should be understood through value cocreation for all stakeholders. The challenge of redesigning business ecosystems is to find the 'win-win-win' setting (Antikainen et al., 2013) that balances the self-interests of the involved actors and sustainability impacts. Therefore, the need for change communicated through BMs influences and facilitates their actions to shape joint goals. Therefore, decommissioning is challenging for established firms within an existing BM and ecosystem, as in the case of the oil and gas industry. Measuring the quality and potential impact of a transformation project's different scenarios is pivotal for a successful process to be successfully implemented.

In future research, it could be useful to compare the SBMC to the latest mainstream topics of the CBM to better evaluate and quantify the environmental and social impacts of offshore platform decommissioning (Van Elden et al., 2019) and expand the debate on this issue, considering financial and economic indicators.

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ENDNOTES

[1] A circular economy seeks to rebuild capital, whether this is financial, manufactured, human, social, or natural. This ensures enhanced flows of goods and services.

[2] The much-used term refurbishment does not appear in this list, because it can be seen as combination of maintenance and repair (Bakker, 2014).

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SUPPORTING INFORMATION

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APPENDIX A.

TABLE A1. The main existing literature on business models and business model innovation

Authors	Focus	Main empirical evidence
Chesbrough and Rosenbloom (2002)	The role of the business model in capturing value from innovation	'This paper explores the role of the business model in capturing value from early-stage technology. A successful business model creates a heuristic logic that connects technical potential with the realization of economic value. The business model unlocks latent value from a technology, but its logic constrains the subsequent search for new, alternative models for other technologies later an implicit cognitive dimension overlooked in most discourse on the topic'
Johnson et al. (2008)	Reinventing your business model	'A successful model has these components: customer value proposition, profit formula and key resources and processes. To determine whether your firm should alter its business model, Johnson, Christensen, and Kagermann advise these steps: 1. Articulate what makes your existing model successful; 2. Watch for signals that your model needs changing, such as tough new competitors on the horizon and 3. Decide whether reinventing your model is worth the effort. The answer's yes only if the new model changes the industry or market'
Lindgardt et al. (2009)	Business model innovation. When the Game Gets Tough, Change the Game	'Business model innovation is especially valuable in times of instability. BMI can provide companies a way to break out of intense competition, under which product or process innovations are easily imitated, competitors' strategies have converged, and sustained advantage is elusive. It can help address disruptions such as regulatory or technological shifts that demand fundamentally new competitive approaches. BMI can also help address downturn-specific opportunities, enabling companies, for example, to lower prices or reduce the risks and costs of ownership for customers. In our experience, the companies that flourish in downturns frequently do so by leveraging the crisis to reinvent themselves rather than by simply deploying defensive financial and operational tactics. Moreover, during times of crisis, companies often find it easier to gain consensus around the bold moves required to reconfigure an existing business. BMI may be more challenging than product or process innovation, but it also delivers superior returns'
Casadesus-Masanell and Ricart (2010)	Competitiveness: business model reconfiguration for innovation and internationalisation	'The paper reflects on competitiveness by using the business model concept and to understand the need to adapt business models to changes in the environment'
Chesbrough (2010)	Business Model Innovation: Opportunities and Barriers	'Business model innovation is vitally important, and yet very difficult to achieve. The barriers to changing the business model are real, and tools such as maps are helpful, but not enough. Organizational processes must also change. Companies must adopt an effectual attitude toward business model experimentation. Some experiments will fail, but so long as failure informs new approaches and understanding within the constraints of affordable loss, this is to be expected-even encouraged. With discovery driven planning, companies can model the uncertainties, and update their financial projections as their experiments create new data. Effectuation creates actions based on the initial results of experiments, generating new data which may point towards previously latent opportunity'
Osterwalder and Pigneur (2010)	Business Model Generation: A Handbook for visionaries, game changers and challengers	'Formal descriptions of the business become the building blocks for its activities: infrastructure (key activities and resources, partner network); offering (value propositions); customer segments, channels; customer relationships; finances (cost Structure and its characteristics); revenue streams. Many different business conceptualizations exist; Osterwalder's work and thesis propose a single reference model based on the similarities of a wide range of business model conceptualizations. With his business model design template, an enterprise can easily describe their business model'

