



Defining green innovation, its impact, and cycle – A literature analysis

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ABSTRACT

Organizations all over the globe are starting to address environmental-related matters with special emphasis. Several authors believe that for organizations to improve their corporate performance and remain competitive they must minimize pollution and use resources more efficiently. To achieve the previous, green innovations (GIs) ought to be implemented. A lot of knowledge about GIs and everything they entail has been generated over the years. Nevertheless, it is all scattered. There is no consensus among authors and three main concepts (green innovation, sustainable innovation, and eco-friendly innovation) are used interchangeably. Moreover, the advantages of GIs are dispersed within the vast world of information and oftentimes can only be found within articles or books concerning certain specific domains. Likewise, current means for implementing GIs seem to be a completely different topic and unrelated to GIs, as it is hard to find data concerning these in relevant articles. This article is a mere literature review aiming to summarize a topic of a great magnitude such as green innovations and to show what they are, what moves organizations towards them, how can they be achieved, what is being done both in the EU and Finland in that regard, and to and propose a framework to better understand green innovations.

1. Introduction

1.1. Study background and gaps

The world has turned into a rapidly changing place, and so has the business and corporate landscape. During the past few decades, production and consumption patterns have dramatically changed (Kneipp et al., 2019), causing, among other problems, climate change, over-exploitation of natural resources, and loss of biodiversity to the extent that our own life on the planet has been compromised (Panayotou, 2000; Elimam, 2017; Li et al., 2019). Since the aforementioned issues put pressure not only on the environment itself but also on firms' economic and overall performance, organizations all over the globe are starting to address these matters with special emphasis (Tseng et al., 2013; Eikelboom et al., 2018). After the Kyoto Protocol, an agreement to construct a new climate change regime, which expired in 2020 was adopted at the Paris Agreement on Climate Change, held in December 2015. After 2020, a new climate change system was implemented, and countries that were a part of it are facing urgent and crucial challenges in

resolving environmental issues (Roh et al., 2022; Reyes-García et al., 2023). While other initiatives have been made to lower greenhouse gas emissions, the average automobile greenhouse gas legislation, which caps the average greenhouse gas of all vehicles sold by each automaker, has proven to be the most successful (Yang and Roh, 2019; Liu et al., 2023).

According to Soewarno et al. (2019), organizations have an increasing interest in managing resources efficiently and reducing all kinds of harmful emissions into the environment. Moreover, governmental institutions are working on making stricter regulations and laws, to reduce and prevent environmental damage (Soewarno et al., 2019). Additionally, environmental concerns have reshaped consumers' lifestyles. Even though there still are some environmentally unaware people (Afonso et al., 2018), Dyck and Silvestre (2018) claim that societies, in general, are now more conscious about the issues that surround them. This leads to an increase in the adoption of more sustainable behaviors, that will, in turn, help them face the present, and prevent future, social and environmental crises. One popular example is that of consumers being willing to pay premium fares for products that have been

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produced with a minimum impact on the environment (Fraj et al., 2013; Fargnoli et al., 2014; Pekovic et al., 2016; de Jesus et al., 2018). Altogether, current environmental constraints, demands from consumers, and stricter legislation ought to be considered as opportunities by organizations. Nowadays, to improve their corporate performance and remain competitive in the market, organizations must undertake urgent changes in the way they operate so that pollution is minimized and more efficient use of resources is achieved (Khalili and Duecker, 2013; Bolis et al., 2017; Mubarak et al., 2021). These changes are expected to gradually decrease firms' negative impacts resulting from their operations (Kneipp et al., 2019; Soewarno et al., 2019).

Several authors believe a crucial step, and perhaps the first to be taken to trigger the above-mentioned changes, is to implement innovations, as they are strongly connected with competitiveness and business performance (Kneipp et al., 2019; Soewarno et al., 2019; Sztowski, 2021). As early as Schumpeter (1934), innovation is considered to provide organizations with higher chances to achieve a competitive advantage, and thus prevail. Gunday et al. (2011) suggest that the importance organizations associate with innovations influences their expansion potential. Since organizations are facing growth limits due to environmental constraints, practices related to green innovation require immediate attention (Handfield et al., 2005; Sharfman et al., 2009; Schaltegger et al., 2016). Such green innovations are now on the agendas of organizations, policymakers, researchers, and consumers, thereby being considered the means to take care of our current and future needs while dealing with social, economic, and environmental issues (Lin et al., 2014; de Medeiros et al., 2014; Franceschini et al., 2016; Li et al., 2019; Tang et al., 2020; Mubarak et al., 2021; Sztowski, 2021; Kneipp et al., 2021).

The concept of green innovation has seen a shift in the priorities of many firms from "How do we produce products efficiently?" to "How do we develop more eco-friendly materials or reduce the generation of pollutants in the production process?" (Ma et al., 2018). The demands of society have grown as producers are seen as contributing to the improvement of the natural environment or quality of life in society. Manufacturers have started to see themselves as an entity that faithfully fulfils the needs of society. Manufacturing businesses have different opinions about green innovation, but the action needed to align with important economic, environmental, and social goals has emerged as a major worry. This study aims to analyze the connection between green innovation, which promotes innovation jointly, and these green breakthroughs in order to better reflect them in the good's manufacturing procedure. Due to the costs associated with green innovation and the uncertainty surrounding whether expertise and equipment can be acquired through green innovation and linked to actual company efficiency, numerous businesses questioned the efficiency of green innovation and ignored it as an unneeded expenditure (Rodrigues and Franco, 2023). Thus, if all businesses that must execute green innovation are burdened with the costs and cost-benefit implications of doing so, they ought to work together more to ensure that sustainable development is feasible (Roh et al., 2021).

Although large companies are considering green innovation nowadays due to environmental policies and strategies, however, it is not widely adopted by small and medium-sized enterprises (SMEs). There have been few empirical studies concentrating on the importance of green innovation in SMEs, and understanding how to decrease the time, cost, and hazards of producing green innovation (Bai et al., 2019; Polas et al., 2021; Yi et al., 2021; Rodrigues and Franco, 2023), but those are not enough to generalize the green innovation in SMEs sector. Most of the studies on green innovation in SMEs are done through qualitative study rather than quantitatively such as analyzing the implementation costs and associated risks. SMEs may view green innovation as an unnecessary expense or even believe that it will impede their early development and growth. However, it is essential for SMEs to be actively involved in green innovation that is anticipated to reduce production waste while enhancing productivity, corporate reputation, and

corporate competitiveness under a strong international watchdog like public environmental awareness and a carbon tax.

