Fostering Regenerative Processes Through Responsible Advanced Design and Circularity

4. Fostering Regenerative Processes Through Responsible Advanced Design and Circularity. The Emergence of Collaborative and Ethical Practices in Complex Sectors: The Case of the Packaging System

Abstract This contribution moves from the convergence of the systemic approach of Advanced Design (AD) with the principles of Responsible Innovation (RI), with the aim of promoting more collaborative and ethical practices in complex scenarios. Responsible Innovation originates from the broadening of the scope of the so-called 'Responsible Research and Innovation' (RRI), established by the European Community. From the overlaps and integrations between the principles of RI and the tools and practices of AD, Responsible Advanced Design (R-AD) arises as a new approach to change and regeneration, especially to address current crises. R-AD relates deeply to the concept of Regenerative Sustainability, which takes more account of the particularities of different contexts and brings sustainability to a more holistic view. To include both the three dimensions of Sustainable Development – environmental quality, economic prosperity, and social equity – and key concepts such as People, Planet, Prosperity, Peace, and Partnership, as promoted by the SDGs, circularity and its 9Rs strategies were then considered to be integrated into the R-AD approach. This led to the definition of an extended conceptual model of anticipatory, cooperative, and transformative design, essential to address current crises, from a local and global perspective, and to foster regenerative processes in particularly challenging sectors. To refine and test the model, it was thus applied to the analysis of a selection of case studies, both from the Mediterranean region (Italy) and Latin America (Chile), choosing as an exemplary field of study the so-called Packaging System, which is a multidisciplinary and cross-sectoral system involving different actors and interchange relationships for the development of a complex artifact such as packaging.

4.1 Responsible Advanced Design as a New Approach to Change and Regeneration

4.1.1 The Advanced Design Approach

Within the so-called "new galaxy of design" [42, p.19], in recent years, numerous theoretical reflections have emerged on how design practices and approaches offer different perspectives and possible solutions to respond to current crises, with the intention of sustaining change and regeneration and to activate more inclusive forms of innovation capable of considering both the environment and what is part of it among the stakeholders [6]. Among this multitude of approaches, this paper focuses on Advanced Design (AD), framed as part of Design of Processes and seen as a systems approach that relies on multi-stakeholder collaborative practices that can drive transformative change within the realities in which it operates.

As early as 2009, AD began to raise questions about "the relationship between the evolution of the time factor and design-driven innovation" ([13], cited in [10, p.22]), bringing to light how the concept of anticipation and future studies [49][50][66] can be drivers to support an "advanced design approach" capable of responding to the complexity of the ever-changing innovation dimension. The maturation of this methodology, as emerges from the reference literature [14][27][35][12] leads it not only to open the vision of industrial design to the concepts of anticipation but to propose itself as a discipline (approach) that intervenes in the complexity of relationships related to the changing context [8], and the processes of innovation conditioned by environmental and social factors and lack of resources.

In fact, even for AD, sustainability (of processes, relationships, innovation, etc.) is a point of interest and investigation. Through the factors that characterize it, it intervenes on two levels of the design process: the first aimed at the community, trying to change people's behavior by involving them in the value chain through the application of its principles; the second aimed at the designers themselves, leading them to reflect on what the impact of their work might be in the long term.

Celaschi [8][9] and Iñiguez Flores et al. [36] have defined attributes and areas of intervention that characterize AD in comparison to other approaches and that support their application in real-world contexts. The analysis of the contributions and experiments carried out in recent years by the Advanced Design Unit (ADU)[1] at the University of Bologna, and the Latin Network for the Development of Design Processes,[2] has led to delve into AD on a theoretical level, creating a synoptic framework of the elements that characterize it and highlighting the gaps on which we

[1] https://adu.unibo.it/

[2] https://www.forumdesignprocess.org/dgdw22/past-editions/

need to intervene to make design approaches more responsible, ethical and collaborative and in line with the Sustainable Development Goals (SDGs) from UN's Agenda 2030[3] and the Green Deal of the European Commission[4] meant to outline interventions to transform policies on energy, climate and circularity.
The above-mentioned synoptic framework considers four integrated and interconnected macro-fields of action [56][57] and constitutes a system of application for the various contexts in which AD operates. These macro-fields are defined as follows.

