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Technological Innovation in Sweden from a Degrowth Perspective

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Abstract : This research focuses on the relationship between technological innovation and degrowth. The aim is to highlight the importance of degrowth discourse and contribute to a conception of entrepreneurial innovation that could allow for a degrowth society to emerge. It is observed that for a possible transition towards degrowth, entrepreneurial innovations are likely to face barriers; the study also finds that solely degrowth-aligned technologies are not sufficient. For degrowth-aligned innovation economy to be possible, these efforts must be supported by larger societal pivots, involving multiple actors and institutions. The study's contribution is in seeking to advance understandings of innovation from a degrowth-aligned perspective.

Keywords: Degrowth; technological innovation; ecosystem;

Supervisor : Svetlana Gross

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1. INTRODUCTION

The alarm bells about the extent of environmental degradation and looming privation of resources were rung by seminal works such as "The Silent Spring" (Carson, 1962) and "The Limits to Growth" (Meadows et al., 1972). These works placed themselves as oppositional to the economic growth paradigm, in view of this environmental depletion. Whilst they laid out the problem, wishing to "underscore the challenge rather than the difficulty of mapping out the road"(Meadows et al., 1972), the Brundtland Report "Our Common Future", put forth the optimistic concept of sustainable development, "a process of change in which the exploitation of resources, the direction of investment, the orientation of technological development, and institutional change are made consistent with future as well as present needs" and that "technology and social organization can be both managed and improved to make way for a new era of economic growth" (WCED 1987). The 2018 report by the Global Commission on the Economy and Climate - an initiative for a global partnership of research institutes and other institutions, including the World Bank and regional development banks, the International Monetary Fund, International Energy Agency, Organisation for Economic Co-operation and Development, United Nations agencies- stated , "We are on the cusp of a new economic era: one where growth is driven by the interaction between rapid technological innovation, sustainable infrastructure investment, and increased resource productivity. We can have growth that is strong, sustainable, balanced, and inclusive"(NCE, 2018). This is the conception of a solution to environmental degradation that prevails till today, and the importance of technology within this has only grown. The economist Robert Solow, had stated that "Technology has to be the main part of the solution. To the extent that we talk in terms of any moral obligation, it's our obligation as rich countries to find ways for the rest of the world to develop economically with a proper respect for the environment (Solow, 2002).

The European Union often serves as one the players at the helm of sustainability policy-building, and research and innovation are espoused as the key tools for achieving sustainable economic development. Horizon 2020 is the research and innovation agenda and funding scheme of the Union, and posits that by "coupling research and innovation, Horizon 2020 is helping to achieve this with its emphasis on excellent science, industrial leadership and tackling societal challenges" (Kugleta, 2017). This sets the brief for member nations as well, with Sweden positioning "eco-innovation" as a "key component in Sweden's national environmental policy strategy, and the country is in the forefront in developing new technologies in areas like bioenergy, smart grids, green building, waste and recycling, green vehicle technologies, water resource management, ocean energy and solar power Sweden has also shown that it is possible to combine economic growth with a decreased carbon footprint" (van Rooijen et al., 2019).

With these prevailing notions of persistent growth, and the necessity, and inevitability of technological progress and innovation, it is necessary to delve further into them and address the critical, problematic assumptions within them.

1.1 SOCIO-ECONOMIC METABOLISM

Researchers and scientists now posit that human undertakings have altered the Earth on the geo-physical level to a degree that a new geological epoch ought to be defined - the Anthropocene. Human societies cannot be divorced from the environment, and ought to be conceived as "a hybrid of the material or biophysical realm and a symbolic or social realm" (Pauliuk & Hertwich, 2015) . In this context, "socioeconomic metabolism research has gained in prominence in the science and policy communities and has been a "rising conceptual star" in guiding research and policy formulation" (Schandl et al., 2015). Socio-economic metabolism refers to the sum total of the material and energetic flows into, within, and out of a socio-economic system (Fischer-Kowalski & Amann, 2001). Socioeconomic metabolism bridges the social, economic, and biophysical sciences and has value for each of those communities of thought (Schandl et al., 2015). Capturing material flows through economies allows for the visualization of economies as physical as well as financial entities, and also serve as an indicator of the planet's capacity to sustainably assimilate the economy's impact. Material flows into an economy in physical terms are a measure of that economy's dependence on resource extraction, alongside associated environmental impacts. Material flows out of an economy are a measure of the effective loss of useful materials. Various initiatives to assess human activity in this context have materialised, with the notion that with this, humans can recognise and anticipate their negative impacts on the environment, and take measures to mitigate those impacts.

The circular economy is framed as one of the key strategies in transitioning towards a sustainable future. It focuses on regenerating natural environments and recirculating resources for use, instead of generating waste. Given this framing, the Circularity Gap Reporting Initiative aims to assess the progress that has been made on this front. The 2020 Report states that circularity is in reverse, down to 8.6 % from the previously reported 9.1%. They estimate the volume of globally extracted resources per year, which amounted to 92.0 billion tonnes in 2017; these extracted resources were complemented by 8.65 billion tonnes of cycled resources, bringing total material inputs to 100.6 billion tonnes. 32.6 billion tonnes of materials are collected as waste. The majority of this stream, 23.9 billion tonnes, was lost; being landfilled, incinerated, wasted at mining operations or being unregistered waste fractions, that is, 8.6% was cycled. The initiative estimates that a further increase of 8.4% in circularity- a doubling in circularity - is needed for there to be meaningful effects. The report concludes that while countries are not on track to meet their climate goals, the uptake of circular strategies is occurring at a slower pace than is needed (Circularity Gap Reporting Initiative, 2020).

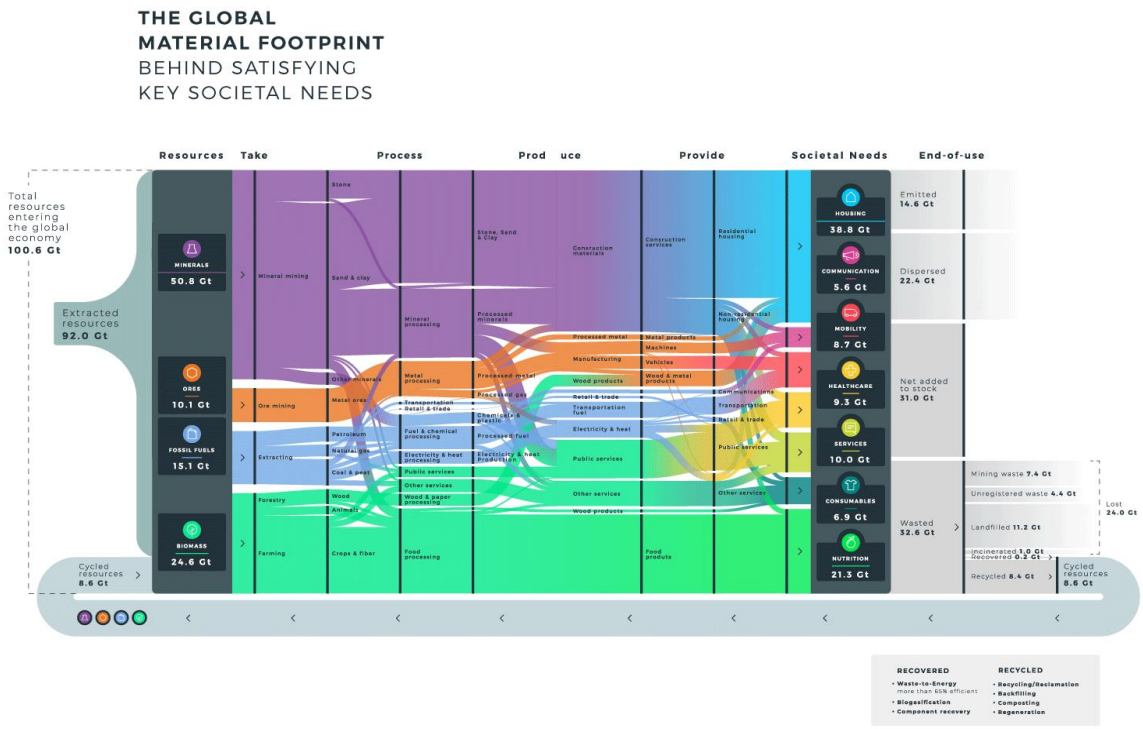
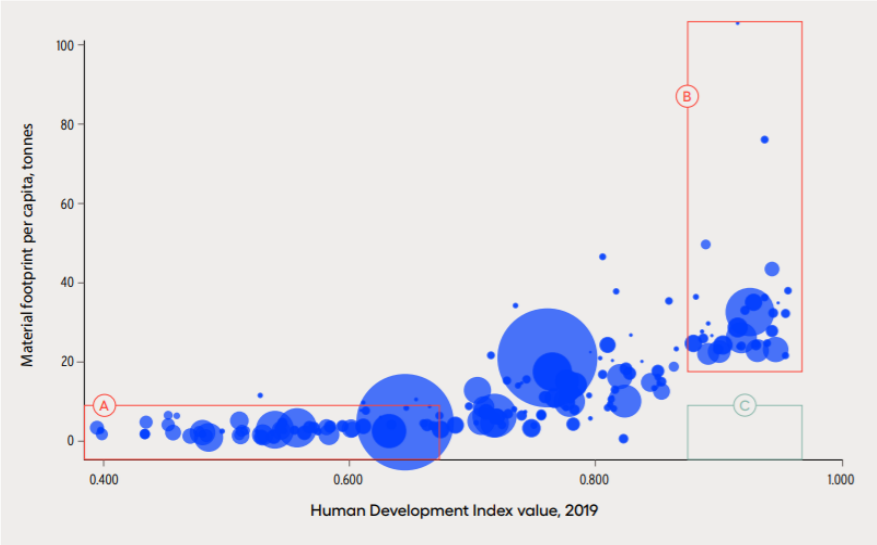


Figure 1. (Circularity Gap Reporting Initiative, 2020)
Volume of globally extracted resources per year, along with resource end-of-use paths.