1.2. Study objectives and research questions

Based on the study gaps, this study elaborated several study objectives to promote green innovation in companies which can offer them an invaluable and incomparable resource that helps them build their capacities and provide superior competitive advantages. The study objectives are as follows.

- to identify the most common ways by which green innovations are known and understood;
- to understand how the benefits vary from field to field and to find a link between them;
- to discover what is behind the willingness of firms to implement green innovations; and
- to acknowledge the various means (e.g., initiatives and policies) that help global SMEs to achieve a successful implementation of GIs in organizations.

To address the identified study objectives, this study also formulates three research questions (RQs), which can be stated as follows.

RQ 1. How to promote green innovation in organizations through integrating its concepts, benefits, and driving forces into one?

RQ 2. What are the available ways to foster green innovation in organizations?

RQ 3. What are the policies and initiatives required to adopt green innovation in organizations?

The rest of the article is organized as follows: Section 2 provides the literature review concerning green innovations and offers a background for the paper as well as arguments as to how the implementation of more environmentally friendly practices is an urgent matter. Moreover, researchers' most-used concepts are described and common grounds for this specific paper are established along with the motivations that take organizations towards green innovations. Section 3 outlines the methodology adopted for this study, while Section 4 explains the necessary tools and mechanisms that enable green innovations to happen. Section 5 displays, as examples, popular policies, initiatives and programs being undertaken both at a European Union level and at Finland's national level to foster green innovations. Section 6 infers relationships between the previous chapters and proposes a framework to better understand green innovations and how they are achieved. Section 7 explores the overall study conclusions about the topic and provides valuable hints for further research.

2. Literature review

The amount of research on green innovation (GI) has developed and grown over the past few decades as a result of its numerous and crucial applications, as well as the growth of environmental consciousness and the provision of green products and applications (Takalo and Tooranloo, 2021). Green innovation, a crucial component of sustaining the protection of the environment is crucial for organizations and societies. Studies in this area have primarily seen an upward trend in recent years. Furthermore, pollution is becoming a serious threat to the survival of humans. Many individuals and neighbourhoods have turned to GI as a means of achieving sustainability and economic development (Severo et al., 2017; Kneipp et al., 2019). GI is now a crucial instrument that companies may use to grow their market share and sustain themselves over time. A successful GI enhances the market position, draws clients, offers eco-friendly services, and gains a competitive edge. Due to these advantages, GI is a topic of discussion among researchers and administrators of numerous organizations (Liu et al., 2023).

Given the multiple crises (e.g., environmental, social, food, economic) the global community has been facing for quite some time now, new management models represent an opportunity to overcome current challenges. Environment-focused management, for instance, has been gaining momentum within today's social and corporate environments, and thus organizations are now keener to commit to more sustainable practices (Molina-Azorín et al., 2009; Pane Haden et al., 2009). Several authors have acknowledged the implementation of environmental practices to be a way to contribute to the safeguarding of the natural environment (Gold et al., 2009; Cheng et al., 2014; Severo et al., 2017). Nowadays, organizations are more interested in the sustainable aspects of their operations for they know, that to remain competitive, they have to invest in innovations that include and promote sustainable development (Mariadoss et al., 2011; Kneipp et al., 2019). Such innovations need to add value to services and products while aiming at reducing the environmental impact coming (mainly) from industrial operations (Kneipp et al., 2019).

Green innovation, which is defined as an innovation activity in which a business gathers and applies outside knowledge to facilitate innovation activities or takes knowledge to external markets to earn money, has been suggested to get through these challenges and successfully implement green innovation (Takalo and Tooranloo, 2021). As stated by Kamboj and Rahman (2017), enthusiasm for green and sustainable innovation research have been increasing over the past few decades. The former has led to a better understanding of how societies become more sustainable through the implementation of enhanced social practices and the adoption of new technologies. In today's literature, the concept of sustainable innovation and two more concepts (green innovation and eco-innovation) can be found regarding the types of innovations that mainly aim to prevent negative environmental impact (Roh et al., 2023).

2.1. Concepts of green/eco/sustainable definitions

Green innovation was defined by Kemp and Pontoglio (2007, p. 10) as "a product, production process, service or management or business method that is novel (to the firm that implements it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy) compared to relevant alternatives". Eiadat et al. (2008) said *green innovations* refer to innovations that focus on preventing pollution, reducing waste, and implementing environmental management systems in organizations.

Concerning the concept of *sustainable innovation*, Szekely and Strebel (2013) defined it as the creation of something new (processes, business models, operational practices) which has a positive impact on the three dimensions of sustainable development: social, economic, and environmental. Similarly, Adams et al. (2016), described *sustainable innovation* as a change in products, practices, and processes, and even in values and philosophy, with the ultimate goal of creating value in the social, economic, and environmental dimensions.

In terms of *eco-innovation*, Yayavaram and Chen (2015) defined it as the kind of innovation that brings a firm closer to achieving environmental goals whilst lessening its negative impacts on the environment. On its part, the European Commission (2013) refers to it as "all forms of innovation (technological and non-technological) that create business opportunities and benefit the environment by preventing or reducing their impact, or by optimizing the use of resources".

Although there are minor differences among the three notions, they are often used interchangeably as synonyms in current literature (Leal-Millán et al., 2017). For the previous reason and practical matters, the present paper refers to the concept of green innovation (hereafter GI), as in the end, they all imply organizations' need and willingness to start working with different approaches (e.g., new markets, new technologies, new legislation, and new environmental circumstances) and get rid of "ancient" operational practices (Seebode et al., 2012).

2.2. Driving forces of green innovations

Green innovation possesses distinctive, differentiating characteristics that imply a requirement for specific governance and policy methods to promote them. The drivers of the development and dissemination of green innovation need to be better understood in order for business leadership and public policy to speed up and guide green innovations. The term "driver" in this study means a green innovation stimulus that can be either a motivating factor or a facilitating factor. The scholarly literature on green or eco-innovation drivers is reviewed in this study, along with the distinctive and usual traits of green innovation, and the conceptual basis of each. Few studies offer a thorough literature assessment of the factors that encourage green innovation (Hojnik and Ruzzier, 2016; Gast et al. (2017); Chen and Liang, 2023).