1. *Time, Future, and Anticipation*. AD by its very nature is an approach that connects past, present, and future, and inserts the time factor as a field of action [11] within the design process, seeking to "anticipate change, and to make it accessible through the materialization of processes, paths, artefacts and conjectures" [15, p.807]. AD is based on the ability to imagine possible, probable, potential futures [12] and applies to the context reacting to changes through continuous innovation.
2. *Innovation of Collective Sharing Processes*. People, the community, and the territory (productive, institutional, etc.) are the actors and active agents for the development of new design forms capable of responding to current challenges. Therefore, the AD through co-design processes and collective intelligence practices seeks to involve all the actors of the territorial eco-system along the value chain [10] thinking that "the collective, social and shared construction of the vision is the key to the success" [10, p.28] of more sustainable products, services, systems.
3. *Transformative Innovation*. It is based specifically on three principles: i) adaptivity [46][36], through which AD supports change and activates collective forms of learning, and allows design to read critical issues into opportunities through the anticipation of practices; ii) sustainable transformation, leading designers to reflect on what their responsibilities are in transforming the way individuals and communities act in projects; iii) cultural change, through iterative and continuous experimentation, creating forms of design that start from the future and lead to changes in the present [12].
4. *Knowledge Innovation*. The sharing of knowledge and the activation of collective knowledge constitute forms of innovation [12] characterized by: (1) interdisciplinarity and cross-fertilization between both academic and non-academic competencies; (2) forms of "Reflection-in action" [53] in which design is read as a reflective practice; (3) "learning by doing" training systems and by the collective [36] and co-produced learning processes.

[3] https://sdgs.un.org/goals

[4] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

4.1.2 The Emergence of Responsible Advanced Design

Through an integrated and cooperative approach, AD aims to outline possible futures towards which to move. However, it must integrate with other systems and approaches, not typical of design, to adapt to the current emergencies, such as lack of resources, climate change and technological acceleration, and the demand for systems and forms of innovation that are more responsible, ethical, and capable of involving all players in the territorial ecosystem in a more inclusive manner.
AD has thus opened to the principles and concepts of Responsible Research and Innovation (RRI), formalized in 2011 in the context of the European Community's development policies and included – since 2013 – within the Horizon 2020 projects. RRI is an approach that anticipates and assesses the potential implications and expectations of society regarding research and innovation, integrating in the projects some identifying concepts that can be summarized in six pillars: Ethics, Open Access, Gender Equality, Public Engagement, Science Education, and Governance [2]. RRI implies that societal actors (researchers, citizens, policy makers, companies, institutions, agencies, etc.) collaborate throughout the research and innovation processes to better align the results with society's values, needs and expectations [26, p.8-10][25][62].
In addition to the emergence of RRI within European Community policies, the concept of Responsible Innovation (RI) has also been established in academic research [37] and experimented in different application contexts, such as education, manufacturing, social, etc.
According to Stilgoe, Owen & Macnaghten [55] anticipation, reflexivity, inclusivity, and responsiveness are the four dimensions most frequently used as the framework for further implementation of RI. In their contribution, as well as in subsequent academic research and discussions, it is emphasized that these same dimensions coexist in an integrated way in the process.
Further key dimensions of RI of particular interest for this reflection are Care [5], Time, and Transparency. Such dimensions, together with anticipation, reflexivity, inclusiveness, and responsiveness, complete the reference system that aims to enhance forms of RI within the complexities of territories. Taken together, these seven principles, when integrated with AD, can provide the framework for establishing the approach of Responsible Advanced Design (R-AD) [58][56].
This systemic inclusion allows the AD approach to incorporate a co-construction of the future strongly characterized by a multidimensional quintuple-helix [6][33] collaborative system, as well as inclusive and ethical design, production, learning and decision-making processes to innovate products, services, organizations, and processes cooperatively and responsibly. Also, the seven dimensions of RI assumed as drivers of the R-AD approach make AD more permeable to the intrinsic values of the context, more sensitive to assessing the impact of design actions throughout the process (from conception to implementation), and more attentive to considering and listening to a wider sample of stakeholders.