TABLE A1. (Continued)

Authors	Focus	Main empirical evidence
Zott and Amit (2010)	Business Model Design: An Activity System Perspective	'The authors conceptualize a firm's business model as a system of interdependent activities that transcends the focal firm and spans its boundaries. The activity system enables the firm, in concert with its partners, to create value and also to appropriate a share of that value. They suggest two sets of parameters that activity systems designers need to consider: design elements content, structure and governance that describe the architecture of an activity system; and design themes novelty, lock-in, complementarities and efficiency that describe the sources of the activity system's value creation'
Teece (2010)	Business models, business strategy and innovation.	'The essence of a business model is in defining the manner by which the enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit. It thus reflects management's hypothesis about what customers want, how they want it, and how the enterprise can organize to best meet those needs, get paid for doing so, and make a profit. The purpose of this article is to understand the significance of business models and explore their connections with business strategy, innovation management, and economic theory'
Markides, (2013)	Business model innovation	'Redefine the business. Redefine the who. Who is our customer? A company should think of new customers or new customer segments and develop a game plan that serves them better. Redefine the what. What products or services are we offering these customers? A company should think of new customer needs or wants and develop a game plan that better satisfies these needs. Redefine the how. Companies should leverage existing core competencies to build new products or a better way of doing business and then find the right customers. Start the thinking process at different points. For example, instead of thinking, "This is our customer, this is what he or she wants, and this is how we can offer it," start by asking: "What are our unique capabilities? What specific needs can we satisfy? Who will be the right customer to approach?"'
Björkdahl and Holmén (2013)	Business model innovation the challenges ahead	'A business model innovation can include a process innovation, a new revenue model or other types of innovation. Therefore, we argue that a business model innovation is a new integrated logic of how the firm creates value for its customers (and users) and how it captures value. In this view, a business model innovation is not a 'mere' product or service innovation, nor is it a process innovation. In the general case, a business model innovation may include new ways for the firm to create value and new firm offers, new ways for the customers to view the firm's offers (positioning innovation), changes to how the firm views its activities (paradigm innovation) and operations (process innovation). Thus, a business model innovation is a new integrated logic of value creation and value capture, which can comprise a new combination of new and old products or services, market position, processes and other types of changes'
Schneider and Spieth (2013)	Business model innovation: Towards an integrated future research agenda.	'The particular characteristics of business model innovation are discussed and three distinct research streams addressing prerequisites, process and elements, and effects of business model innovation are identified. A tentative theoretical framework emphasising the need to distinguish between developing and innovating business models as well as to apply an entrepreneurial perspective for further research on business model innovation is proposed'
Spieth et al. (2014)	Business model innovation state of the art and future challenges for the field.	'We propose in this article a role-based approach to categorize the literature and argue that the respective roles of explaining the business, running the business, and developing the business can serve as three interrelated perspectives to present an overview of the current business model innovation field and to accommodate the selected contributions of this special issue. We refer to contributions from entrepreneurship, innovation and technology management, and corporate strategy to explicate the three elaborated perspectives and to summarize the main contents of the special issue articles'

(Continues)

TABLE A1. (Continued)