Lee et al. (2018) acknowledged societal expectations; Singh et al. (2020) stated organizational capabilities; Francoeur et al. (2017) highlighted executive compensation; Leonidou et al. (2017) indicated the firm's capabilities and resources as the drivers for green innovation. Moreover, Bossle et al. (2016) mentioned market pull; Chen (2008) articulated customer demand; Cuerva et al. (2014) indicated technological resources and capabilities, product differentiation and public subsidies; Galbreath (2019) underlined assimilation potential, female leadership, and export intensity; and DeBoer et al. (2017) identified green competitors as the green innovation drivers. Hart (1995) forecasted that sustainable development would be the model to follow in the business environment and suggested that a firm's competitive advantage is based on the firm's relationship with the natural environment. Now, more than ever, the previous statements can be said to be true, as Boons (2011) affirms that the concept of GI is heavily related to more extensive concepts such as sustainable development, which refers to "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987).

2.3. Benefits of green innovations

Adoption of the concept and mindset towards green innovation contributed to a competitive advantage for firms. This study contributed to the firm's understanding of the proper value and positioning of green innovation. To meet the need for protecting the environment, green innovation is employed to improve sustainability management efficiency. To offset the environmental expenses, firms can use green innovation to boost resource productivity. Additionally, businesses that forge ahead in emerging markets will benefit from "first mover advantages," which let them command higher prices for eco-friendly goods, enhance their brand image, market their eco-friendly products and services, and even open up new markets (DeBoer et al., 2017; Kneipp et al., 2019; Mubarak et al., 2021). It has long been said that GI brings sustainable and positive advantage to organizations which will, in turn, help them remain strongly in the market (Hurley and Hult, 1998; Lawson and Samson, 2001; Aragón-Correa and Sharma, 2003; Tomomi, 2010; Wu, 2013; de Medeiros et al., 2014; Dong et al., 2014; Kneipp et al., 2019; Lo and Shiah, 2016; Soewarno et al., 2019; Chesbrough, 2020; Hermundsdottir and Aspelund, 2021). However, several other benefits that organizations obtained from the adoption of GI have been recognized. Table 2 depicts some of them that were extracted from existing literature.

Although the benefits are many, they are not expected to be observed immediately after GI is implemented in an organization (Lee and Min, 2015). In fact, according to Kneipp et al. (2019), they are to be seen in the long term, and only if organizations bear the required conditions to properly implement them. In the same vein, it is important to mention that the process of achieving the above-mentioned benefits is not linear (implicating failures, going back to initial stages, recycling and discarding ideas), and it requires a sequence of many innovations over time and not only the implementation of a particular one (Calantone et al., 2003; Tidd, 2006). Nowadays, the adoption of GI strategy supports firms

Table 1
Driving forces of Green Innovation.

Driving forces	Source
Organizational capabilities	Singh et al. (2020)
Technology push	
Market pull	Bossle et al. (2016)
Customer demand	Chen (2008)
Technological resources and capabilities	Cuerva et al. (2014)
Product differentiation	
Public subsidies	
Societal expectations	Lee et al. (2018)
Executive compensation	Francœur et al. (2017)
Firm's resources and capabilities	Leonidou et al. (2017)
Assimilation potential	Galbreath (2019)
Female leadership	
Export intensity	
Green competitors	DeBoer et al. (2017)
Policies and legislation	Gast et al. (2017)
Personal values and ideas	

Table 2
Benefits of green innovation.

Benefit	Source
Competitive advantage	Hurley and Hult (1998); Lawson and Samson (2001); Aragón-Correa and Sharma (2003); Tomomi (2010); Wu (2013); de Medeiros et al. (2014); Dong et al. (2014);
Energy saving	Kneipp et al. (2019); Lo and Shiah (2016);
Corporate environmental mgmt.	Soewarno et al. (2019); Chesbrough (2020);
Development of intra- and inter-recycling policies	Hermundsdottir and Aspelund (2021)
Pollution reduction	
Digitalization capability	Lee and Roh (2023b)
Enhanced marketing diffusion	Hilary (2000); Nidumolu et al. (2013)
Lower operational costs	European Commission (2013); Nidumolu et al. (2013); Mubarak et al. (2021)
Development of new markets	Aragón-Correa and Sharma (2003); European Commission (2013); de Jesus et al. (2018)
Reduction of harmful emissions	Mubarak et al. (2021)
Green design and product development	Shrivastava (1995); Zhu et al. (2012); Fargnoli et al. (2014); Kneipp et al. (2019)
Increased market share and higher sales	Cheng et al. (2014)
Lower retention of earnings and higher return on assets	Przychodzen and Przychodzen (2015)
Boosted corporate image	Aragón-Correa and Sharma (2003); Chen (2008); European Commission (2013); Chang and Chen (2013)
Carbon footprint reduction	Kumar (2020)
Use of greener energy sources	
Better packaging methods	Shrivastava (1995)
Higher profit margins	(Hilary, 2000); Sood and Tellis (2009); Doran and Ryan (2012); Cheng et al. (2014)

to invest in environmental preservation efforts, which is also fit for either social obligation or being compelled to. Firms all around the world faced hurdles as a result of the trend towards severe international environmental protection regulations and agreements as well as the increase of consumer environmentalism. Businesses can invest towards green products and processes that enable them to request larger revenues and to enhance their corporate image in addition to increasing resource productivity through green innovation (Singh et al., 2020; Hermundsdottir and Aspelund, 2021).

2.4. Barriers to green innovations

Although, we always discuss the benefits or opportunities of green innovation initiatives there are many barriers too. Some of the barriers can be outlined too as follows (Abdullah et al., 2016; Gupta and Barua, 2018; Chien et al., 2021; Huang et al., 2022).