The resultant seven dimensions of the R-AD approach then are:

1. *Anticipation*. AD interprets anticipation as “the exploration of the infinite possibilities open to the imagination [where the design process] contributes to building the future” [11, p.131]. RI uses it to predict the effects of a given project proposal while also assessing its risks [40] and surfacing potential impacts to respond with sustainable solutions [20].
   Features: ethical and inclusive public engagement, open access of design practices and the dissemination of knowledge, ethics in the design process and in the involvement of people.
   Tools: to make this process closer to reality and adaptable in the long run, it is necessary to activate co-design practices by developing collective anticipatory imagination and problem solving; it is also necessary to use tools to measure the social, economic, environmental, and cultural impacts not only of products/services but also of the design process.
2. *Reflexivity*. Within AD, the designer is not seen as a sole authorial figure, but as a professional capable of activating an open design space in which users and community can be heard and can bring their input into the process of conceiving and developing ideas. In RI "responsibility makes reflexivity a public matter" ([65], cited in [55, p.1571]) bringing to light the role of the individual as a social engagement in the project [40].
   Features: principles of transparency about actions, processes, and results; user involvement through responsible forms of knowledge and learning; peer to peer innovation education; enabling non-stereotypical project thinking.
   Tools: use of tacit knowledge, experiential, interactive and collaborative learning systems, internal to the realities involved or open to the whole community; the development of multi-level formats such as seminars, training days, peer-to-peer meetings or academies guided by design practices can make these systems more permeable and more collaborative.
3. *Inclusion*. It could be meant both as the "continuous involvement of society" [32, p. 2969] and as an open process capable of accommodating all the groups of actors that are part of the territorial ecosystem. In order not to fall back on an already pre-established information process, it is necessary to activate collaborative forms of actor involvement by working on both micro and macro scales and by bringing out the contribution of both the individual and the community.
   Features: encouraging ethical, transparent, and universally accessible forms of co-creation; involving interdisciplinary expertise; respecting diversity and incorporating gender equity policies in the various design, production, communication, and training processes.
   Tools: use of co-design practices that follow the responsible-driven characteristics of the model, application of responsible design concepts not only at the product/service conception stage but throughout the value chain.
4. *Responsiveness*. This dimension is interpreted in the sense of the ability to adapt to the spatial capital present in each context and to react fluidly to the sudden

changes we constantly experience, thus being able to scale and vary the project according to what we are facing.
Features: responding actively and ethically to the transformation of the planet and the lack of resources; activating and maintaining a collaborative network between actors.
Tools: within this dimension, AD is the discipline that through scenario design and prototype development can think of different ways to anticipate problems and is able to find solutions to meet ecological, economic challenges.