The Human Development Report 2020, published by the UNDP, states that in order to make the interactions between social and ecological systems more visible, it is useful to look at material and energy flows in our societies and their impact on planetary processes. "Improvements in human development as measured by the Human Development Index were fuelled by using resources that generated today's ecological crises (countries in rectangle B of figure)" (UNDP 2020). Low development countries currently within rectangle A cannot follow the path charted by the developed countries. Moreover, high human development countries cannot persist being where they are. The report calls for efforts that ease pressures while allowing for development where needed, which is progressing to the rectangle C. Simulations using shared socioeconomic pathways scenarios to assess their impact of these choices on greenhouse gas emissions and climate change illustrate the alternatives. The business-as-usual scenario, would move five world regions to high income status, but temperatures would climb 3–5 degrees Celsius above pre industrial levels.



Note: Includes only countries with more than 1 million inhabitants. Bubble size is proportional to population.
Source: Human Development Report Office based on data from the United Nations Environment Programme.

Figure 2. (UNDP 2020)
Human development and corresponding resource use

Closing material cycles—extracting less and recycling more— has been touted as a crucial requirement. However, about half of materials extracted globally are used to build or renew in-use stocks (such as infrastructure), making them impossible to recycle in the short run. Material stocks would have to increase another 4-fold (to more than 150 times the 1900 stock) if one envisions a global convergence to the level of stocks of developed countries. Around 44 percent of processed materials (those not used to build stocks) are used to provide energy, making them unavailable for recycling as well. No exemplary substitutes are available for all major uses of 62 metals (UNDP 2020).

As much as three-quarters of the biosphere has been transformed into anthropogenic biomes—or anthromes. Rates of species extinction are estimated to be hundreds of times higher than those that would be expected without human interference. There are claims that we are undergoing the sixth mass extinction in the planet's history; for reference, the earlier five mass extinctions wiped out 70–95 percent of all species (UNDP 2020).

"Decoupling" economic growth from emissions and material use is proclaimed to be the key to alleviating pressures on the planet while improving living standards. The question of this being sufficient and feasible provides a starting point to explore whether it could help reformulate the human development journey in the Anthropocene.

1.2 ECO-ECONOMIC DECOUPLING

Green growth is the most prominent strategy espoused for tackling climate change. The idea presents that human society can alleviate its negative impacts on the environment and reduce emissions, while sustaining economic

growth. Influential organisations champion this strategy, outlined in publications such as Organization for Economic Co-operation and Development's (OECD) "Green Growth Strategy" (2011), the United Nations Environment Programme's (UNEP) report "Towards a Green Economy" (2011a), and the World Bank's "Inclusive Green Growth: The Pathway to Sustainable Development" (2012). This would be achieved by the refinement of production and manufacturing processes, adoption of cleaner energy sources and engendering technological innovation. The concept of "decoupling" is essential to the realisation of a green-growth strategy. The UNEP posits, "a key concept for framing the challenges we face in making the transition to a more resource-efficient economy is decoupling. As global economic growth bumps into planetary boundaries, decoupling the creation of economic value from natural resource use and environmental impacts becomes more urgent" (UNEP, 2011b). Given the weight accorded to this notion, it is vital to assess it further.

Decoupling can be further classified into relative and absolute decoupling. Relative decoupling aims at more efficient processes, that is, economic output increases, as do emissions and resource use, but at a smaller rate than before. Absolute decoupling refers to situations wherein resource use and emissions decline in absolute terms, even as economic output continues to rise (Jackson 2017). Gross Domestic Product (GDP) is utilised as the measure of economic growth. Organisations and scholars stress the importance of absolute decoupling over relative decoupling when aiming at the reconciliation of GDP growth with sustainability goals (UNEP 2011a, Parrique et al 2019, Jackson 2017).

Nicholas Georgescu-Roegen, who is often cited as one of the pioneers of ecological economics or bioeconomics, whose work has served as one of the key insights into much of what will be discussed in the following pages, described the industrial economic process as " *an hourglass in which the stuff of the upper half stands for low entropy and by pouring down it degrades into high entropy (waste). To express the irrevocability of the process, I specified that, in contrast to the usual ones, the "thermodynamic hourglass" cannot be turned over*" (Georgescu-Roegen, 1986). Economic systems extract low entropy from the environment and expel high-entropy waste. This means that the economic system is a linear process, which creates problems on the output side; "the capacity of the environment to absorb an exponentially growing economy shows unprecedented signs of stress" (Dragan & Demetrescu, 1988).

A recent analysis, which synthesised 835 peer-reviewed articles on the subject of decoupling found that the kind of massive and swift reductions in emissions and material use that would be necessary to halt global warming "cannot be achieved through observed decoupling rates" (Haberl et al., 2020). The empirical studies assessed decoupling related to final, useful energy, exergy, use of material resources, as well as CO2 and total GHG emissions. The authors find that relative decoupling occurs for material use as well as GHG and CO2 emissions but not for useful energy, a quality-based measure of energy use (Haberl et al., 2020). Moreover, absolute decoupling, which presents real potential towards easing pressures, particularly from economies with overextended metabolism, is partial, temporary and rare (UNDP 2020).

Furthermore, Parrique et al (2019) argue that decoupling-driven economic growth is not only a compromised hypothesis, but also an unrealistic one. They furnish multiple arguments for the same. The first would be the rise in energy expenditures. When extracting a resource, cheaper options are generally used first, the extraction of remaining stocks then becoming a more resource- and energy-intensive process. Furthermore, one can expect rebound effects, wherein efficiency improvements are often partly or totally compensated by a reallocation of saved resources and money to more of the same consumption, which is also termed as the Jevons' Paradox. There is also, often problem shifting when technological solutions to one environmental problem can create new ones and/or exacerbate others, such as the pressing requirement for lithium, copper, and cobalt resources to furnish electric mobility. The potential for recycling should also be reassessed according to the authors. Recycling rates are slow to increase and recycling processes generally still require a significant amount of energy and virgin raw materials. A critical point the authors present is that there occurs a lot of cost shifting. Decoupling in some local cases was only resulting mostly from an externalisation of environmental impact from high-consumption to low-consumption countries enabled by international trade. The decoupling strategy takes consumption levels as granted; economic models have limitations in incorporating key biophysical functions and they remain limited in exploring the ranges of flexibility that can emerge as a result of changing economic and social behaviour (UNDP 2020).

The Human Development Report asserts the notion of human agency in addressing these complicated challenges, "on the potential to empower people to make different choices, individually and collectively". The formulation has to go beyond that of people as only users of resources, towards individual and collective recognition of the requirement to establish regenerative relationships with the biosphere. The need is to "understand the conditioning imposed by biophysical factors on what can be achieved in meeting people's aspirations: not a few people's, but all people's". A focus on the services that enhance wellbeing can help identify opportunities to generate human benefits with less material use (UNDP 2020). The report also highlights the research and advocacy of the Degrowth perspective, to look beyond efficiency gains from technologies. An overall downscaling in aggregate economic activity is also required, which could be achieved through the degrowth of production and consumption in high-consuming countries and a shift away from growth-focused development in the Global South (UNDP 2020).

1.3 TECHNOLOGY AND INNOVATION

Decoupling is an increasingly questioned assumption and one which remains tied to the notion of continuous technological progress. Innovation has consistently remained central to the addressal of sustainability issues.The 'IPAT' model, for example asserts that "environmental (and social) (I)mpacts could be remedied by either reducing the human (P)opulation (for example, by decreasing fertility), by reducing the consumption of materials and energy (Affluence) or by advances in (T)echnological developments . Since population control is highly controversial and lifestyle changes are not negotiable for many, mainstream sustainability debates focus instead on the eco-efficiency of technology, dematerialisation of the human economy towards a service economy or an absolute decoupling of material and energy use from income" (Kerschner et al. 2018). However, Bonaiuti (2018)

indicates that total factor productivity increase has fallen to pre-industrial levels and industrial societies are entering a phase of declining returns of innovation. Pansera & Fressoli (2020) frame the problem as "proponents of technological determinism and productivism neglecting the fact that the innovation process is socially, culturally and politically constructed", and innovations "reflect the values, ideologies, and worldviews of the society in which they emerge'. High consumption societies are presumed to be a given, with existing material artifacts only needing replacement by cleaner alternatives - more electric vehicles, more energy efficient devices. Kerschner et al. (2018) describe technological development within this narrative as "seen as value neutral , while it is evident that it is increasingly shaped by vested interests such as those of large international corporations who effectively promote false solutions to environmental problems' .

Given the evident blind-spots of the growth conceptions, greater credence for a Degrowth paradigm is important. It also puts forth the necessity of developing notions of innovation that align with Degrowth-oriented frameworks. Kerschner et al. (2018) assert that "technology can be a starting point around which imaginable futures can be constructed for a Degrowth society. At the same time, narratives and imaginaries about a future Degrowth society may help to select or purposefully develop technologies".

1.4 PURPOSE AND RESEARCH QUESTION

Kerschner et al. (2018) having convened a special issue on technology and Degrowth, as well as having encapsulated prior work on this topic, stress the need for case studies in Degrowth and Technology research, which reflect upon how technology can be a starting point for futures. Building on the perspectives of Degrowth, this may allow for the selection, and purposeful development of technologies.

Audretsch (2004) asserts that an important dimension for the promotion of innovation is the promotion of entrepreneurship, serving as a mechanism of knowledge spillover. According to Lindholm Dahlstrand's (2007) research on innovation, Sweden has high R&D spending and innovative activity; moreover, it has a high share of technology-based entrepreneurship, with 15 per cent of all new Swedish firms being technology-based. There is a burgeoning environment in Sweden around the development of environmentally sound technologies, with a vocabulary growing with appellations such as cleantech/greentech/sustaintech ventures. As Lindholm Dahlstrand (2007) emphasizes the role of entrepreneurship in technology development, coupled with a drive to pour investments into such clean-technology ventures in Sweden, there is an opportunity to present evaluative cases on the technologies under development in these new ventures and the environment that helps foster them.

Technologies and innovation are culturally, socially and politically constructed (Pansera & Fressoli 2020). Within the Swedish context, there is an opportunity to undertake a reflective, deliberative consideration of the dominant socio-technological imaginaries on this proposed path towards sustainability; to assess institutions and practices in order to counter undesirable technological dynamics, particularly when the technologies present potentials for biophysical and socio-economic equanimity.