- (i) Urgency lack: Due to the risk that long-term projects pose to immediate revenue, numerous enterprises perceive an overall absence of eagerness.
- (ii) Neglecting 99%: Some companies make the mistake of concentrating on improving the 1% of the ecological footprint of their goods while ignoring the remaining 99%. The organization's reputation could be harmed by this.
- (iii) Afraid of losing control: For a business to successfully collaborate, it must also get over its fear of sacrificing authority over its business. In a perfect partnership, both parties seek out terms that are advantageous to both.
- (iv) Insufficient revenue: Because the costs associated with enforcing environmental laws are so expensive, some businesses might not generate sufficient funds to move to green innovation.
- (v) Afraid of failure: To avoid the embarrassment of admitting that their efforts were not successful, many companies are reluctant to examine present practices.

3. Study methodology

This study adopted an in-depth review of existing literature in the field of green innovation. It analyses various published articles related to green and sustainable innovation. Different prestigious databases such as Scopus, Science Direct; Springer; Wiley; Web of Science; Scopus; JSTOR; and Scholar Google. In addition to published articles, we also considered various published books, book chapters, reports, conference proceedings, working publications and web content related to green and environmentally friendly innovations. From such published content, it was possible to better see what comes before and after green innovations and frame them as a never-ending cycle.

In this literature survey, we used various keywords such as 'green innovation', 'eco-innovation', 'sustainable innovation', 'environment-friendly innovation', etc., which are commonly found in the literature. Such keywords, help to collect a wide range of study contents as used for study and analysis. Additionally, other keywords such as 'driving forces of green innovation', 'means of green innovation', and 'benefits of green innovation', are used to collect and study the relevant literature associated with green and sustainable innovation.

The use of the keyword 'Driving forces of green innovation', extracts relevant information that motives why entities would think of innovating in a green manner. Then comes the 'Means of green innovation', which collects necessary information to build the mechanisms that allow an entity to work toward green innovations. The last keyword 'Benefits of green innovation', which also makes available various relevant information about green innovation which can be used to motivate organizations to move towards green innovation practices.

From the literature survey, it is noticed that current literature has vast information as to what green innovations are, what their benefits are, and what it takes to reach them. However, it seems to be scattered. The paper at hand represents an overview of green innovations, hence a compilation of the most relevant aspects of them: concepts, motives to seek them, enablers, and benefits. The review of several journals and papers has afforded the authors the possibility to write the present article and develop the idea of a Green Innovation Cycle.

4. Means to achieve green innovations

A wide range of means to put GIs into action in organizations has been identified, three of the most mentioned by researchers: workforce empowerment, digitalization through adopting digital tools, and collaboration with outside partners (Lee and Roh, 2023a). Eikelboom et al. (2018) affirm that for organizations to successfully implement GIs, they must capacitate their employees and give them the freedom to experiment with green initiatives. Through the latter, employees will notice the environmental efforts the organizations are undertaking, which will ultimately have an impact on their willingness to be part of

such organizations. Veleva et al. (2017) found that it has become significantly complicated for low environmentally-conscious firms to hire and maintain staff, thus turning employee engagement into a crucial means to becoming green. In the same context, managers are urged to acknowledge current and potential environmental issues. By making GI a top priority and by developing environmental incentive campaigns amongst employees, greener processes and products will be achieved (Huang and Li, 2018) and a green identity will be built, making sustainability a task for all members of the organization (Soewarno et al., 2019).

Implementing GIs is not an easy thing to do (Horbach et al., 2012). Organizations cannot achieve GI while acting isolated, thence, they are required to seek new know-how and expertise beyond their boundaries (Hofman and de Bruijn, 2010; Chesbrough, 2020; Mubarak et al., 2021). Throughout the years, several organizations have been reluctant to adopt GIs due to the initial costs they entail and the uncertainty of whether they will improve business performance or not (Mubarak et al., 2021). That is particularly true with SMEs, who are often unable to exclusively depend on their resources to produce knowledge. Thereupon, their option is to collaborate with outside partners and competitors to use each other's know-how, resources, and expertise with the mere goal of boosting general GI knowledge and capabilities (Chesbrough, 2006; Georgiou and Clarysse, 2006; de Marchi, 2012; de Marchi and Grandinetti, 2013; Tang et al., 2020). Moreover, Najafi-Tavani et al. (2018) highlighted the importance of collaborating with research institutions to improve product and process design competencies.

Co-creating, sharing, and transferring knowledge is key to accomplishing GI (Ghisetti et al., 2015). For that, a diverse array of GI actors should be included in the GI process (Behnam et al., 2018). Special emphasis was put by Kim et al. (2016) on organizations that have actively and successfully implemented GI practices, as they should find ways to disseminate inter- and intra-organizational environmental management knowledge, with the ultimate goal of achieving sustainable development. Harnessing digital technologies' full potential will demand the interrelation between various fields (biotechnology, mathematics, nanotechnology, computer science, manufacturing, engineering, social sciences, and others) (TWI - The World in 2050 Initiative, 2019). Moreover, it must be said that the business world can no longer be conceived without the interaction between machines and humans. Henceforth, digital tools and mechanisms, also referred to as "Industry 4.0 technologies" by Mubarak et al. (2021), are needed. Such technologies include but are not limited to, Big data, Cyber-Physical Systems (CPS), Blockchain, and Internet of Things (IoT).

Big data is useful, for instance, to choose investors, suppliers, and partners. Overall, this digital tool has the potential to enhance the quality of life in society and to indirectly take care of the environment (Atzori et al., 2010; Khaitan and McCalley, 2015; Alcácer and Cruz-Machado, 2019; Mahmood and Mubarak, 2020). The use of CPS and IoT eases communication processes between cyber and physical elements of a network (Atzori et al., 2010; Khaitan and McCalley, 2015). The former facilitates collaboration and cooperation among partners in networks where data sharing is an essential activity, while the latter is used to store, transfer and deploy information without the need for human controls. In its turn, blockchain can be blended with CPS, IoT, and robotics and become quite an intricate but useful tool to boost the quality of GIs (Mubarak et al., 2020). With blockchain, organizations can promote their co-creating networks and safely share important and confidential information (Mubarak et al., 2021).