Authors	Focus	Main empirical evidence
Khanagha et al. (2014)	Business model renewal and ambidexterity: structural alteration and strategy formation process during transition to a cloud business model.	'Business model innovation activities can range from incremental changes in individual components of business models, extension of the existing business model, introduction of parallel business models, right through to disruption of the business model, which may potentially entail replacing the existing model with a fundamentally different one'
Foss and Saebi (2017)	Fifteen years of research on business model innovation: How far have we come, and where should we go?	'We argue that the literature faces problems with respect to construct clarity and has gaps with respect to the identification of antecedent conditions, contingencies, and outcomes. We identify important avenues for future research and show how the complexity theory, innovation, and other streams of literature can help overcome many of the gaps in the BMI literature'
Hacklin et al. (2018)	Strategies for business model innovation: How firms reel in migrating value.	'Based on our analysis we conclude that when value is rapidly migrating across industries and between firms, proactively substituting key elements of the primary business model provides a better fit with the new value landscape than launching secondary business models in parallel. We suggest four underlying mechanisms that link business model innovation, value migration and subsequent outcomes. Unpacking business model innovation allows us to discuss contingencies for the main business model strategies, specifically in terms of limitations to and opportunities of changing the primary business model and the practice of parallel business models'
Pieroni et al. (2019)	Business model innovation for circular economy and sustainability: A review of approaches.	'This paper provides a review of approaches for business model innovation for circular economy and/or sustainability, based on a systematic review of academic literature and practitioner-based methodologies. The systematic literature review identified 94 publications and 92 approaches (including conceptual models, methods or tools). The different approaches were categorized according to the business model innovation process, following a three-stage dynamic capability view. Subsequently they were compared based on five characteristics (nature of data, boundaries of analysis, level of abstraction, time-based view, and representation style), to allow for a better understanding of how to use the approaches in research and practice. Based on the review, key findings outlining trends and a reflection about the interface of the scopes of circular economy-oriented and sustainability-oriented business model innovation are presented'

Source: Own elaboration.

TABLE A2. The main existing literature on sustainable and circular business models

Authors	Focus	Main empirical evidence
Svensson et al. (2011)	A corporate effort towards a sustainable business model	'The company's efforts towards a more sustainable business model can broadly be divided into factors within the company and factors outside the company. The case study demonstrates how the carbon footprint on the Earth can be reduced by focusing and influencing factors outside the company "sown production facilities"'
Boons and Lüdeke-Freund (2013)	Business models for sustainable innovation: state-of-the-art and steps towards a research agenda.	'As the current literature does not offer a general conceptual definition of sustainable business models, we propose examples of normative requirements that business models should meet in order to support sustainable innovations. Finally, we sketch the outline of a research agenda by formulating a number of guiding questions'
Laukkanen and Patala (2014)	Analysing barriers to sustainable business model innovations: Innovation systems approach	'The central idea of this paper is to examine how the societal transition towards sustainable business models can be achieved. Through a qualitative Delphi study, we assess and categorize the key structural and cultural barriers to sustainable business model innovation. By applying innovation system approach, we explain how to overcome existing barriers by strengthening the functions of innovation system'

TABLE A2. (Continued)