The aim of this study is to make a step towards understanding how innovation could be constituted to become an integral part of a degrowth economy. To understand this, it is essential to look into the current systems of entrepreneurial innovation and prevailing ideas about implementing innovations. This line of enquiry can be split into three questions to be addressed:

- ***What are the narratives around the role of technological innovation and its relationship to economic growth?***
- ***How is technological innovation aimed at addressing sustainability challenges conceived and implemented in Sweden?***
- ***What is the potential of technological innovation as presently conceived, as an agent of change towards or against a Degrowth society?***

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

To address the research questions presented above, literature on degrowth and innovation within degrowth concepts has been studied.

2.1 DEGROWTH

Degrowth has been gaining currency as a subversive development pathway for human development. It has traced its evolution from an "activist movement into a vibrant multi-disciplinary academic field. It draws from anthropology, sociology, and philosophy, and links to inter-disciplinary research in ecological economics and industrial ecology". The Degrowth literature encompasses both conceptual framings of Degrowth- especially as a critique to growth-led development- to work on devising measures, policies and systems to achieve a Degrowth society. Degrowth has been defined as a movement having three pillars : theoretical, activist, and political (Cosme et al., 2017).

The theoretical pillar draws on two broad strands- that of the French décroissance movement with "its historical origins in the critique of development, modernity, and political ecology concerns", and "the sustainable degrowth literature tracing the critique of economic growth and the notion of a necessary "declining" state of the economy argued by Georgescu-Roegen (Cosme et al., 2017). Critiques of modernity, calls for the abandonment of consumerism and the importance of having autonomous individuals and societies, as espoused by the works of André Gorz, Ivan Illich and Cornelius Castoriadis, also feed into the Degrowth work. (Cosme et al., 2017). The other two pillars of degrowth, activist and political, are connected to social grassroots movements (Cosme et al., 2017).

Kallis et al., (2020) describe it as "a remarkably diverse network of thinkers and actors experiment with different initiatives, and engage in healthy debates about what degrowth is, and what forms it can or should take in different

contexts". This also presents divergent definitions, but some proponents prefer it to be that way; "advocates of degrowth do not find it relevant to have a precise definition, and prefer to focus on the purposes of the movement itself" (Weiss & Cattaneo, 2017). It might be erroneously cited to be, but Degrowth is not "negative growth, a paradoxical expression and absurdity which represents the domination of our imagination by growth. It is known that the simple deceleration of growth plunges our societies into distress because of unemployment and the abandonment of the social, cultural and environmental programs which ensure a minimum quality of life" (Latouche, 2010). Degrowth is an "umbrella keyword" Kallis (2011) with different strands stipulating pathways to a desired society. Negative growth might be called for, but "only during the time needed for a transition to an economic system that does not collapse with economic contraction" (Weiss & Cattaneo, 2017). Another pathway is that of a steady-state economy which requires a "constant stock of capital, maintained by a low rate of throughput that is within the regenerative and assimilative capacity of the ecosystem" (Daly, 2008). A common objective however, is to "expose the impossibility of exponential economic growth in a finite world and to outline alternative trajectories for social development" (Boonstra & Joosse, 2013). Whatever the transition process and the imagined end-state- with regards to material dimensions- may be, it should be sustainable in both environmental and social dimensions (Weiss & Cattaneo, 2017).

2.1.1 DEGROWTH OBJECTIVES

Cosme et al. (2017) broadly categorize the common objectives of the Degrowth umbrella as : (1) promote the transition from a materialistic to a convivial and participatory society (2) fair distribution of income and wealth, and (3) reduce the environmental impact of human activities.

The goal of promotion of a transition from a materialistic to a convivial and participatory society derives from Ivan Illich's work on conviviality. Conviviality is oppositional to "industrial productivity" (Illich, 1973) and "focused on autonomous individuals satisfying human needs, social solidarity, friendship and mutual giving" (Kerschner et al. 2018). The most commonly put forward proposals to achieve this goal are downshifted lifestyles; reduced working hours; and assigning value to unpaid and informal activity. The emphasised values are voluntary simplicity and downshifting (Cosme et al., 2017).

Fair distribution calls into focus the notion of justice, wherein Degrowth encompasses demands for justice between the Global North and Global South in an intra-generational context, and also addresses intergenerational justice, by focusing for instance on the need to respect planetary boundaries (Cosme et al., 2017). There are facets to fair distribution in this context : (i) when people have equal rights, liberties, and opportunities (equality of outcomes); (ii) when it is possible to find a reasonable way of distributing the goods, wealth and (iii) when the context of decision-making is taken into account, since justice can be context-dependent (Cosme et al., 2017). Policy instruments that redistribute income and wealth, such as taxation and social payments are commonly advocated for in order to achieve fair outcomes. The redistributive aims and tools seek to undermine power hierarchies, resisting accumulation of wealth in the hands of a few in order to alleviate structural inequalities.

Sustainable scale of resource usage in order to reduce human environmental impacts calls for a planned reduction in resource usage. The approach has to be a discriminating one, scaling down ecologically destructive and socially less necessary production (for example, firearms, private and polluting transportation), while expanding socially important sectors like healthcare, education, care and conviviality (Hickel, 2020). While resource extraction cannot be culled, it can and has to be brought within "the regenerative capacity of ecosystems, and wastes within their absorptive capabilities" (Cosme et al., 2017). While "green" sectors such as renewable energies are emphasised, they are sustainable only when combined with lower production and consumption.

Degrowth can then be encapsulated as a process and an objective whereby material and energy consumption are curbed, more frugal, but more participation-intensive lifestyles are encouraged, and income and wealth are redistributed.

2.2 DEGROWTH AND TECHNOLOGY

Krier and Gillette (1985) describe technological optimism as "an article of faith as well as a term of art". This optimism asserts an essential belief in the bounty of human ingenuity and drives the narratives behind the framings of green-growth and circular economies. "If the world is running short of food, we can count on technological innovation to increase the productivity of agricultural land and the acreage of arable land itself, through better seeds, better fertilizers, herbicides and pesticides, and better irrigation techniques. If environmental quality is threatened, more effective pollution-control technology can be developed to deal with the problem" (Krier & Gillette, 1985). Given the dominant pro-growth narrative ("growth fetishism" (Pansera & Owen, 2018)) which espouses technological innovation and Schumpeterian notions of creative destruction, the Degrowth movement has positioned itself as a counter-movement, dominant perceptions of sustainability, including the role of technology (Kerschner et al., 2018).

Drawing on the work of Ivan Illich and Jacques Ellul, some Degrowth scholars have maintained a scepticism of technology. There are calls for the "conscious minimisation of the use of technology" (Kerschner et al., 2018). Market-developed and driven technologies intensify the requirements for resources and raw materials, while similar strains are not noticed when innovation aims at frugality and sharing. Heikkurinen (2018) for example, has argued that the practice of technology is incompatible with Degrowth from a biophysical perspective. "The more technological the practice, the more objects are utilised" (Heikkurinen 2018). Scholars also highlight the unintended side effects of technologies that may solve one problem but create many new ones (the 'hydra effect') (Kerschner et al., 2018). For example, the greater calls for renewable energy sources do not sufficiently assert the requirements for rare earth elements and deleterious mining required for accessing them. They also spawn mining wastes, which create problems and energy requirements around their disposal. Beyond the ecological facets of technology, their deployment often entails social and economic consequences as well. Growth-focused technologies can impact social equality, by eventually increasing poverty and contributing to an unequal access to natural resources.

However, as Georgescu-Roegen marked out technological development as a main characteristic of human evolution, and the embeddedness of and reliance on technology in modern societies, scholars look to work towards perspectives on technology that are more reflective of existing situations. Moreover, with the active efforts towards the development of eco-compatible technologies, the challenge is being reframed as that of assessing technologies that could be aligned with Degrowth objectives. Kerschner et al., (2018) assert the need for "Degrowth Technology", as well as for "deliberation to form new institutions and practices that counter undesirable technological dynamics".

The first point of departure for assessment of Degrowth-suitable technologies is an assessment of its bio-physical impacts. In this respect, technologies need to be "feasible" and "viable". Feasibility means that the technology can be technically and economically implemented. However, (Muraca & Neuber, 2018) highlight the fact that while technologies may be feasible, their "viability" can be suspect. Technologies are viable when "they can maintain the corresponding material structure which supports its resource and sink functions and consequently supports human activity indefinitely under current environmental conditions'' (Muraca & Neuber, 2018). This means that they do not "rely upon stocks or non-renewable resources imported from other places, taken away from future generations, or with heavy environmental impacts" (Muraca & Neuber, 2018). Viability also calls into question the irreversibility of transformative processes and includes the perspective of future consequences. (Muraca & Neuber, 2018).

Bio-physical assessment is an essential criterion for technology assessment, however, social and political aspects of technologies also need to be considered, in alignment with the holistic visions of Degrowth societies. The distribution of access, availability, control, and impacts of technologies requires dimensions of appropriateness and conviviality. Technological development expands dimensions of creativity and provides new tools for the same, but it also stems from the concentration of specialization. Appropriateness refers to the need to reflect about the context and local circumstances (are suitable materials and skills available?) (Vetter 2020). Convivial technologies are contextual and dependent on local knowledge, values, purposes and worldviews. That means that they have to build on, as well as support local knowledge and skills and promote production and consumption reflective of the specific contexts and settings, in resistance to any 'social engineering'. Another aspect is that they should be maintained with local materials and be repairable and adaptable without the help of external experts. Overall, convivial and appropriate technologies tend to support sufficiency and creativity.

The twin goals of viability and conviviality might not be fully achievable in all contexts, but are important dimensions to enrich and inform the process of technological progress and development. Moreover, an often cited difficulty is not stemming from the nature of the technology itself, but the "problematic interdependency between capitalism and technology" (Kerschner et al., 2018). Wells (2018) calls for "debate but at the microeconomic level of organisations, the technologies they employ in production or service delivery, the technologies embedded in the products and services they deliver, and the management structures that shape not only the need (or not) for growth but also the wider ramifications of those constituent technologies". Attention needs to be turned towards "values innovation, wherein technological innovations need to be linked to profound shifts in the values underpinning business" (Wells 2018). Wells (2018) also brings attention to the oft-ignored

dimension of business activity within Degrowth perspectives. As "the primary organisational template able to mobilise and bring to bear technological innovations on a scale and at a pace that can materially alter net sustainability" (Wells 2018), technological innovation needs to be assessed within the context of business frameworks.