5. *Care*. It is "a peculiarly human activity that includes everything we do to maintain, preserve or adjust our world, with the goal of living in it under optimal conditions" ([59, p. 3], cited in [58]). This concept relates to caring for self, others, community, and planet [23] and thus caring for the future with the aim of rethinking the way we innovate and the principles and policies to achieve it.
Features: building new sustainable and inclusive behaviors and processes; and anticipating the needs of others and the planet.
Tools: the use of design semi-finished products, a typical tool of AD, leads to having a set of possible paths to follow as a basis for building new designs more in line with future demands from past experiences [12][10]; in addition, the use of responsible-driven impact monitoring systems can help to keep products alive longer.
6. *Transparency*. It pervades and characterizes many of the other dimensions. The principles of transparency are incorporated within the project actions, starting as early as the preliminary stages (team definition) to the long-term verification of the viability of a project.
Features: making the project, production, distribution, actions, peculiarities, and limitations visible and accessible. Involving the various actors through open and inclusive dialogue systems. Informing in an ethical manner.
Tools: the tools are the same as those described in the other dimensions enhanced by principles of transparency.
7. *Time*. Different levels of time and its relationship to different spheres are considered in the actions and tools implemented by R-AD: the time of impact in relation to change, which usually takes place over a long period of time and must be compared with the accelerated or slow pace of what surrounds us (humans, non-humans, environment, etc.); the time of people; the time of a productive process; the time to make a relationship cohesive; the indefinite time of certain actions; the time of adaptation; the time in which innovation processes can change; etc.
Features: respecting the time of people and the environment; activating forms of collaboration and knowledge between the actors of the inclusive territorial ecosystem; considering time as a project variable [9][11][12].
Tools: imagination (through scenarios and prototypes that imagine possible, probable, and potential futures).

4.2 Responsible Advanced Design and Circularity for Regenerative Processes

4.2.1 Regenerative Sustainability and Circularity as Key Factors for Design Practices

As seen so far, R-AD is an approach that arises from the overlaps and integrations between the principles of RI and the tools and practices of AD. This approach relates deeply to the concept of Regenerative Sustainability [30][63], which takes more account of the particularities of different contexts and brings sustainability to a more holistic view [31][34]. According to Leah Gibbons [30], "regenerative sustainability focuses on transforming the worldviews, paradigms, and thinking underlying manifested reality and, thus, (un)sustainability" [30, p.4].
Regenerative Sustainability is rooted in various design practices and theoretical perspectives that over time have promoted key concepts such as responsibility, care or the virtuous relationship between humans and nature, traceable to authors such as Victor Papanek [47] or Victor Margolin and Sylvia Margolin [45], to name a few. In addition, it has its foundation in design approaches such as Ecological Design [61], Regenerative Development and Design [43][44] or, more specifically, Regenerative Design for Sustainable Development [41]. These approaches have allowed Regenerative Sustainability to evolve, leading to the development of a more systemic perspective, capable of working across multiple domains and scales of territories and actors.
Regenerative Sustainability integrates complex systems in a deeper and more balanced way and sees ecosystems as networks of dynamic processes in connection with each other, adapting not only to human needs but also to those of other living things, where the role of community is crucial in developing processes of behavioral change, relationships and coping with ongoing social, economic, and environmental crises. The system of interaction between people, environment and the natural system that fosters a form of cooperative, co-evolutionary relationships to achieve co-benefits [19][44][34] "encourages all system components to evolve, regenerate, and produce more than they consume to improve both the ecosystem's health and people's quality of life" [34, p.5].
The need to go 'beyond sustainability' that underlies Regenerative Sustainability has fostered the development of several projects and experiments in which regenerative processes have been applied to different fields, including architectural design, urban and regional planning [67]. Moreover, it is also of particular interest in the field of production, and in the development of product systems that have a strong impact on the territory in all its complexity, from an environmental, cultural, and social point of view.

Based on the point of view of Jenkin and Pedersen Zari [38] who see Regenerative Design as a linear system of production flows that is transformed into a cyclic system, it is arguable that the concept of 'regenerative process' in the field of our interest (product system) can be linked to the concept of Circularity.
In this perspective, it is useful to recall the definition of Circular Economy according to the Ellen Macarthur Foundation,[5] which refers to it as a systemic approach to economic development designed to benefit business, society, and the environment: in contrast to the linear economy model, circularity "is restorative and regenerative by design" [22]. Our approach to regenerative design thus draws on this notion of circularity, which aims to iteratively build and rebuild the overall health of the system in which it operates.
In recent years, the concept of circular economy has been investigated, particularly for its operational vision applicable to the world of production that can align with the parameters of sustainable development [29][39]. In defining the principles and practices characterizing and operationalizing the circular economy in different contexts, the so-called 9Rs framework has emerged [24][68][52][54][60][51]. According to a schematization by Kirchherr et al. [39, p.224], adapted from Potting et al. [51, p.5], in this framework each "R" refers to a specific circularity strategy:

- *R0 Refuse*. Make product redundant by abandoning its function or by offering the same function with a radically different product.
- *R1 Rethink*. Make product use more intensive (e.g., by sharing product).
- *R2 Reduce*. Increase efficiency in product manufacture or use by consuming fewer natural resources and materials.
- *R3 Reuse*. Reuse by another consumer of discarded product which is still in good condition and fulfils its original function.
- *R4 Repair*. Repair and maintenance of defective product so it can be used with its original function.
- *R5 Refurbish*. Restore an old product and bring it up to date.
- *R6 Remanufacture*. Use parts of discarded product in a new product with the same function.
- *R7 Repurpose*. Use discarded product or its parts in a new product with a different function.
- *R8 Recycle*. Process materials to obtain the same (high grade) or lower (low grade) quality.
- *R9 Recover*. Incineration of material with energy recovery.

The strategies are numbered according to the degree of circularity that can be achieved through them, inversely proportional: from R0, which coincides with maximum circularity (circular economy) to R9, which corresponds to low or no circularity (linear economy). The strategies are also divided into three main categories based on the circular economy goal to be achieved and elaborates possible courses of action to achieve them:

[5] https://ellenmacarthurfoundation.org/

- Smarter product use and manufacture (R0 > R2).
- Extend life span of product and its parts (R3 > R7).
- Useful application of materials (R8 > R9).

The 9Rs framework is of particular interest because more than others it defines strategies for making systems truly circular. From 2008 to 2017, thanks to the work of several authors [51][60][39], it has been possible to model and implement this framework, expanding on the so-called 3Rs – referring to the actions of Reduce, Reuse and Recycle – which dates to the first Earth Day in 1970.

4.2.2 Integrating the 9Rs of Circularity with the Responsible Advanced Design Approach: An Extended Conceptual Model

According to Geissdoerfer et al. [28] and Kirchherr et al. [39], authors who have dealt with the Circular Economy have not yet equally considered the following factors: the commitment to strengthen and improve societal welfare at the level of social equity; long-term strategies in relation to future generations and thus the time dimension; and the role of consumers and the community within the process.
Based on this premise and what has been discussed so far, to develop a "'holistic view' of environmental quality, economic prosperity, and social equity as three dimensions of Sustainable Development" ([64][21], cited in [39, p.227]), as well as to respond to the need to include key concepts such as People, Planet, Prosperity, Peace, and Partnership, as encouraged by the SDGs, circularity and its strategies (9Rs) were considered to be integrated into the R-AD approach.[6] This led to the definition of an extended conceptual model of which the dimensions, as described above, are Anticipation, Reflexivity, Inclusion, Responsiveness, Care, Transparency, Time, and Circularity.
This model can thus be useful for analyzing both existing realities and for guiding more collaborative, ethical, and ecosystem-based practices for regenerative processes, which are essential for addressing current crises from a local and global perspective. This model thus allows us to analyze case studies or guide design projects through a framework that verifies not only whether they have been applied e.g. recycling, reuse or repair systems from an environmental perspective, but also how they have been implemented within a context at the social and cultural level, e.g., whether they have adhered to principles of equity, whether they have involved through transparent and inclusive processes the actors in the system, etc.

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[6] This theoretical investigation is currently undergoing and is also being applied in research projects funded such as "Made in Italy Circolare e Sostenibile" (https://www.mics.tech), particularly within the thematic line "Spoke 1 - Digital Advanced Design: technologies, processes, and tools". This project was developed under the Extended Partnership, line 11 of the PNRR (Italy's National Recovery and Resilience Plan).