Authors	Focus	Main empirical evidence
Planing (2015)	Business model innovation in a circular economy: reasons for non-acceptance of circular business models	'For practitioners working on new innovative business models in the realm of the circular economy this paper provides a basic framework for clustering their concepts. By learning about consumer motives leading to non-adoption, this paper also provides support for designing better and more successful business models'
Joyce and Paquin (2016)	The triple-layered business model canvas: A tool to design more sustainable business models.	'The Triple Layered Business Model Canvas is a tool for exploring sustainability-oriented business model innovation. It extends the original business model canvas by adding two layers: an environmental layer based on a lifecycle perspective and a social layer based on a stakeholder perspective. When taken together, the three layers of the business model make more explicit how an organization generates multiple types of value economic, environmental and social'
Antikainen and Valkokari (2016)	A framework for sustainable circular business model innovation	'Currently, there is a lack of frameworks for supporting business model innovation in companies in the context of a circular economy. The current tools do not offer the needed understanding in the changing business environment and breaking up of current value chains. Furthermore, the impact of the circular economy models and sustainability should be understood through value creation for all stakeholders. The challenge of redesigning business ecosystems is to find the "win-win-win setting" that balances the self-interests of involved actors and sustainability impacts'
Lieder and Rashid (2016)	Circular Business Model Innovation: Inherent Uncertainties	'Circular business models based on remanufacturing and reuse promise significant cost savings as well as radical reductions in environmental impact. Variants of such business models have been suggested for decades, and there are notable success stories such as the Xerox product–service offering based on photocopiers that are remanufactured. Still, we are not seeing widespread adoption in industry. This paper examines causes for reluctance. Drawing on a hypothesis-testing framework of business model innovation, we show that circular business models imply significant challenges to proactive uncertainty reduction for the entrepreneur. Moreover, we show that many product–service system variants that facilitate return flow control in circular business models further aggravate the potential negative effects of failed uncertainty reduction because of increased capital commitments'
Yang et al. (2017)	Value uncaptured perspective for sustainable business model innovation	'This paper contributes to theory by proposing the concept of value uncaptured and offers a framework for using it as a novel perspective for sustainable business model innovation. Four forms of value uncaptured are used to trigger innovation: value surplus, value absence, value missed and value destroyed. In the context of sustainability, each value is considered not only from the perspective of economic value, but also from the perspectives of environmental and social value'
Evans et al. (2017)	Business model innovation for sustainability: Towards a unified perspective for creation of sustainable business models	'The paper examines bodies of literature on business model innovation, sustainability innovation, networks theory, stakeholder theory and product service systems. We develop five propositions that support the creation of SBMs in a unified perspective, which lays a foundation to support organizations in investigating and experimenting with alternative new business models. This article contributes to the emerging field of SBMs, which embed economic, environmental and social flows of value that are created, delivered and captured in a value network'
Baldassarre et al. (2017)	Bridging sustainable business model innovation and user-driven innovation: A process for sustainable value proposition design	'This research aims at combining principles from both sustainable business model innovation and user-driven innovation to develop more successful, radical and user-centered sustainable value propositions. Sustainable business model innovation entails developing value propositions that create value for multiple stakeholders at the same time, including customers, shareholders, suppliers and partners as well as the environment and society. User-driven innovation allows developing solutions that are meaningful for people and profitable for business by involving potential customers, users and/or other stakeholders in an experimental and iterative design process'
Bocken et al. (2018)	Experimenting with a circular business model: Lessons from eight cases	'Experimentation is an important capability in the transition to a sustainable business. We focused on circular economy as a driver for sustainability. The process and role of business model experimentation were analyzed. A circular business experimentation framework was developed and applied. We found that 1) experimentation creates internal and external engagement to start business sustainability transitions 2) experiments can help test assumptions in every building block of the business model 3) collaboration with external partners can ease experimentation, and 4) experimentation processes are iterative and require regular learning and sustainability checks'

(Continues)

TABLE A2. (Continued)

Authors	Focus	Main empirical evidence
Lüdeke-Freund et al. (2018)	The sustainable business model pattern taxonomy 45 patterns to support sustainability-oriented business model innovation	'…we offer a synthesis and consolidation of the available knowledge about SBMs. Following the notion of patterns as problem–solution combinations, we developed, tested, and applied an emulate-method and multi-step approach centered on an expert review process that combines literature review, Delphi survey, and physical card sorting to identify and validate the currently existing SBM patterns. Ten international experts participated in this process. They classified 45 SBM patterns, assigned these patterns to 11 groups along ecological, social, and economic dimensions of sustainability and evaluated their potential to contribute to value creation. The resulting taxonomy can serve as a basis for more unified and comparable studies of SBMs and for new business model tools that can be used in various disciplines and industries to analyses and develop sustainability-oriented business models in a consistent manner'
Guldmann et al. (2019)	A Design Thinking Framework for Circular Business Model Innovation	'Circular business model innovation (CBMI) can support sustainable business transitions, but the process is poorly understood and there is a lack of tools to assist companies in CBMI. This article aims to contribute to closing this gap by developing a framework for CBMI based on a design thinking approach, which can support the CBMI process. A design thinking process typically consists of three innovation spaces, an exploratory, an ideation, and a prototyping and testing space. (…) this paper identifies two additional spaces, an introductory and an alignment space, for CBMI. The results derived from the six case companies indicate that the developed framework including its tools and techniques are useful for CBMI'
Guldmann and Huulgaard (2020)	Barriers to circular business model innovation: A multiple-case study	'The purpose of this article is to provide an overview of the barriers that hinder adoption of circular business models to facilitate circumvention of the barriers and a faster uptake. The research shows that barriers to circular business model innovation are found at all socio-technical levels and, overall, most barriers are encountered by companies at the organizational level, followed by the value chain level, the employee level and, finally, the market and institutional level'

Source: Own elaboration.