2.3 INNOVATION ECOSYSTEMS

Scholars have proposed the adoption of a more systems-based approach, specifically a construct of innovation ecosystems to capture the complexity of the innovation process. The ecosystem is constituted of a network of actors who combine specialized and complementary capabilities in order to innovate. Ritala & Almpanopoulou (2017) suggests that the concept is one that is "reflecting the ever-increasing connectivity of innovation activities; it joins the long list of other terms describing the networked and systemic nature of innovation".

A definition that encapsulates the concept is this, "relationships that are formed between actors or entities whose functional goal is to enable technology development and innovation. In this context, the actors would include the material resources and the human capital that make up the institutional entities participating in the ecosystem (e.g. business schools, business firms, venture capitalists (VC), industry- university research institutes, federal or industrial supported Centers of Excellence, and state and/or local economic development and business assistance organizations, funding agencies, policy makers, etc.)" (Jackson 2011). With this perspective in mind, one is guided to call into the accounts of government, startup accelerators, venture capitalists, private investors, foundations, entrepreneurs, and mentors. They each play a significant role in creating value in the ecosystem by transforming and supporting new technologies and ventures into reality through access and financial investment.

2.4 SYNTHESIS

In the sections to follow, the ventures under consideration and the technologies developed by them are not marked by having degrowth as the aim; the jump-off point for their inclusion in the study is their possession or espousal of certain desirable characteristics, primarily concerning bio-physical dimensions of the technology, viability and feasibility, for example, reduction in material and energy throughput, preference for recycled materials, enhanced durability, etc. Building upon this, lines of inquiry will aim at gauging the presence of, or inclinations towards other, qualitative aspects of degrowth and degrowth-aligned technology. These would be split along two lines, the principles of operation of organizations, as well as their values. Where values are concerned, gauging the perspectives on profit maximization; and the social dimensions of the constitution of the organization and of engagement with business collaborators and facilitators. The other line will follow the operations, with appropriateness and conviviality the pillars; inquiries on motivation for establishment of the venture, whether it stemmed from inherent need in society; localization of production, and embeddedness in local communities.

Further, achievement of degrowth-aligned innovation environments requires that one include various structures and agents that need to undergo a deep transformation (Maxton, 2018), and not look at solely ventures and their innovations. Charting the relations between entrepreneurial ventures and the innovation environment and

ecosystem is thus one of the pillars of inquiry in the following sections, as it allows for the framing of the values of organizations and their being bolstered or frustrated in this context. Values and guiding principles of ecosystem actors will be inquired after. This holistic approach, viewing the firm embedded in economic structures, would also allow ascertainment of barriers and constraints that the ventures do, as well as are likely to face in sustaining the principles of operations. Mapping the values, operations and narratives of entrepreneurial ventures and other ecosystem actors will help identify whether degrowth-aligned properties are present (despite not being espoused) or emerging and the dimensions of this innovation ecosystem with most potential as well as most frustration for degrowth technology innovations.

3. METHODOLOGY

This chapter outlines the process of selection and use of the method most suited to the nature of enquiry and the proposed research questions. It outlines the methodological approach and philosophical stance (3.1), the research design (3.2), the process of data collection and analysis (3.3), ethical considerations (3.4), and evaluation of data validity (3.5).

3.1 Approach and Philosophical Stance

A qualitative research approach has been adopted, since it is important to frame narratives and values associated with technology development, beyond a more objective positioning of technologies on the basis of the aspects defined by Pansera et al. The qualitative approach allows for a "close involvement with the people being investigated, so that one can genuinely understand the world through their eyes" ; it allows for an understanding of behaviour, values, beliefs, in terms of the context in which the research is conducted (Bell et al., 2019). Moreover, in aid of contributing to a developing research field seeking empirical insights, the approach allows concepts and theoretical elaboration to emerge out of data collection (Bell et al., 2019).

The philosophical stance adopted for the purposes of this study is a critical realist one. The critical realist position can be described in terms of "ontological realism, epistemological relativism and judgmental rationality" (Groff, 2004) A critical realist view, i.e. embeddedness of the social within the ecological (Bhaskar, 1989), appears to be a natural fit with the vision of degrowth.

3.2 Research Design

The process depends upon a case-study approach, wherein developing technologies can be assessed and framed within the narratives of the entrepreneurs behind them. A case study method is highlighted by Tellis (1997) as ideal when holistic understanding is required. It provides an opportunity to understand a phenomenon in depth and within its own context. The primary source of data were semi-structured interviews. The context and situation of these cases within an innovation ecosystem is important. Therefore, a qualitative study of other

ecosystem actors is also conducted through semi-structured interviews. While interviews were essential for this study, multiple other sources of data were also used such as websites and interviews, allowing for a holistic understanding. Gillham (2000) asserts that a wealth of sources of information is a key attribute of case study research.

3.3 Data Collection and Analysis Process

The section describes how empirical data was collected and subsequently analysed. It first outlines selection of interview cases, collection of information through semi-structured interviews, and then the analysis process for the collected data.

Study Sampling

The search for possible firms and thus interviews was carried out by scoping various platforms aimed towards startups developing technology geared towards the climate challenge. The technologies are often dubbed as "cleantech" or "greentech" or "sustaintech". The principal platform was Swedish Cleantech, representing a cooperation between "authorities, industry and stakeholder associations". Swedish Cleantech aims for the development, commercialisation and export of Swedish environmental technology". The "cleantech" section of the investment portfolio of Almi Invest, an independent public venture capital company, which also touts a GreenTech fund. The "sustaintech" section of the investment portfolio of Sting, a non-profit organisation, composed of representatives from the business sector, academia and the public sector (the City of Stockholm, Stockholm County Council and County Administrative Board). Startups hosted by Norrsken foundation, a non-profit aiming at businesses aiming to "solve the hardest and biggest problems". Finally, "greentech" startups listed on The Hub, an online community platform. Invites for participation were sent out to startups belonging to different industries, such as food technology, those involved with the provision of water, the renewable energy sector, as well as sustainable materials development. Startups span across industries, because the aim is to assess the development of sustainability-technology within startups in Sweden. Organisations and institutions aiming to aid the development of technological innovation - such as innovation agencies, startup accelerators, research agencies - have been contacted, in order to account for the perspective of other innovation ecosystem actors. Search for such relevant organisations entailed seeking out the ones with a policy brief towards innovation, and references to any such organisations in the interviews with startups.

Interview Process

The primary source of data in this research were semi-structured interviews. This allows for the exploration of certain key, predefined themes of enquiry, and to allow for novel insights to emerge. Interviews are tailored according to each firm in order for the questioning to be more pertinent. For firms, a general interview framework included questions about their motivations, aims, and obstacles. For innovation ecosystem actors, a general interview framework included questions about how they envisage the role of innovation, on their investment process and criteria, the appropriate balance between the financial and non-financial return of their investment,

and how respondents sought to ensure that their investments would yield such returns. In total 12 interviews were conducted, each lasting between 30 and 60 minutes. The interviews were conducted face-to-face via video-telephony service Zoom.

Data Analysis

Frameworks for conducting interviews had been developed, both to aid the interview and data analysis process. Two guiding frameworks had been utilised, one for interviews with startups, and one for other innovation actors. Awareness of the themes from the reviewed literature before and during data collection and analysis stages were helpful to retain a sense of knowing "what to look for" (Yin, 2014). Augmenting this useful guiding framework, value was placed in specific examples. Analysis was then conducted via coding and themes-construction. For each case, the language of coding and themes was maintained.

3.4 Ethical considerations

Each participant signed an informed consent letter, which was obtained from every participant before the beginning of the interview. Every participant was given time to assess, the option to pose questions and contemplate their participation. The confidentiality of participants was respected at all times. All participants have been anonymised and anonymity would be maintained within the work as far as possible. Data protection is of the highest priority as well. To ensure this, the study was conducted in compliance with the European Union (EU) General Data Protection Regulation (GDPR). Only the information relevant to present research was collected, barring any sociable pleasantries exchanged.

3.5 Data Quality

Transferability

Transferability refers to the degree to which the results of qualitative research can be generalized or transferred to other contexts or settings.The information within this thesis is limited to the specific context in Sweden and which limits further applicability. However, the transferability has been enhanced by presenting a thorough description of the research context and the assumptions that were the basis of the research.

Dependability

Dependability emphasizes the need for the research to secure validity of findings over time. In order to uphold the dependability of the study, the principles and criteria used to select participants and detailed information about the participants has been provided, so that if replicated with the same or similar participants within the same context, results can be upheld.

Confirmability

Confirmability refers to whether the results could be confirmed or corroborated by others. To achieve this, the information obtained via interviews has been both augmented by publicly-available information sources. Furthermore, following a guiding framework for both the interview and analysis process helped retain objectivity in the summarization of the information.

4. FINDINGS

The findings are organised in two ways. Firstly, findings from startups presented as individual cases in section 4.1, synthesised findings from various innovation ecosystem actors are presented in section 4.2. Narratives on growth from all concerned actors, startups and other agents are encapsulated in section 4.3

Table 1 : Overview of Interviews

No.	Designation	Organisation	Location	Interview Medium
1.	Founder	Easy Urban Gardening AB	Stockholm	Zoom
2.	Business Developer	Aquammodate	Gothenburg	Zoom
3.	Head of Technology	SaltX Technology	Stockholm	Zoom
5.	Chief Technology Officer	Epishine	Linköping	Zoom
6.	Senior Research Officer	Formas	Stockholm	Zoom
7.	Sustaintech Coach	Sting	Norrtälje	Zoom
8.	Programme Manager, Innovation Management	Vinnova	Stockholm	Zoom
9.	Sustainability Innovation Lead	Axfoundation	Stockholm	Zoom
10.	Investment Analyst, GreenTech Fund	Almi Invest	Stockholm	Zoom
11.	Founder	Trellis Road	Stockholm	Zoom
12.	Startup Scout, Water and Energy	WIN	Lund	Zoom

4.1 Startups

In this section findings from individual startup cases are reported. Multiple data sources were utilised to derive the findings. Insights were derived from interviews, with quotes from interviews demonstrating relevant insights. This section presents the main findings from each case in a form of a narrative aimed to overview each case. For the present study an in-depth understanding of different degrowth business elements related to both the environment and society in broad terms, which may be embedded within small firms, is necessary alongside a possibility of understanding of attitudes, values and motives representing a shift in values which degrowth advocates (Paulson, 2017).