To refine and test the model, it was applied to the analysis of a selection of case studies, both from the Mediterranean region (Italy) and Latin America (Chile), choosing as an exemplary field of study the so-called “Packaging System” [16][17], which is a particularly complex, multidisciplinary, and cross-sectoral product-service system involving several different actors and interchange relationships.
In addition to its peculiar complexity, the choice of this field of application is due to the authors' participation in the activities of the "Packaging Innovation Observatory”,[7] which is the result of a research project carried out by the Advanced Design Unit at the University of Bologna. The Observatory was conceived in 2019, then implemented and formalized in 2021, with the aim of monitoring, interpreting, narrating but also acting on innovation processes related to packaging, not only as an object but as a cultural phenomenon, an expression of contemporary complexity. Design, understood as a mediator between the knowledge [7] of different scientific and technological fields, was the starting point of a process of analysis and design to create a system capable of spreading knowledge and multiplying collaborative projects in the packaging sector in its different declinations, as well as to bring out the trends of responsible innovation in this context. The role of the Observatory is therefore not only research and analysis around packaging to monitor the state of the art, but also storytelling and networking, with the aim of triggering innovation processes.

4.3 Packaging System as an Exemplary Scope in a Transterritorial Perspective

4.3.1 Packaging System as a Complex Sector Coping with Current Crises

Packaging has considerably expanded its functions over time. It is an object of use, which allows to contain the product, protect it, store it, transport it, and at the same time, facilitate its physical interaction with the user. Also, it is a communication device (communication prosthesis), characterized by functions, among others, of appellative, persuasive, informative and prescriptive kind [4][16][17].
Packaging is a complex artifact that, beyond its nature as an object of use, is in effect a driver and accelerator of the social, economic, and environmental phenomena in which it is immersed and can convey socially or environmentally relevant messages and information, affect quality of life and climate, monitor safety, and connect people and businesses.

[7] https://adu.unibo.it/osservatoriopack/

For its multifaceted nature, the project of a package requires different skills and the intervention of multiple disciplines: for that reason, it should be understood as the result of an integrated set of choices made by a plurality of actors, where each performs a specific role – direct or indirect – in its definition. These actors, together with the relationships that are established throughout the product life cycle, define the so-called "Packaging System" [16][17], in which design may play an important role in direction and mediation, potentially giving shape through the project synthesis to solutions which are an expression of the confluence of the needs of the different parties involved and the multiple functions of the artefact, linking the communicative dimension to the operational and instrumental aspects, along with the perspective of process and the anticipatory vision of experimenting with materials and production systems.

Within this system, all the actors of the supply chain are involved, from the designer to the producer, from the distribution system to the end consumer: a plurality of subjects operating in an interconnected manner, in a value chain that is referred to as the "Value Web" [3].

If we look at innovation processes - to be understood as the ability to adapt to change - within this system, the most effective ones have indeed proven to be those where quintuple-helix forms of collaboration are activated [6], where all stakeholders can collaboratively intervene in packaging development from the earliest stages of design, and where the results of experimentation and design practices with a regenerative approach can have an immediate impact on the market, not only in terms of the product or service, but also of a means of communication that can convey responsible and ethical messages, responding to current emergencies (social inequalities, climate change, etc.). Packaging, in fact, is considered by public opinion to be one of the causes of the various crises that plague the planet, crises of an economic, social, environmental and health nature [18]; moreover, it is a ubiquitous artifact in our daily lives, significantly influencing our needs as a society, community and productive culture [16][17].

The community of people working in the Packaging System today must be resilient and sustainable, an indispensable but difficult transition for the manufacturing world. The need to embrace change and thus trigger innovation requires a new way of reading the design and production process, the relationships that underlie it and the impacts it generates and must rely on a renewed system of tools and practices to move through this constantly adapting reality. As Carmelo Di Bartolo explains, quoting Renzo Piano in turn, "when you make innovation you have to create the tools to make it" [48].