TABLE A3. The main literature contributions on offshore installation decommissioning

References	Focus	Main empirical evidence
Hamzah (2003)	International rules on decommissioning of offshore installations: some observations	'This paper, which is concerned mainly with international law and practice on the decommissioning of offshore installations, examines the various global and regional instruments, which attempt to regulate decommissioning. In considering the way forward, particularly for Third World countries, it is concluded that there is a need for oil-producing countries to enact comprehensive national legislation on this subject'
Osmundsen and Tveterås (2003)	Decommissioning of petroleum installations – major policy issues.	'Following the Brent Spar controversy, the OSPAR countries reached a unanimous agreement in 1998 for the future rules for disposal of petroleum installations. The vast majority of existing offshore installations will be re-used or returned to shore for recycling or disposal. For installations where there is no generic solution, one should take a case-by-case approach. We provide a survey of international economic and regulatory issues pertaining to disposal of petroleum installations, and provide specific examples by analyzing the Norwegian decommissioning policy. Implications of disposal decisions for the fishing industry, a central stakeholder, are analysed'
Schroeder and Love (2004)	Ecological and political issues surrounding decommissioning of offshore oil facilities in the Southern California Bight	'To aid legislators, resource managers, and the general public, this paper summarizes and clarifies some of the issues and options that the federal government and the state of California face in decommissioning offshore oil and gas production platforms, particularly as these relate to platform ecology. Both local marine ecology and political climate play a role in decommissioning offshore oil production platforms. Compared to the relatively supportive political climate in the Gulf of Mexico for "rigs-to-reefs" programs, conflicting social values among stakeholders in Southern California increases the need for understanding ecological impacts of various decommissioning alternatives (which range from total removal to allowing some or all of platform structure to remain in the ocean). Additional scientific needs in the decommissioning process include

TABLE A3. (Continued)

References	Focus	Main empirical evidence
		further assessment of platform habitat quality, estimation of regional impacts of decommissioning alternatives to marine populations, and determination of biological effects of any residual contaminants. The principal management need is a ranking of environmental priorities (e.g., species-of-interest and marine habitats). Because considerable numbers of economically important species reside near oil platforms, National Oceanic and Atmospheric Administration Fisheries should consider the consequences of decommissioning alternatives in their overall management plans. Management strategies could include designating reefed platforms as marine protected areas. The overarching conclusion from both ecological and political perspectives is that decommissioning decisions should be made on a case-by-case basis'
Parente et al. (2006)	Offshore decommissioning issues: Deductibility and transferability	'Dealing with the decommissioning of petroleum installations is a relatively new challenge to most producer countries. It is natural to expect that industry's experience in building platforms is much greater than the one of dismantling them. Even if manifold and varied efforts are underway towards establishing international "best practices" standards in this sector, countries still enjoy rather extensive discretionary power as they practice a particular national style in the regulation of decommissioning activities in their state's jurisdiction. The present paper offers a broad panorama of this discussion, concentrating mainly on two controversial aspects. The first one analyses the ex-ante deductibility of decommissioning costs as they constitute an ex-post expense. The second discussion refers to the assignment of decommissioning responsibility in the case of transfer of exploration and production rights to new lessees during the project's life. Finally, the paper applies concepts commonly used in project financing as well as structures generally used in organizing pension funds to develop insights into these discussions'
Ekins et al. (2006)	Decommissioning of offshore oil and gas facilities: A comparative assessment of different scenarios.	'A material and energy flow analysis, with corresponding financial flows, was carried out for different decommissioning scenarios for the different elements of an offshore oil and gas structure. A comparative assessment was made of the non-financial (especially environmental) outcomes of the different scenarios, with the reference scenario being to leave all structures in situ, while other scenarios envisaged leaving them on the seabed or removing them to shore for recycling and disposal. The costs of each scenario, when compared with the reference scenario, give an implicit valuation of the non-financial outcomes (e.g., environmental improvements), should that scenario be adopted by society. The paper concludes that it is not clear that the removal of the topsides and jackets of large steel structures to shore, as currently required by regulations, is environmentally justified; that concrete structures should certainly be left in place; and that leaving footings, cuttings and pipelines in place, with subsequent monitoring, would also be justified unless very large values were placed by society on a clear seabed and trawling access'
Zawawi et al. (2012)	Decommissioning of offshore platforms: A sustainable framework.	'The decommissioning activities for fixed offshore platforms in Malaysia are expected to rise significantly. For many of the approximate 300 oil platforms, their service life is approaching the end. Thus far, only a handful of offshore platforms in Malaysian waters have been decommissioned mainly due to lack of regulatory framework and weak decommissioning plans. The shortage of decommissioning yards provides another major challenge in managing onshore disposal. With a number of options viable in decommissioning our used platforms, a review of these possibilities is timely. The scope of this paper entails the decommissioning methods particularly in the Gulf of Mexico, where conditions are similar to Malaysian waters. Evaluations of methodology as well as sustainability implications are discussed. The usual methods of decommissioning involve any of these options: complete removal, partial removal, reefing or re-using. Employing the aspects of sustainability as a pillar of the study, a conceptual framework of a viable decommissioning scheme is drawn. It was conceptually found that refurbishing the whole of the structure as a livable hub has its own unique potentials. Given the calm conditions of Malaysian waters and the sturdy design of the platforms, the restored structures hold possibilities either as ocean townships or futuristic cities such as a 'sea-stead'. This novel idea of decommissioning is presented and further discussed in the paper'
Fowler et al. (2014)	A multi-criteria decision approach to decommissioning of	'Thousands of the world's offshore oil and gas structures are approaching obsolescence and will require decommissioning within the next decade. Many nations have blanket regulations requiring obsolete structures to be removed, yet this option is unlikely to yield optimal environmental, societal and eco-nomic outcomes in all situations. We