Table 3. Overview of Startup Cases

No.	Organisation	Innovation
1.	Easy Urban Gardening AB	Hydroponic growing equipment and technology
2.	Aquammodate	Natural water purification technology
3.	Saltx Technology	Nanocoated salt for energy storage
4.	Bright Day Graphene AB	Green graphene for energy storage
5.	Epishine	Printed organic solar cells for low energy light harvesting

4.1.1 Easy Urban Gardening AB - Gaia Grow

Easy Urban Gardening has developed Gaia Grow System™, a modular vertical urban gardening system for growing vegetables, herbs and medicinal plants without using soil, through a hydroponic growing technique.

Origins and Motivation

The origins of the enterprise were not from a conceived and planned business idea but from nebulous interest, says the founder. *"I could not admit that in the beginning, we didn't really understand what we were doing. It was just...it was just something kind of a hobby... And you know, curiosity and you know, a mixture of that kind of ideas".*

This exploratory approach, coupled with trends in society, started to lead towards the calcification of a business enterprise : *"And and as the time went on, and you understood from media and every other channels that you are reading that, oh, man, this this might fit in in these kind of big super trends... but even though in the very beginning the trends were more about greens and being healthy and eating less meat and more vegetables and things like that.*

From that point, let's say, three, four years ago, it was transformed over to become more and more about pure sustainable issues. So that's also been sort of a journey for us".

The company website highlights a World Economic Forum Report,"Shaping the Future of Global Food Systems" from 2017, which sought to address the challenge of "nutritiously and sustainably feeding 8.5 billion people in 2030". The report's emphasis on steering progress through innovation and the emphasis on "right now an investment opportunity in hydroponics and vertical farming.", helped reinforce the viability and potential of their enterprise.

Technological Innovation

The Gaia Grow System™ is a hydroponic growing unit. It makes it possible to organize an indoor farm, adapted for home environments in order to grow vegetables, herbs and medicinal plants without using soil, which negates the need for pesticides.

The website brings to attention the design characteristics of the technology, "Gaia has undergone four years of iterative design for both aesthetics and technique, culminating in a product that is the epitome of Scandinavian elegance". The system is modular. A single grow box can be used on its own, or several can be stacked together for greater density. This renders the system flexible enough to serve small apartments and full scale urban hydroponic farms.

The hydroponic technique allows for growth of vegetables using one tenth the fresh water of traditional croplands. It also addresses the problems that stem from sustaining the urban food supply, such as fossil fuel dependent transportation and plastic packaging, since it allows for consumption at source.

Operationalization

The founders witnessed greater resources being directed towards environmental enterprises like theirs saying, *"In general and startup companies in general who are maybe focusing on sustainable issues and finding solutions to transform, you know the environment and have technical solutions for the future sustainable, you know, societies. That's started. Oh yeah, that's gone up".*

They highlight institutions and governments that have aided their efforts owing to the sustainability efforts of their enterprise *"we have had help from the Swedish government. And we also had quite a lot of help from European financing because we did a pilot study with all the equipment for ten families throughout Sweden and so we got a loan and so yes, we have had some help";* but accessing these is can be tedious process, especially when buffeted by competition from other enterprises, *"but the the other side of this is that when you get involved with these kinds of organizations, it's so time-consuming to work out the application and to you know fill in that in because they have a lot of limitations. It's really, really time consuming. And then you file and submit the application and then you find out that there are 600 other startup companies you know asking for the same thing".*

The competitive jostling for public sector resources necessitates that they turn to other capitalist structures, which are marked by similar hurdles, but also unethical behaviors, such as *"the other thing that we have experienced*

*is that there is so much money laundering" ; t*hey highlight the fact that new enterprises are particularly vulnerable to such practices : *"you're a very easy target for those kind of people and for not..not legitimate money because what you have, such a strong drive to take what you have been working with to go commercial... you are really crying for capital".*

Sustainability concerns

The founders highlight the strong social dimensions of their technique and product. They bring forth the idea that it provides agency to the consumers, some manner of control over their lifestyles **:** *"I think it's very hands-on and very visible that you were growing something. So I think it's a very good kind of reminder of being connected back with nature that will hopefully lead to other steps to a more eco-friendly lifestyle".*

The founders want to enact their business with strong social dimensions as well, with aspirations to aid communities in poor socio-economic situations : *" They have no way, no tools to get out of their situation because they don't own any land, they can't grow anything. But if you grow using this, and they have access to fresh water, that's the only thing, they can try to produce something that other people want and they can start. So we have had discussions. And we have had requests from a couple of African countries. And particularly from women, in lower socioeconomic situations who want to start up projects using the Gaia grow system on a more bigger scale".*

They also assert commitment towards sustainable resourcing and raw materials, *"I think that'll be great if we can have very holistic products. At the end that does kind of take all the criteria that it is sustainable, packaging, sustainably sourced and things like that, ... local. We are going to produce this partly of plastic materials and we have started to look a little bit into what kind of material we could use and should use in order to be perceived as, you know, sustainable...new what's called bioplastic materials that are coming up now".*

Ambitions

The first aim is to operationalize the business with the technology in its present state, *"what we have developed so far, we need to capitalize on that and get cash flow and gain some contribution"*, and gain a foothold about the product, *"feel comfortable with, you know, the hardware and how it works and we can learn a lot".* With the potential achievement of this stage, they assert their ambitions to grow further : *"then we are going to go big ... you know worldwide absolutely. There's no reason to hold back then but we'd like to, you know, probably take the first very, very first step, you know, carefully".*

They also envision potential development beyond individual customers : "Industrial vegetable farming could utilize the modularity of Gaia Grow System™ in many ways. As a greenhouse farming kit, you only have to stack the Gaia grow boxes to a level you find appropriate and practical.For smaller private greenhouse making, Gaia Grow System™ will support a number of restaurants located in the city neighborhood."

4.1.2 Epishine

Epishine, headquartered in Linköping, was founded in 2016 and develops energy harvesting modules are optimised for indoor light conditions. It is owned by the founding team together with institutional investors.

Origins and Motivation

The CTO, describes the origins of the enterprise : *"The background of Epishine, is a research group at Linkoping University. Professor Olle Inganäs, he and a group has been working with organic electronics and organic photovoltaics for 30 years or something like that. And he is a big, big, big name in this field and I joined his group as a masters' thesis student in 2010 somewhere and then, I ended up doing my PhD. I mean the potential for organic photovoltaics was sort of limited? We still thought that there could be a bunch of niche markets for the technology. So we spun off a company in 2016".*

The enterprise derives incentives from the acceleration of Internet-of-things systems. The website highlights the potential of "...the global digital transformation. This will rapidly lead to a countless number of small sensors and displays that today are powered by batteries. This is not sustainable, neither from an environmental perspective nor from a maintenance perspective. All electronic devices that today are powered by small batteries that last for a year or more can potentially be powered by harvesting ordinary indoor light with this innovation".

Technological Innovation

The novel concept rests on the harvesting of low energy lighting indoors. By being small, thin and flexible, the light–cell, printed on recyclable plastic and easily integrated into wireless products, converts the ambient light into electricity. The light–cells can be used to partly or completely power wireless sensors and similar devices.

The innovation also presents a strong ecological dimension, given the cells are non-toxic, based on organic electronics and encapsulated in recyclable plastics. The company asserts that it reduces environmental impact by up to 99% and cuts maintenance costs by replacing batteries in wireless devices.

It is also uniquely scalable, due to the fact that the entire manufacturing process is based on different printing techniques, roll-to-roll. The thin and flexible cells can easily be integrated into typical plastic-based electronics housings.

Operationalization

The enterprise got constructive momentum from infrastructure within the university which was conducive to their purpose : *"So basically the infrastructure in Linkoping, you have these Innovation offices and the way they worked was really helpful for us. I was part of something they called Mentor for Research where you as a scientist, could sort of apply for this. And then I had some sort of entrepreneurial training program for a year. And then they also really pushed us, they helped out with some patent applications and they also helped out with matchmaking".*

The transition from a scientific concept to a market-oriented product required business expertise. *"I think this was one of the keys for us to succeed to really be able to matchmake with an experienced entrepreneur. Because without*

him, there wouldn't have been a company today. Because as a scientist you, at least for myself, really underestimate how hard it is to sell a product, you are quite naive and thinking we develop this and then, of course, the entire world is going to buy it. You realize that it doesn't really work like that. "Also Matthias has been really skilled in and worked really hard on investor dialogues to make sure that we get funding. And funding from places like Vinnova and the Energy Agency".

The challenge of commercialization of the technology highlights the fact that new innovations are not directly motivated by addressing market problems and demand; those have to be highlighted or created: *I mean, for physical products, which have a quite high complexity that they want to develop and in parallel you also want to develop a completely new market. I mean, that there are two really, really large challenges to work with, but I still think that... I mean, we could show progress both in terms of the them production development and and in terms of the market development.*

Accessing a network of knowledge and expertise has been a crucial process for the enterprise : " *We also got a lot of help from the board and from investor's to sort of lift us, and perspectives we got in a chairman; we did a lot of industrial experience also, and we've been working with a lot of advisors and consultants. So, sort of the strategy has been to try to let the people within the company grow, and then sort of taking in the experience from the outside and pushing different aspects like the quality work etc. And also a lot of advisors in terms of supply chain."*

Sustainability concerns

The company underlines their consideration of ecological sustainability **:** *"Working on life cycle assessments; on light powered applications versus battery-powered applications and making sure that we wouldn't also take in the life cycle assessment and eco toxicology aspects in. We then look at what materials we use in the process. And what we do to sort of further reduce the climate impact."*

They also assert their socially-oriented considerations *: "Also, for the product, combining improving sort of user friendliness and improving the integrability of different sizes shapes and and then also, still, keeping the aspect of making sure that we further improve the climate impact".*

They have sought to reinforce their development by accounting for, and making room for user-dialogue*: "So basically already from the start we started out to work with potential customers and having dialogues with them, on how we should adapt the product etc. And I think this has been extremely important for us to sort of have these dialogues. We were also quite fortunate to have this. Also, it... sort of interaction interface, with customers to really understand what is required from the product to be attractive".*

Ambitions

The initial aim is to substantiate the viability of the business and the technology and utilise those gains to access other objectives : *"the ambition is to prove that this initial market with the indoor... that that we can make a good*

revenue from this and then reinvest the revenue to be able to do partly or self-financed the stage to where we go for, for outdoor products".