Many more digital tools have been identified as pivotal when transitioning to a more sustainable and circular economy. For instance, Deloitte (2022) highlights the following in their "recipe for a circular economy transformation": smart mobility, cloud services, social platforms, 3D printing, artificial intelligence, augmented and virtual reality, e-commerce platforms, machine learning, and predictive analytics. These technologies can support firms in their quest to reach the GI

benefits stated in the previous section. Bag et al. (2018) and Piyathanavong (2019) claimed that investing in digital technologies is a necessity for firms committed to GI and is no longer an option. Furthermore, Kumar (2020) assured that an increase in digital practice among organizations will bring sustainable growth for all.

5. European policies and initiatives for green innovation

The European Union has made it clear time and time once more that it wants to lead the world in combating climate change. The EU is actively involved in global climate discussions and has implemented policies to lower the production of greenhouse gases and promote the use of renewable energy sources. The EU hasn't done enough to address production in some industries, though, and hasn't been able to effectively cut its greenhouse gas emissions. Ursula von der Leyen, who is the president-designate of the European Commission, has pledged to enhance and expand EU climate policy (von der Leyen and Ursula, 2019). With her proposed European Climate Law, the EU would have achieved carbon neutrality by 2050, probably becoming the first region to accomplish so. A broad policy foundation that addresses the energy, ecological, contemporary, economic, social, and environmental components of this extraordinary process is necessary to achieve this challenging aim. Von der Leyen has proposed the European Green Plan in a nutshell, outlining roughly twenty different ideas.

According to von der Leyen and Ursula (2019), these include raising the EU's 2030 decrease in emissions focus from 40% to 55%, enacting a carbon border tax, creating an environmentally friendly Europe Funding Plan, partially converting the European Investment Bank (EIB) to a climate bank, expanding the EU emissions trading system (ETS), and creating a novel industrial strategy for the European continent. Therefore, the European Green initiatives still needs to be constructed even though it has certain broad characteristics. By providing a workable strategy centered on what may be viewed as the European Green initiatives four fundamental pillars—carbon pricing, sustainable investment, industrial policy, and a just transition—this policy contribution aims to aid in the formulation of the policy. The decarbonization of industry will be centered on innovation, which is the driving force behind it. In order to attain climate neutrality and spearhead worldwide decarbonization from an industrial perspective, Europe needs to transform into a global hub for clean energy, sustainable mobility, and intelligent building technology. Europe needs to make greater and more investments in R&D in order to achieve this. Some of the initiatives at European level are discussed in the following sub-sections that support to become EU an environmentally friendly region in the globe.

5.1. Green initiatives at the European Union level

Since the beginning of the 21st century, green innovations have been widely studied (Rennings, 2000; Managi, 2015; Crespi et al., 2016). In the European Union, it has been the Eco-Innovation Observatory (EIO) has monitored and studied the matter in question since 2009 (Bahn-Walkowiak et al., 2020). Those studies and observations have substantially contributed to the fact of environmental sciences, economics, and management are now linked and aligned to one another (Crespi et al., 2016).

Green innovations started to play an important role in policy creation about a decade ago, in an attempt of policymakers to bring together environmental, social, and economic visions. In terms of the Sustainable Development Goals (SDGs) and according (Kanie and Managi, 2014), GI is decisive in achieving seventeen of them. In Europe, GIs are considered a crucial factor to strengthen and enable the development of technologies, business models, and institutional structures (EEA, 2014; Bahn-Walkowiak et al., 2020). Such has been the importance given to green innovations in the European Union that they have taken serious actions to face the current environmental issues to reach a sustainable society. An example of that is the European Green Deal, which has some other

initiatives and programs supporting it, namely the New Circular Economy Action Plan, the Biodiversity Strategy for 2030, the Zero Pollution Action Plan, and the Digital Europe Programme.

5.2. European Green Deal

Released by the European Commission in 2019, the European Green Deal has the visionary goal of making the EU a resource-efficient, modern, and competitive economy (European Commission, 2019) while making sure the net emissions of greenhouse gases are brought to zero by 2050, the economic growth is decoupled from resource use and that no place or person is left behind. As presented on the initiative's webpage, the European Green Deal has the objective of providing citizens with.

Fresh air, clean water, healthy soil, and biodiversity
Renovated, energy-efficient buildings
Healthy and affordable food
More public transport
Cleaner energy and cutting-edge clean technological innovation
Longer lasting products that can be repaired, recycled, and re-used
Future-proof jobs and skills training for the transition
Globally competitive and resilient industry

In the context of the European Green Deal, Bahn-Walkowiak et al. (2020) identified a series of technologies that ought to be targeted to reach the aforementioned objectives. These technologies are digitalized energy markets, smart grids, disaster prediction, electronic product passports, smart traffic management systems, climate-proofing of building stock, cloud and edge computing, distance monitoring of air, water, and soil pollution, artificial intelligence, and digitalized information on food (e.g., nutritional value, environmental footprint).

5.3. New circular economy action plan

Under the scope of the European Green Deal, the New Circular Economy Action Plan (NCEA) was made public and admitted in early 2020 as a means to aid the EU's objective of becoming climate-neutral by 2050 (European Commission, 2020a). The NCEA introduces several measures to achieve the following objectives.

Ensure waste reduction and prevention
Focus on sectors where circularity potential is high (ICT and electronics, vehicles and batteries, textiles, plastics, building and construction, water, food)
Promote development of sustainable products as a norm
Empower consumers and public buyers
Lead global transition to a circular economy

Bahn-Walkowiak et al. (2020) appointed some technologies to reach the NCEA objectives mentioned above. The technologies where the emphasis should be put on our machine learning algorithms, IoT-led services, smart controls "intelligent efficiency", artificial intelligence models, cloud-based technologies, blockchain, fintech, smart data use, data-based new indicators, and metrics.

5.4. Biodiversity strategy for 2030

On its part, the Biodiversity Strategy for 2030, also a building block of the European Green Deal, was announced on May 2020. It focuses on protecting nature and reversing ecosystems degradation and it stresses the importance of developing society's resilience against future threats (European Commission, 2020c).