(Continues)

TABLE A3. (Continued)

References	Focus	Main empirical evidence
	offshore oil and gas infrastructure	propose that nations adopt a flexible approach that allows decommissioning options to be selected from the full range of alternatives (including 'rigs-to-reefs 'options) on a case-by-case basis. We outline a method of multi-criteria decision analysis (Multi-criteria Approval, MA) for evaluating and comparing alternative decommissioning options across key selection criteria, including environmental, financial, socioeconomic, and health and safety considerations'
Henrion et al. (2015)	A multi-attribute decision analysis for decommissioning offshore oil and gas platforms.	'The 27 oil and gas platforms off the coast of southern California are reaching the end of their economic lives. Because their decommissioning involves large costs and potential environmental impacts, this became an issue of public controversy. As part of a larger policy analysis conducted for the State of California, we implemented a decision analysis as a software tool (PLATFORM) to clarify and evaluate decision strategies against a comprehensive set of objectives. Key options selected for in-depth analysis are complete platform removal and partial removal to 85 feet below the water line, with the remaining structure converted in place to an artificial reef to preserve the rich ecosystems supported by the platform's support structure. PLATFORM was instrumental in structuring and performing key analyses of the impacts of each option (e.g., on costs, fishery production, air emissions) and dramatically improved the team's productivity. Sensitivity analysis found that disagreement about preferences, especially about the relative importance of strict compliance with lease agreements, has much greater effects on the preferred option than does uncertainty about specific outcomes, such as decommissioning costs. It found a near-consensus of stakeholders in support of partial removal and "rigs-to-reefs" program'.
Kruse et al. (2015)	Considerations in evaluating potential socioeconomic impacts of offshore platform decommissioning in California.	'The 27 oil and gas platforms offshore southern California will eventually reach the end of their useful lifetimes (estimated between 2015 and 2030) and will be decommissioned. Current state and federal laws and regulations allow for alternative uses in lieu of the complete removal required in existing leases. Any decommissioning pathway will create a complex mix of costs, benefits, opportunities, and constraints for multiple user groups. To assist the California Natural Resources Agency in understanding these issues, we evaluated the potential socioeconomic impacts of the 2 most likely options: complete removal and partial removal of the structure to 85 feet below the waterline with the remaining structure left in place as an artificial reef generally defined as a manmade structure with some properties that mimic a natural reef. We estimated impacts on commercial fishing, commercial shipping, recreational fishing, no consumptive boating, and no consumptive SCUBA diving. Available data supported quantitative estimates for some impacts, semiquantitative estimates for others, and only qualitative approximations of the direction of impact for still others. Even qualitative estimates of the direction of impacts and of user groups' likely preferred options have been useful to the public and decision makers and provided valuable input to the project's integrative decision model. Uncertainty surrounds even qualitative estimates of the likely direction of impact where interactions between multiple impacts could occur or where user groups include subsets that would experience the same option differently. In addition, we were unable to quantify effects on ecosystem value and on the larger regional ecosystem, because of data gaps on the population sizes and dynamics of key species and the uncertainty surrounding the contribution of platforms to available hard substrate and related natural populations offshore southern California'
Brigitte et al. (2018)	Decommissioning of offshore oil and gas structures–Environmental opportunities and challenges.	'Thousands of offshore oil and gas structures are approaching the end of their operating life globally, yet our understanding of the environmental effects of different decommissioning strategies is incomplete. Past focus on a narrow set of criteria has limited evaluation of decommissioning effects, restricting decommissioning options in most regions. We broadly review the environmental effects of decommissioning, analyses case studies, and outline analytical approaches that can advance our understanding of ecological dynamics on oil and gas structures. We find that ecosystem functions and services increase with the age of the structure and vary with geographical setting, such that decommissioning decisions need to take an ecosystem approach that considers their broader habitat and biodiversity values. Alignment of decommissioning assessment priorities among regulators and how they are evaluated, will reduce the likelihood of variable and sub-optimal decommissioning decisions. Ultimately, the range of allowable decommissioning options must be expanded to optimize the environmental outcomes of decommissioning across the broad range of ecosystems in which platforms are located'