Successful first stage implementation is also seen as a crucial signal of the future health of the enterprise, and also as a marker of capability *: "I think this is, this is really important. I think it's from our perspective extremely important to prove that the the first stage on the indoor market to really show that that we can set up a production we can set up the sales and marketing organization. We can build the quality management systems within the company, to really get the product out to really start making a revenue."*

They have mapped out stages of potential and desired product diversification : "The second phase is outdoor applications where... we don't directly compete with silicon, so it could be lightweight constructions where you need semi-transparency, maybe for windows. And then in a third phase, the more visionary sort of long-term perspective, ending up at a scale where we actually can compete with silicon on cost per kilowatt hour. We would dramatically lower our climate footprint. Have a bit higher performance, power conversion, efficiency, and doors compared to, to sort of the competition".

For the enterprise, international growth is undisputed, but they underscore the kind of considerations that would be required for such expansion : *"So I mean at this stage we are setting up production line and as we are using a roll-to-roll process, we have a huge capacity but then of course I think in terms of setting up production in other countries, I think we sort of need to follow the market there and and see when does it make sense to put up a production at another place? Sweden is a quite good place for production because of our electricity. So from that perspective, it makes much more sense to actually have the production in Sweden, but of course, this is something we will adapt to and look into as we grow".*

4.1.3 Bright Day Graphene AB

Bright Day Graphene aims to offer sustainable graphene made from biomass, optimized for use in energy storage and high tech products.

Origins and Motivation

Bright Day Graphene sprang from a conscious desire to work towards more altruistic motives. The co-founder, says *"But I knew that I wanted to do something that felt more meaningful and I thought it was going to be connected to doing good in the world. And I met my business partner Anna. And she was telling me about her ideas that she had on how to make better energy storage by producing green materials. And I said something like, well, maybe I can help you to realize this and she was, like, wow, I've been waiting for someone to say that. Let's do it. And so we did."*

The combination of research work already being undertaken by one of the co-founders, and market opportunity for that work guided their efforts to start work in this field. *"My co-founder, who is the technical side of our company, said, well you know when you look at all the forests in Sweden, there are some materials that we could use*

that are really not used in the right way. Now, it's mostly burnt. I think I know how to do it and then she invented a new way to make graphene because we liked graphene as a material because it has such potential that wasn't really realized".

Graphene is a material that possesses strength and conductivity , but can't be manufactured on a commercial scale. It has potential applications in the fields of energy storage and conversion, flexible electronics, sensors, composites and coatings, and biomedical applications. For the founders of Bright Day Graphene, "there is a hole in the market here and with our green graphene we want to bridge the gap between these two".

Technological Innovation and Benefits

The environmental motives and orientation of the company are linked to the development of sophisticated technology. Scalable manufacturing of graphene also seeks to make it a sustainable process. Bright Day Graphene's process provides opportunities to produce large volumes of graphene from biomass, which is a renewable resource. That process also enables the extraction of larger flakes, which significantly improves the properties. This gives better electrical conductivity and higher transparency. They have termed their graphene as green, because it is made from a sustainable source and uses no toxic chemicals in the production. It seeks to serve the twin purposes of greater environmental compatibility as well as higher performance.

The graphene has potential application for graphene batteries, since the capacity becomes 45 % higher and the charging time 5-8 times shorter within graphene enhanced batteries .

Sustainability concerns

Environmental concern is paramount for the company, as evinced by the statement, "W*ith every new employee that we hire, we are very focused on showing the value of environmentally friendly thinking because there is always a tendency that you want to make compromises to receive the performance that you need, especially in the lab. And we are very clear on ... Oh, that's a great idea, but no, no, we don't go that way. So that's very important to us to hold that line and be consistent in that. Because as soon as we start making compromises, iIt's so easy to slide off the road that we are on."*

Moreover, the founders are conscious of their circle of association when developing their product, and look for partners with aligned values"*We are doing life cycle analysis on our process at the moment. It's within one of the projects that were running now to make sure that we keep that [sustainability] central the whole time because that is so important to us and I think since we're using a residual stream from the pulp and paper industry, ... as long as that's the raw material, it's kind of easy for us to maintain the circularity, but then of course, the pulp and paper industry must also do their homework on this. So we need to select what partners we are working with that they, take their responsibilities as well".*

Operationalization

To get the implementation of the ground, research was crucial, and the company encountered hurdles with resources required to carry out such research. *" Because most companies like ours come from the university world, ... there has been research going on for several years in an institute or university and then they make a company out of it when they have reached a certain level. You often talk about the technology readiness level. We started at zero on that day and most companies started at least level 3 or 4, so it was really hard to fund."*

They also highlight the nature of funding that research-led enterprises like Bright Day Graphene had opportunities to access : *The first steps, ... we had some funding that we started out with, invested our own capital and we worked for free for a couple of years and then we turned to Vinnova for grants. And we also turned to some private funds that gave us grants of different kinds. I find that most venture capitals, they don't want to invest in .... I mean, it's the risk level which is too high because we have a long way to market and we can't really show any market traction because we're still scaling up and exploring our technology. So it's definitely hard to fund the early stages"*

The founders also point to preferences within funding criteria; environmentally-aligned technologies, with women at the helm, signal positive signs for funding accessibility: *"You need to match the calls to start with and that has been easy for us because we are within greentech, within energy and we are female founders. We tick a lot of boxes on the calls that they have, but then of course the competition is high."*

They have been supported by scientific institutions that allow access to expensive equipment to complete scientific endeavors and research projects *"RISE has been a really good partner to us, they have expertise; it has been really good to use RISE for certain research that we cannot do ourselves. And, they have really experienced researchers and a lot of equipment that is expensive, that we can't afford to have ourselves. But RISE is also expensive to use, their hourly rate is high".*

The challenge of commercialization of the technology highlights the fact that new innovations are not directly motivated by addressing market problems and demand; those have to be highlighted or created *: "Since this technology is kind of disruptive, the graphene market has not really been able to produce a high-performing material on a larger scale. The market that we are targeting, is not really there yet. It needs to be developed. So we also have the challenge of scaling up our production, at the same time as building the market, and they should follow each other."*

Ambitions

Local situations conducive to the development of the specific technology do not limit the company from having a growth-forward international perspective, *"We have always been thinking globally and seen it as a global market. Because there is so much biomass in Sweden, it's easy for us to start here. We have so much forest and we*

have large companies within pulp and paper. So we started here. But we already have contact with Brazil, with Portugal. There are companies all over the world that we are talking to".

Though profit is not positioned as the primary motive, its role in capitalist environments is not denied. Profit serves as the marker of making the ecologically-aligned enterprise viable: *"Our main focus, we believe that sustainability should come first and profitability comes second, but we believe that they walk hand in hand so they will it will just if we are able to produce what we want to do, a highly sustainable and high performance material, then that will be so attractive that the profitability will be generated automatically".*

4.1.4 Aquammodate

Aquammodate, based in Gothenburg, seeks to offer energy-efficient desalination of sea water into safe drinking water and sustainable production of ultrapure water.

Origins and Motivation

A business developer at Aquammodate describes the origins of the enterprise from the founder's research : *"I mean, obviously it came from the PHD research which was very, ... I mean, the application was towards water purification, so I think that connection was kind of easy to make but also the co-founders have the passion or drive to or yeah, try to make an impact. So I think that connection was kind of easy but I think it came mostly from their research".*

The website highlights statistics that define the challenge and provide the incentives for Aquammodate. 900 million people lack access to safe water; Aquammodate is " devoted to providing clean drinking water to almost 1,000,000,000 people that are in the greatest need".

Technological Innovation

They have developed a bio-inspired method for water purification. Natural cell membranes work like a water filter to reduce the amounts of harmful pollutants entering the cell. Aquammodate uses naturally abundant components to mimic this solution. The method stabilizes aquaporins utilising lipids and silicon dioxide (silica). The lipids are dual purpose since they both mimic the natural environment of the aquaporins and act as the impermeable component in the filter. Silica provides the biological components with mechanical and chemical robustness while preserving their structure.

This method allows for purification using only natural materials, while saving energy. The technology has purported potential to lower the energy consumption of water purification processes up to 85% compared to the present, maintaining a high selectivity and purity, whilst only using renewable and naturally abundant

components. The technology has the potential to radically reduce the CO2 emissions per m3 (kg) by 65%. That results in 150 000 tonnes/year less CO2 emissions for 80% of the European point-of-use market.

The target applications of the technology are multiple; for achieving safe drinking water through desalination of sea-water; decontamination from microplastics and pharmaceutical residues; obtaining ultrapure water; and removal of harmful substances from industrial waste water.

Operationalization

The business developer feels that the potential applications of their technology eases the navigation of the funding and resource environment : *"In many ways, it's been very thankful working in this space. I mean, the whole world obviously knows that water scarcity is a huge problem that affects every continent. So, it's been in that sense, it's been easier getting in touch with potential investors, there's a lot of soft funding out there".* Aquammodate had acquired access to grants from Vinnova, in order to continue development with co-development partners.

Given the stage which they are at :*"We've done this and been doing this at lab scale and that leap from... for example, production of higher scale ... at the moment that's the biggest challenge",* network building to access expertise has been felt to be crucial. *So far it's been focused on the business side, ... networking. Like we've been part of incubators accelerators for also just like platforms and networks and that that has so far been mainly focused on. The intention is to sort of lead that into help on the tech side as well with strong relationships and good communication. That's the goal of anything, you can sort of collaborate and in that collaboration, or in those collaborations be able to accelerate the tech progress as well.* They were also accepted to the EIT Climate-KIC accelerator program, an "EU acceleration programme focused on climate impact by cleantech commercialisation". They also form part of Wave 3 of the Katapult Ocean accelerator program, which focuses on startups within transportation, ocean health, harvesting, energy and provides workshops, network & learnings sessions.