Food insecurity
Forest fires
Impacts of the climate change
Disease outbreaks

It also aims at protecting and restoring nature by investing in it as a

way to economically heal from the crisis caused by the COVID-19 pandemic. Moreover, it has the ambition to create and maintain the already existing ecosystems for recreational purposes and to closely work with farmers on the adoption of greener practices, for they are of crucial importance to biodiversity preservation. Similar to the previously presented European actions, Bahn-Walkowiak et al. (2020, p. 40) selected a group of technologies that will act as the enablers for accomplishing the goals set by the Biodiversity Strategy for 2030. These technologies are web-based data platforms, digital soil mapping, artificial intelligence, machine learning, space technologies, virtual watersheds, satellite images, smart electronics, sensor technologies, big data analyses, IoT, mobile applications, and blockchain.

5.5. Zero pollution action plan

Eliminating pollution is one of the EU's greatest concerns. As a part of the European Green Deal, the Zero Pollution Action Plan was officially released in May 2021 and it focuses on eliminating water, air, and soil pollution. To achieve that, a set of targets has been defined to be reached by 2030 (European Commission, 2021c).

To improve air quality (reducing by 55% the number of premature deaths caused by air pollution)
To improve water quality (reducing plastic waste at sea by 50%, microplastics into the environment by 30%)
To improve soil quality (reducing the use of chemical pesticides by 50% and reducing nutrient loss)
To reduce residual municipal waste by 50%
To reduce by 30% the number of people chronically disturbed by transport noise
To reduce by 25% the ecosystems in the EU where air pollution represents a threat to biodiversity

It as well contemplates the use of digital interfaces to be achieved, which has been identified by (Bahn-Walkowiak et al., 2020). These are monitoring of waste streams, air quality monitoring, prevention and monitoring of industrial pollution, and prevention and control of hazardous chemicals.

5.6. Digital Europe programme

Presented in February 2020 and accepted in June 2020, the European Commission has launched the Digital Europe Programme (DIGITAL) as a sign of their acknowledgment that digital technologies are of crucial importance in the transition to a green and circular society. It focuses on enabling citizens, businesses, and public administrations with digital technologies (European Commission, 2020b). DIGITAL will strengthen the EU's key digital competencies by providing funding and improving the use and reach of several technologies including artificial technologies, advanced computing, cybersecurity, data infrastructure, governance, and processing, with an emphasis on sectors such as energy, manufacturing, health, agriculture, environment and climate change (European Commission, 2021b).

5.7. Green initiatives at Finland national level

According to the Eco-Innovation Index, developed by the Eco-Innovation Observatory (European Commission, 2021a), Finland has been among the top three scoring countries since 2012. In 2021, Finland was the second-most eco-innovative country in the EU scoring 157, only behind Luxembourg (171). The EU average was 121 (European Commission, 2021a). The rather high positions in terms of eco-innovations obtained by Finland throughout the years are due to the strong support Finland gives to the start-up ecosystem and the large amount of resources invested in R&D. As stated by Bahn-Walkowiak et al. (2020), both R&D and startups have the potential to develop academic publications and patents, thus allowing the country to become innovative and sustainable. The article at hand presents some of the national, regional,

and local efforts undertaken in Finland to develop green innovations, stimulate entrepreneurship and enhance digital skills.

From the more general to the more specific, the Finnish National Agency for Education promotes environmental education and circular economy knowledge from an early age so that they acquire the basis to better understand and address climate issues in the future (Finnish National Agency for Education, 2022). As a part of the Finnish Ministry of Education, Science and Culture there is the Academy of Finland, an expert organization that funds, promotes, and aspires to strengthen high-quality scientific research (Academy of Finland, 2022). Another Finnish government organization is Business Finland, which promotes innovation, funding, trading, and investment (Business Finland, 2022).

Some of the most renowned private initiatives are Edtech Finland, an industry association within the educational and learning technology field aiming to develop the entire industry (Edtech Finland, 2022). There is also Sustainability Leap, an online platform meant to inspire the Finnish society to adopt a more sustainable mindset by saving resources and encouraging them to adopt cleaner and more efficient ways to use energy (Sustainability Leap, 2022). Another example is Sitra, which states on its website that they “collaborate with partners from different sectors to research, trial and implement bold new ideas that shape the future” (Sitra, 2022). On the non-profit spectrum, there is the Green Building Council Finland, an association within the building and construction industry that collects, works with, and adds knowledge to the sustainable development of this specific field. It promotes dialogue and discussion for the betterment of the construction industry policies and encourages the adoption of better methods and practices in the built environment (Green Building Council Finland, 2022). Also, a non-profit organization, Junior Achievement Finland (Nuori Yrittäjyys) is the leading entity in terms of entrepreneurial education in the country. They focus on work-life competencies and financial education among people of young age (Junior Achievement Finland, 2022).

Several EU-funded initiatives are being carried out in certain regions in Finland, a couple of them CIRCWASTE and GreenoVET. On the one hand, the CIRCWASTE project (2016–2023) (Circwaste), taking place in North Karelia, Central Finland, South Karelia, and Southwest Finland, aims at promoting resource efficiency and preventing and managing waste streams in such regions. CIRCWASTE is co-funded by the EU LIFE program. On the other hand, the GreenoVET project (2020–2024), co-funded by the Erasmus+ program (GreenoVET, 2022) is being undertaken in the Vaasa region (and three other regions in Europe). It promotes Vocational Education and Training (VET) Excellence in Green Innovation in Europe while seeking an innovative, inclusive, and sustainable economy. Other regional initiatives are the ones seen in the Turku area, Vaasa area, and Southwest Finland. In Turku, STEAM refers to a knowledge path meant for childhood, basic, and upper secondary education that provides younger generations with a broader understanding of technology and scientific knowledge (City of Turku Education Services, 2022). In Vaasa, something similar has been developed but with an emphasis on energy competencies, as Vaasa is the “energy capital” of the Nordics (Häggström, 2017). The Energy Education path in Vaasa aims to provide individuals, also from an early age, with the necessary skills and knowledge to be prepared for working life within the energy field (Energiapolku, 2022). In Southwest Finland, Environment Now (Ympäristö Nyt) has been developed as the region’s environmental service. It serves as the platform where information is shared and cooperation is sought. Among other topics, they address environmental education, the circular economy, and the current state of the environment in the region (Ympäristö Nyt, 2022).