TABLE A3. (Continued)

References	Focus	Main empirical evidence
Bull and Love (2019)	Worldwide oil and gas platform decommissioning: A review of practices and reefing options	'Consideration of whether to completely remove an oil and gas production platform from the seafloor or to leave the submerged jacket as a reef is an imminent decision for California, as a number of offshore platforms in both state and federal waters are in the early stages of decommissioning. Laws require that a platform at the end of its production life be totally removed unless the submerged jacket section continues as a reef under state sponsorship. Consideration of the eventual fate of the populations of fishes and invertebrates beneath platforms has led to global reefing of the jacket portion of platforms instead of removal at the time of decommissioning. The construction and use of artificial reefs are centuries old and global in nature using a great variety of materials. The history that led to the reefing option for platforms begins in the mid-20th century in an effort for general artificial reefs to provide both fishing opportunities and increase fisheries production for a burgeoning U.S. population. The trend towars reefing platforms at end of their lives followed after the oil and gas industry installed thousands of standing platforms in the Gulf of Mexico where they had become popular fishing destinations. The National Fishing Enhancement Act and subsequent National Artificial Reef Plan laid the foundation for Rig-to-Reefs. Reefing platforms in the Gulf of Mexico is a well-established practice that is also applied globally. Deliberation of reefing decommissioned platforms and many years of scientific study beneath California platforms has culminated in a California State law that now allows consideration of the concept. This paper summarizes the history, practices, published science, and available information involved when considering the reefing option. It is hoped that this material will inform the public, policy makers, and regulators about their upcoming decisions'
Akinyemi et al. (2020)	Data integration for offshore decommissioning waste management.	'One-way of mitigating decommissioning costs is through the sales and reuse of decommissioned items. To achieve this effectively, reliability assessment of decommissioned items is required. Such an assessment relies on data collected on the various items over the lifecycle of an engineering asset. (…) this research developed a data integration framework that makes use of Semantic Web technologies and ISO 15926 - a standard for process plant data integration - for rapid assessment of decommissioned items. The proposed solution helps in determining the reuse potential of decommissioned items, which can save on cost and benefit the environment'
Invernizzi et al. (2020)	Developing policies for the end-of-life of energy infrastructure: Coming to terms with the challenges of decommissioning.	'Here, we introduce the magnitude and variety of these challenges to raise awareness and stimulate debate on the development of reasonable policies for current and future decommissioning projects. Focusing on power plants, the paper provides the foundations for the interdisciplinary thinking required to deliver an integrated decommissioning policy that incorporates circular economy principles to maximise value throughout the lifecycle of energy infrastructures. We conclude by suggesting new research paths that will promote more sustainable management of energy infrastructures at the end of their life'.

Source: Our elaboration.