Sustainability concerns

Though stating that they are not yet at a stage of practical addressal of some challenges, they assert their commitment to ecological sustainability : *"Obviously want to make an impact in being able to provide drinking water, safe drinking water in an efficient way but the whole sustainability aspect doesn't end there. So we want to lower net energy, of course but circularity is extremely important. We're at such an early stage right now, so don't have a plan for the brine but it's definitely something that we're going to have a solution for. Dumping the brine isn't a viable solution".* Brine is hypersaline water, the by-product of desalination, which is often directed back to the sea and can devastate ecosystems.

They underscore that they cannot rely on any inherent ecological sustainability of their technology, especially when it comes to accessing funding : *"Of course you have to follow the money. Of course if you want to survive but make that in the end that could be your...like a downfall if you are only following that. So, I think one major key is to align with corporations and partners that believe in the same things that we actually want, to make a difference".*

Ambitions

The goal, which is also the challenge, is ensuring provision of clean water in water-stressed areas. Local socio-economic contexts could pose a challenge : *"In some cases, it can mean that even though our solution is cost efficient, some of these areas can not afford it, maybe. So that's where we have to be creative and make it happen anyways. We could be partnering up with larger corporations and creating a partnership that ...we produce this water for you, but the terms are that x x amounts or this percentage goes to this area. So, we're definitely looking into different... what we call creative solutions to be able to actually make an impact in a practical sense".*

4.1.5 SaltX Technology

SaltX Technology is a Swedish innovation company that has developed a patented nanocoated salt suitable for high temperature thermochemical energy storage.

Origins and Motivation

The foundational technology behind SaltX has been industrially scalable and has been used in the energy, processing and chemical industries for many decades. SaltX tweaked the technology and applied it in a fundamentally new way by augmenting it with a few important innovations. By building upon a proven technology, their path toward commercialisation became simpler and less risky.

Technological Innovation and Benefits

The salt that has been developed is based on a limestone-based material with patented nanocoating. The nanocoating prevents the material from becoming sticky and helps to retain the original crystalline form of the salt. With nano-coating, it is possible to charge and discharge the energy many times and to have a system with a long lifetime value.

The advantage of treating the limestone-based material with nano-coating is that the material is non-corrosive (prevents rusting). With a non-corrosive material, the building of the energy storages is not dependent on high quality materials which makes the SaltX storage a very cost-effective solution.

SaltX nanocoated salt is non-toxic and can be reused or recycled.

Operationalization

The challenges of accessing the right funding for the venture were highlighted. *"There are different types of investors, there are different types of requirements and these requirements can evolve and change quite, quite rapidly. If one can have state funding which can be relatively nice to get... there are not so many strings attached. And if you go over to the EU funding then it's virtually impossible even though they say, oh, well, these funds are for small and medium-sized enterprises...it's impossible as well. With venture capital ... it varies very wildly, what investors are interested in and what they're looking for. And then if you go for short-term venture capitalists, then you will end up...the whole idea is to get a return on investment as quickly as possible, so it's usually not very interesting for them. Like ours, which looks at more infrastructural things because they take quite some time, when it's mostly them finding*

of most interest going into technology and software, optimization type things, and smart AI".

Sustainability concerns

SaltX asserts that they "strive to work with circular and resource-efficient working methods that have a positive impact on health, the environment and the climate – both internally and together with our customers and partners".

Within the context of this goal, they have identified some key challenges and assert their aim to address them. "*Water usage is definitely something that we need to do. We need to consider how our salt reacts with water and so that it's something that we've been looking at a lot of time in recycling, water is very possible. There's a lot of research that goes into that and our system should be a closed system, but there will always be a certain amount of leakage. There's that amount of water that will need to be there and we need to sort out that the other thing is that the production of the material is also quite CO2 intensive".*

They highlight consideration of social dimensions as well, asserting, "We work actively to ensure that our workplace is characterized by equality, diversity and respect for each and every employee. We have a vision of having as even a gender distribution as possible among our employees. Our work environment must be developmental and offer a good balance between leisure time and work" (SaltX).

Ambitions

SaltX outlines a goal of carrying out consistent improvements. "An important part of our development journey is an awareness of the outside world's expectations and reactions, which helps us to evaluate our work and ultimately achieve our goal – to create technological solutions that benefit the climate".

4.2 Innovation Ecosystem Actors

4.2.1 Overview of Organisations

Table 3. Overview of Innovation Ecosystem Actors

No.	Organisation	Description
1.	Vinnova	Swedish government agency that administers state funding for research and development.
2.	Almi Invest - GreenTech Fund	Public venture capital company with special focus on

		making climate-smart investments .
3.	Sting	A non-profit organisation, serving as an accelerator for startups.
4.	Formas	Government research council for sustainable development.
5.	Win	Enabling innovators to fast-track their ideas into commercial businesses in water, public safety and energy through expertise and tools.
6.	Axfoundation	Independent, non-profit organization for building a sustainable society.
7.	Trellis Road	Investor for foodtech startups.
8.	RISE Research Institutes of Sweden	Research institute and innovation partner.

- **Vinnova :** Vinnova is a government agency under the Ministry of Enterprise and Innovation, and the national contact authority for the EU framework programme for research and innovation. They work towards building Sweden's innovation capacity, while contributing to sustainable growth. Their work is governed by the Swedish government. The work is based on the global sustainable development goals of the 2030 Agenda adopted by the United Nations.

- **Almi Invest - GreenTech Fund :** Almi Invest is a sector independent public venture capital company, serving as a bridge to private equity and contributing to a venture capital market throughout Sweden. The GreenTech fund of SEK 650 million focuses on climate-smart investments that reduce CO2. Almi Invest GreenTech is partially financed by the Swedish Energy Agency along with the EU, Almi Företagspartner and Almi Invest.

- **Sting :** Sting is owned by a public-private foundation, the Electrum Foundation, and KTH Holding. The Electrum Foundation Board consists of representatives from the business sector (Ericsson, IBM and real estate owners), academia (KTH Royal Institute of Technology, Stockholm University and Swedish ICT) and the public sector (the City of Stockholm, Stockholm County Council and County Administrative Board). Sting's activities are financed with public funds, from Electrum and partners Vinnova, KTH, Stockholm County Council and Stockholm Region; and with private funding from partners, as well as through self-funding. Sting aims to serve as an attractive ecosystem for tech startups, and to help accelerate Sweden's most promising tech startups and increase their chances of success.

- **Formas :** Formas is a government research council for sustainable development. They fund research and innovation, develop strategies, perform analyses and conduct evaluations. Their areas of activity include the environment, agricultural sciences and spatial planning. They cite the aim of making it easier for Sweden to achieve environmental objectives.

- **Win :** Win coheres its own experts, mature companies, scientists and authorities, to co-create circular

solutions to solve challenges within the focus areas of water, energy and public safety. They offer a place, platform, expertise and tools to enable innovators to fast-track ideas into commercial businesses.

- **Axfoundation :** Axfoundation is an independent, non-profit organization working towards sustainable development by initiating and running projects together with the private sector. Together with about 225 partners across sectors and industries they seek to tackle local and global sustainability challenges based on practical issues related to "future food", circular economy, sustainable production and consumption

- **Trellis Road :** Trellis Road has set the purpose of investing in and supporting early-stage high-impact foodtech startups, typically by investing small tickets alongside strong lead investors in seed rounds.

- **RISE Research Institutes of Sweden :** RISE is a research institute and innovation partner. It works to ensure business competitiveness and contribute to a sustainable society through international collaboration with industry, academia and the public sector. It also cites the promotion of the innovative development of society as a whole as one of its missions. RISE's mission is formulated in Swedish Government research and innovation bills as well as any owner instructions issued by the Government.

4.2.2 Narratives on Innovation

The narratives accorded to innovation at the various ecosystem actors are presented.

For RISE, renewal and growth are the main goals and innovation is the tool to achieve them. The website states the vision as "[RISE] shall be internationally competitive and facilitate sustainable growth in Sweden by strengthening competitiveness and innovation in the business community".

The Axfoundation which espouses circular economy practices, asserts that "by decoupling economic growth from the ever increasing extraction of raw materials and non-renewable resources, circular business models are designed to keep resources at their highest value for the longest possible time while minimizing waste" (Axfoundation).

The startup scout at WIN considers technological innovation as an important tool for achieving sustainability targets, but highlights their insufficiency *"It's not enough . . . you cannot reach sustainability with innovation and technology alone. It may be an enabler and or I would say it might make the journey much easier. The seed of the next problem, we need to be able to put a kind of a cap on growth"*.

Vinnova also levels mild criticism at the prevailing standards for evaluating innovation. "Economists tend to prefer "technology-neutral" performance standards, but this risk favouring marginal improvements to existing technologies whilst discouraging more radical, long-term solutions" (Elg 2014).

The sustaintech coach at Sting highlights an interesting dimension to the conception of innovation aimed at sustainability " *I mean the fact that we are meeting on Zoom... Zoom as sustainability technology in the way that we can reduce transport, physical transports. So I think you can include a lot of different technologies but some are directly connected to sustainability and where other ones are perhaps indirectly connected.*" Innovations which

might not have been conceived with explicit sustainability criteria in mind, could still aid those efforts.

4.2.3 Target Projects and their assessment

At Trellis Road, the founder emphasizes the financial potential of innovation projects, and asserts it as a condition for the success of the aims of an innovation. *"It's in our perspective, we are looking for the best startups with a clear impact approach because I think, yes, that's an additional filter, but when we evaluate the startup it's still on the same parameters that any investor would look like because in our perspective, they need to be financially attractive and they need to be, we need to say that. Okay, they can go after big markets and have good financial upside because otherwise we don't think they can have the impact"*.

Almi's GreenTech Fund backs "Swedish early-stage startups that significantly reduce greenhouse gas emissions. Almi welcomes all companies and business concepts that have growth potential". The investment analyst at the fund asserts, *"We're an active owner in the company. So our main thing that we look at is CO2, but also the classic, I guess, venture capital criteria before investing in a company about the team, the business model, the you know.. growth rate"*.

At Sting, while the target includes projects that "solve a major problem in the market, is based on an innovative technology and will have a positive impact on the SDGs", there are other criteria given equal, if not more so weight in the decision-making process. For the coach engaging "sustaintech" startups at Sting, *"Scalability. That's really what we're looking for. Your team and the disruptiveness. And also the fact that it's an international need or demand or global demand. It's our rules and we do not work with companies that wouldn't have a very large potential outside Sweden as Sweden is such a small country"*. Similarly, WIN also asserts its objective of "enabling game changing (disruptive) solutions to faster reach the global market".