A lot has been said about Finnish governmental, non-profit, and private organizations and their attempt to develop an innovative, entrepreneurial, and environmental-friendly mindset in young people. Nonetheless, many efforts have also been undertaken by higher education institutions to offer top-notch know-how and methods in terms of sustainability and green innovations. A few examples are the master’s programs in Creative Sustainability by Aalto University (University,

2022a), Smart Energy by the University of Vaasa (University of Vaasa, 2022), Environmental Change and Global Sustainability by the University of Helsinki (University of Helsinki, 2022). Some other major subjects are being offered, namely Energy Technology at Novia University of Applied Sciences (Novia University of Applied Sciences, 2022), Sustainable Global Technologies at Aalto University (Aalto University, 2022), and Energy Technology at ÅboAkademi (2022).

Besides the master’s programs and major subjects offered by many universities, an agreement was reached between 18 higher education institutions in Finland. It was given the name of Climate University and it allows students of the subscribed higher education institutions and everyone interested to study the courses offered at this newly created “university”. Among others, the available courses are related to circularity, climate, leadership for sustainable change, and statistical tools for climate and atmospheric science (Climate University, 2022). From what is being done in Finland, three broad categories of actors can be identified: public institutions, business firms, and academia/universities. That is the widely-known Triple Helix (TH) model for innovation, developed by Leydesdorff and Etzkowitz (1998). Such a model works under the premise of universities (as scientific organizations) dealing with the true/false, firms determining the profit/loss, and the public sector defining the right/wrong (Björk and Johansson, 2017). As explained by Dzisah and Etzkowitz (2008), the TH model underlines the consistent synergy between the three different actor categories. Due to the nature of the helices, the type of ideas, knowledge, and resources they possess may be different, yet the point where they intersect is where the most interesting innovation environments are found (Ranga and Etzkowitz, 2013).

Having said the previous, it is evident that Finland is right on point in terms of green innovation and sustainability. The country’s constant investment in R&D and its energetic approach to promoting a green mindset among society is due respect. No wonder why Finland has been one of the top-three innovative countries in the past 10 years. The above-mentioned policies and initiatives turn out to be nothing compared to the countless number of them there are currently implemented and there will be within the next few years. There is still much to be done, but as said in previous chapters, the road toward green innovations and a sustainable economy is not an easy one and, more often than not, improvements take time to be seen.

6. Green innovation cycle to accelerate green transitions

Needless to be explained in detail once again, due to many reasons our planet is nowadays fighting against unprecedented environmental problems. But it does not have to fight them alone. Organizations (e.g., government-run, private companies, non-profit) and consumers (from both individual and collective approaches) can and should seize the *opportunities* that the not-so-fortunate current situation has created. In light then of the ever-increasing environmental constraints, consumer demands, and stricter regulations, such opportunities come in the form of operational and mindset change. However, to achieve said changes, there is the need for innovations, and more specifically those with a *green* approach (i.e., environmental risk reduction, resource optimization, economic, social, and environmental value creation).

The paper at hand intends to provide the reader with a better understanding of green innovations and what comes before and after them. For that reason, it frames green innovations as a cycle (See Fig. 1). The cycle starts at the top of the box with “Driving Forces”, being these the motives or reasons why an organization or even an individual(s) would think of *greenly* innovating (See Table 1). Driving forces are influenced by intra-, inter-, and extra-organizational factors, which are then translated into the forces stated in the figure. The cycle continues clockwise to the “Means”. These are the ways and methods that allow an organization to work towards green innovations and, if properly harnessed, eventually achieve them. Such means are divided into three categories: workforce engagement, collaboration, and digital tools/

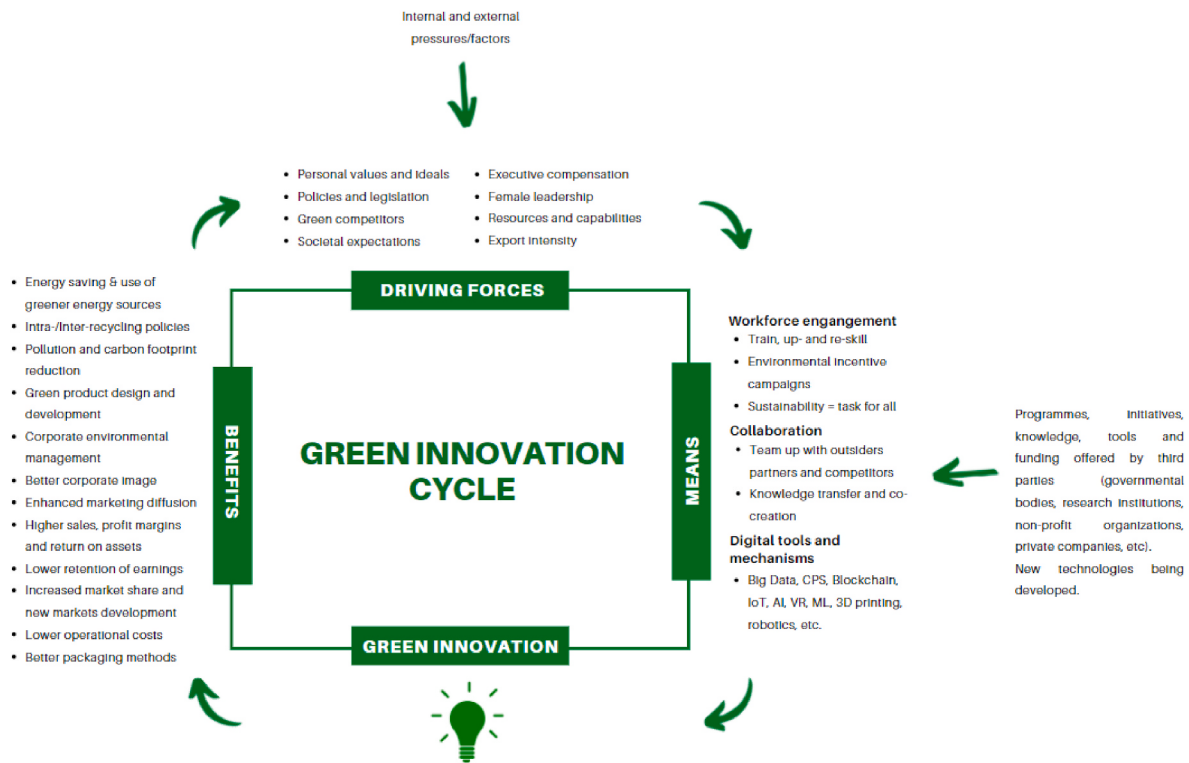


Fig. 1. Green innovation cycle. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

mechanisms, which have been further described earlier in this document. The “Means” have as well an input of their own. This input refers to the efforts (e.g., programs, initiatives, tools, and funding) offered and afforded by third parties namely governmental bodies, academic institutions, and private firms.