The programme manager at Vinnova asserts the importance of funding applicants having *"some kind of sustainable strategy, either the company should be sustainable or the solutions, or the idea they have should address one or several of them in the agenda 2030*", but also highlights other important criteria " *what we focus on is the gender, of course there are some been a lot of research around around this since the 60s. Clearly mixed teams have more conditions to take more qualified decisions than homogeneous teams. That's why we have it as one of our criteria, that they should have a gender equality strategy*".

An interesting notion presented by Trellis Road is their consideration of the demand groups for a particular innovation, and how that affects the capacity for achieving substantial impact. Highlighting a rejected project, *"Very.. yeah, upper middle class target group that we've said no to, for that specific way because we've said that we don't think this product can become mainstream. We think it's the price..just going to be too high, even in the 10-year perspective. So it's actually not going to have that impact"*, they contrast it with similar innovation, but having greater potential for impact : *"They have, for example, on purpose ... more on purpose going directly for a mass market approach and that was something that we were really nice with acting from an impact perspective."*

This section has presented an overview of the criteria that the innovation actors utilize to arrive at target projects for aiding innovation. Potential for growth and scalability emerges as a key criteria across all organisations. There are assertions about consideration of environmental sustainability, however, these are not often based on any

concrete criteria. Concerns about social dimensions of innovation development remit brief mention.

4.2.4 Innovation Implementation

The section gathers findings on innovation actors' conceptions on the innovation process and the requirements for its achievement.
Innovation actors emphasise the role of entrepreneurship in achieving innovation. Further, a key assertion from various actors is the importance of collaborations between various actors that might constitute an innovation ecosystem and enable entrepreneurial ventures. Trellis Road finds that *"I think one of the main sort of take-aways from those years is that I truly believe that startups can create so much change. If you look at the climate challenge, for example, I think we need so many different types of movements. We need policy regulation, and we need consumer awareness, but I do think there's such an incredible amount of power in young individuals, especially deciding to focus on one particular problem and do something about it. And I think it often seems naive to outsiders to be like, okay, I think these startup founders can actually have a big impact, but I think if you spend time working with startups in other sectors, you can see that's actually a reality*".

Axfoundation believes that "entrepreneurship is a powerful force for change. Axfoundation uses business as an accelerator of long-term transformative change". Alongside this, they assert that the kind of complex societal challenges that they seek to address require "broad collaborations between relevant actors in society" and position themselves as "a bridge between parties who would likely not otherwise cooperate" (Axfoundation).

For Vinnova, there are various dimensions to an effective innovation network, and should not be mistaken to be as "institutions to support R&D and help startups over their initial funding difficulties...Firms would struggle to innovate on their own, without interaction with a nurturing environment of both private and public supporting actors and institutions for example higher education, consultants, standards bodies, capital markets et cetera" (Elg 2014).

For Formas, which mainly funds research, synergetic co-operations are important, particularly to help realise research outcomes, and to create feedback loops. *"We have calls [for funding] where you can apply to spend some time outside academia and also where people from outside academia can spend some time- as a sort of exchange program - where we hope to get that can lead to a sort of implementation of research in real life." Moreover, even when funding innovation, "we require cooperation between an academic partner and someone from the private sector or the public sector or both".*

WIN, which has constructed a member body composed of small innovative companies and institutions it deems partners in aiding those companies – large corporations, universities, water utilities, emphasizes how the support it provides to innovation companies also aids these partners. "They all represent the market need for new solutions and innovations. Our partners get a good view of trends and business intelligence; WIN can be an eye opener for what is possible and which technologies could replace the outdated ones "(WIN).

4.3 Narratives on Growth

Ecosystem actors frame scalability of the technological innovations and financial returns as of prime importance for their support of new ventures. Scalability and growth are not assigned further values. They assert the

importance of sustainable dimensions of ventures and their technologies, but growth in monetary performance is never presented as subordinate to those aims. Further, as in the example furnished by Trellis Road, growth is sometimes presented as crucial for achieving the desired environmental and social impact.
The startups do not shift norms or question formal rules of pro-growth financing or business support, even if concerns on sustainability are asserted as primary aims. In isolated- instances, evaluation of financing options led to the dismissal of quick-growth demanding venture-capital. Further, the aims of development of organizations are not presented as one sustained by, and serving regional and local markets, but for expansion into international borders.
On the whole, challenge to economic discourses and practices of growth is not presented by the any of the actors.

5. DISCUSSION

The discussion builds upon the findings of the study in order to address the research questions posed earlier and contextualizes them within the theoretical foundations of the concept of degrowth and innovation ecosystems.

5.1 Narratives on technological innovation

The subjects of the study present research and innovation in Sweden as one of the main drivers of development and prosperity. Research, investment and funding policies highlight technological innovations as contributors to industrial development as well as broader societal change, especially related to the environment. The role of technology is central within the framework. The agenda follows the thread of green growth, with the idea of sustainable development linking environmental and economic objectives. Technological advances are linked to driving economic growth, the creation of jobs and, particularly, the increase of Swedish competitiveness on a global scale. While traces of degrowth positions exist in the innovation ecosystem, generally there is dominance of one framing of innovation advantages, which serves as an indicator for the prospects of degrowth-oriented policy.

There is some limited evidence of the agenda evolving beyond classical growth. There are attempts to combine a growth focus with other developmental goals, including environmental and social criterion, but these cannot be taken as indications of anything other than merely an adaptive agenda.

The Swedish Innovation Strategy encapsulates this, wherein business growth is the ultimate aim, delivered by innovation. “Sweden is a small market whilst development and production across the world is becoming more and more specialised. This produces markets that are niched for different goods and services globally. In order to develop the Swedish innovation climate, it is therefore important that businesses in Sweden, both large and small, have a strong position in interlinked global value chains and knowledge networks”.

5.2 Implementation of Innovation

Ecosystem frameworks and infrastructure are important factors for entrepreneurial innovation in Sweden. Innovation is sustained and developed by the creation of networks between startups, investors, funding agencies, accelerators & incubators and universities. This had been the assumption behind the selection of interview

subjects, and has only been re-asserted by the information collected through the process. The innovation processes are developed through the exchange of information, with actors from different areas of knowledge, organisations, disciplines and sectors meeting and collaborating. This process represents elements of conviviality, wherein no matter the goals of the innovation, its development is contextual and dependent on local knowledge, values, purposes and worldviews. Furthermore, the origins of startups at universities highlights their value and role in innovation. Universities create forums for people to develop knowledge, creativity, expertise and driving forces and aid in the implementation of new solutions. Conviviality is again constituted within this process, as innovations build on, as well as support local knowledge and skills.

Access to capital is highlighted as a fundamental importance for a business's capacity for innovation. Initiatives towards the development of the financial system and promotion of a business's supply of capital are therefore an important element of the improvement of the innovation climate. Currently, institutions both at the public and private level do not institute any significant dimensions of sustainability that could be aligned with degrowth.

5.3 Innovation as agent of change towards a Degrowth society

The technological innovations developed by the assessed startups all aim to make maximum use of all renewable resources. These feasible technologies also inculcate viability, as the emphasis on renewability of the products is often asserted. The innovation ecosystem itself suggests convivial notions and suggests all the possible dimensions that would need to pivot for a degrowth alignment. However, the operationalization of these technologies are constituted in an environment wherein growth narratives prevail. Success of an innovation is still marked by its ability to be scaled up and dispersed widely. A wide perspective on context structures and selection pressures is warranted when encapsulating innovation processes.

Moreover, degrowth literature is strong on socio-economic and ecological critique, however few transitional pathways are proposed. A critical problem at this juncture is that the sort of macro-level goals about resource extraction, property, or employment are distant ideals. Promising micro-scale developments, particularly in technology are buffeted by the hostile context of neo-liberal agenda.

6. CONCLUSION

Degrowth presents a shift from a negative perception of limits as obstacles to a positive perception of limits as important boundaries. As planetary boundaries are breached, and conception of decoupled growth and materialism is failing, it is a uniquely pertinent perspective. An analysis of the Swedish innovation context in an attempt to identify bridges for a degrowth-aligned economic transition yields frustrating findings. Consciousness about the limitations of technological innovation and the limited extraction and assimilative capacity of the planet exists, but the efforts indicate minor adaptive measures, and no bridges to any radical transition.

However, a contribution of this thesis is to make visible the practices and narratives of the innovation network, in order to repoliticise economic discourses and process, while laying out the possible avenues to be challenged to in order to pivot to degrowth-aligned principles. Beyond this, a suggestion for explicit government policies supporting degrowth-aligned innovation and the value in doing so is to be asserted. Moreover, development of performance metrics that specifically focus on degrowth are needed. The material impact of the organizations presented is hampered by and limited in challenging market logics; highlighting the small shifts in narratives and practices of organizations, presents important, first stepping stones towards at least growth agnostic economies.

6.2 Limitations

One can identify certain limitations to the research study. The nature of cases selected imposes limitations. For instance, all firms researched were startups. The study could have benefited from including firms of a variety of sizes. Studying innovation firms of different sizes or more established firms could also be useful for a comparative analysis where differences in implementation of degrowth-aligned elements could be identified. The inclination was to study firms which operate in different industries but that can lead to insights that are diluted or lacking in depth. Moreover, the firms studied do not capture the scope which would represent all industries. Moreover, conducting the study at a certain location imposes limitations. Since the firms studied are based in Sweden, experiences of firms and obstacles they may face can be different in alternative contexts such as different countries, due to differences in legislation, culture, political and economic settings.

One limitation arises from degrowth being a relatively nascent concept, and the nature of innovation and production for degrowth not having certain consensus criteria or being well defined.

6.3 Future Research

Following the limitations of the study, a further scope of research could be carrying out an assessment of a single industry's capability towards achieving a degrowth transition, since industry-specific insights could yield more pointed insights about degrowth elements.

Another avenue to research could be identifying, and developing performance metrics for a degrowth-aligned innovation agenda which would ease the evaluation of innovation processes and allow for the similar studies in a variety of contexts; a map of characteristics for transition towards degrowth, which can be used by researchers, firms and policy-makers.

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