The next step of the cycle demands, firstly, the existence of the driving forces, but also the acknowledgment of their existence by the organization in question. Secondly, the appropriation and exploitation of the necessary means to achieve GI. If the previous two conditions are met, the climax of the cycle happens: “Green Innovations” are produced. Here is where all the efforts made see the light. But it is not only about developing the green innovations themselves but adequately initiating and implementing them. As said in the previous section, although benefits generated from innovation require time to appear, they at some point will. And no clearer name for the next step of the cycle than “Benefits”. These benefits are expected to have an impact mainly on the environmental dimension, but also on the economic and social dimensions of organizations.

Besides the specific additional inputs for “Driving Forces” and “Means”, each step of the cycle is feeding the following. The most interesting part of such a cycle is that the process continues after “Benefits”, thus restarting it. The benefits obtained from GI are expected to change (most likely for the better) the current environmental, social, economic, corporate, and operational conditions. After some time, the world’s needs, status, and limitations are different. Therefore, internal and external pressures, ultimately shaping the driving forces, are different as well. The means are subject to change too, as trends, technologies, and co-creation methods update within short periods, and thus the GIs to be obtained when the cycle is iterated will not be the same, nor the benefits will be.

7. Conclusions

7.1. Theoretical contributions

The world is now facing huge environmental, economic, and social crises. The pace at which the planet’s resources are being used is no longer sustainable and therefore there is a need for a change. A need for a change in the way things are done, and the way we humans behave. If we continue to deplete everything that surrounds us, future generations will not have the chance to enjoy everything we have enjoyed so far and that nature provides us. The cause is not lost yet. There is still time to do something about it and heal those “wounds” we have created on Mother earth for it to recover at least to its pre-industrial conditions.

The way to go is green innovation, which has been found to greatly benefit businesses and thus the environment. Green innovations also have the power to transform consumers’ lifestyles and encourage them to adopt more sustainable behaviors, which will as well have a positive impact on the environment. The previous statements can be considered evidence of green innovations reaching the three key areas for development: economic, social, and environmental. There has been a set of reasons why organizations are willing to move towards green innovations. Some of them are societal expectations, executive compensations, organizations’ resources and capabilities, assimilation potential, female leadership, export intensity, and already-green competitors. One thing is wanting to go green, but another thing is what enables you to achieve it. This paper highlights workforce and collaboration with outside partners and more strongly digital tools as the means to implement green innovation in a given organization or system.

7.2. Managerial implications

The current body of literature on green innovation is mixed, albeit frequently pointing to a beneficial relationship between green innovation and company success. Furthermore, management’s potential towards moderating influence on green innovation has not been given

enough thought. This study investigates how management's concern for environmental issues is important to fostering green innovation and how this strategy improves the company's performance in general. It is also noticed from this study that without considering managerial concern for the environment, we find that both green innovation and green mindset cannot significantly (positively) predict business performance. This study merely investigated that in addition to managerial concern, the use of digital tools and technologies have a favorable impact of green innovation on firm performance. The deployment of digital tools to promote green innovation accounts for a sizable amount of distinctive variation in firm performance.

In terms of digital tools, they have been appointed as necessary rather than optional in today's rapidly-changing world. Hence the importance of promoting their use in working environments and also in learning environments preferably from an early age. For green innovations to make a positive impact requires action from policymakers. In this study, the European Union's initiatives to digitally empower people, eradicate pollution and become carbon neutral are discussed, showing the way to a more sustainable Europe. Moreover, Finland's specific efforts to reach sustainable development were briefly described making evident the presence of the Triple Helix Model in the country. The authors propose to see green innovation as a never-ending cycle with four main stages: 1) Driving forces, 2) Means, 3) Green Innovation, and 4) Benefits. Each step represents an input to the next one and after every iteration, forces, means, innovations themselves, and benefits ought to be different because they will change how reality is perceived.

This study is a mere literature review aiming to summarize a topic of a great magnitude such as green innovations and to show what they are, what moves organizations towards them, how can they be achieved, and what is being done both in the EU and Finland in that regard. From a more general perspective, those initiatives that are launched by the EU are aimed to reach all its member states. However, for a future paper, it would be interesting to compare what initiatives and national policies are being implemented in different countries, how well they are being executed, and perhaps find whether own national initiatives are related to the rather low or high scores those countries receive in the Eco-Innovation Index. It is true that the economy as a whole, societal conditions, and environmental issues quickly evolve. But as long as several efforts both from businesses and individuals are being undertaken, hope will not vanish and a healthy environment will wait for us and our future generations.

7.3. Limitations and future study

This study has several limitations, which are worthy to mention within the scope of this research. It also presents some future research directions. The first limitation of this study can be identified as that this is basically an in-depth literature review on green innovation avoiding the practical examples of its deployments in organizations. The second limitation can be stated that this study is considered publications mostly related to green innovation, avoiding the literature from similar kinds of innovations such as eco-innovation, sustainable management and eco-innovation, open innovation for green initiatives, etc. The third limitation can be pointed out that this study focused environmental policies and initiatives in European countries and Finland specifically rather than any other countries in the world.

In future, this study can be extended in the following directions. Firstly, this study can be directed towards the study of various case companies including SMEs and large companies that are practicing green innovation in their companies and their opinions related to opportunities as well as challenges. Additional studies also can be done in the direction of studying the educational institutions to know how prepared they are to practice the green innovation programs in their curriculums. Furthermore, a further study can be interesting to know the awareness and knowledge of green innovation in the company's personnel. Such kind of study can be used as a valuable source to identify

the skills gaps of the employees related to green innovation and further initiatives can be adopted to improve the up skills and reskills the workers.

Declaration of competing interest

There is no conflict of interest to prepare this article.

Data availability

Data will be made available on request.

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