4.3.2 Advanced Responsible Design and Circularity as Keys to Changing the Packaging System

The stakeholders in the Packaging System operate in a sector that is highly V.U.C.A. - i.e., with a high degree of Volatility, Uncertainty, Complexity and Ambiguity [1] - and highly globalized, but at the same time very specialized and tied to the territory. A significant example in the Mediterranean area is the concentration in Italy of packaging machinery manufacturers in the so-called "Packaging Valley" in Emilia-Romagna region; on the other hand, in Latin America, taking the example of Chile, in addition to the high concentration of packaging manufacturers and processors in the country's capital, manufacturing districts have sprung up in the northern and southern areas in recent years, linked to the food sector, both to foster economic growth in the more peripheral areas of Chile and because of the strong link with local production in those territories.
In a globalized and connected world, where packaged goods circulate nationally and internationally, this specific ecosystem of actors has similar characteristics in different and even geographically distant places, such as in Chile and Italy. Therefore, the differences between these two realities do not relate to the Packaging System itself, but to the specific socio-cultural, political, and economic factors of each country, as well as the degree of maturity specific to each geographic area.
The variables of complexity of the territorial and cultural context add to the already articulated network of supply chain relationships, forcing companies to innovate, to continuously adapt to changes induced by current and sudden emergencies, drawing on solutions that also come from other territories and in a logic of cooperation with the ecosystem, while implementing responsible and regenerative solutions. This ability to adapt to transition is challenging and complex, not only for small and medium-sized enterprises but also for planners, professionals, and trainers.
In this changed global scenario, Responsible Advanced Design intertwined with circularity strategies can thus take on key value in driving change actions in the Packaging System. In addition, precisely because of the kind of "regenerative" and circular vision that is required of us at several levels, packaging is also configured as a cultural path to be traversed, in which the consumer can benefit both in educating to new, more conscious and ethical behaviors, and as a tool for transmitting his or her thoughts, becoming an active player in the process, also thanks to enabling technologies, in a multidirectional dialogue that can also start from the user and reach the brand and any other player.
Consequently, the application of the proposed conceptual model-Responsible Advanced Design intertwined with Circularity-to the Packaging System can lead, on the one hand, to an understanding of which projects are already in line with a regenerative process and, on the other hand, to an understanding of where it is necessary to intervene with more responsible and inclusive actions to move more and more toward Regenerative Sustainability.

4.3.3 Case-Studies

The conceptual model resulting from the integration of the Circularity and the 9Rs framework [39] with the Responsible Advanced Design approach was then applied to selected case studies from Italy and Chile, which are two countries that, as already anticipated, are geographically distant but not so different in terms of the complexity of the packaging sector in each area and its close relationship with the territory. Three projects were chosen for each country in relation to the three main categories into which the 9Rs of Circularity strategies are grouped.

4.3.3.1 Smarter Product Use and Manufacture (R0 > R2)

This category includes Refuse, Rethink and Reduce strategies, which take place when products are conceived, designed, and developed; such strategies are precursor, enabling, and transformative. Precursors, because they occur before other strategies. For this category, the projects selected for analysis are Eco Piping Bags (Italy) and Algramo (Chile).

Eco Piping Bags

Eco Piping Bags[8] is a system of innovative and sustainable flexible containers for skin care products that aims to change the way we use cosmetics, by introducing a new packaging solution as a replacement for the traditional rigid bottles. It is a project developed by UNIFARCO in collaboration with UNIRED, spin-off of the University of Padua. The main features of this product are the following.

- Packaging is minimized, as well as being fully compostable and biodegradable.
- The technological transfer of the shape, reminiscent of a pastry *sac à poche*, affirms new expressive coordinates and proposes consumer experimentation with new usage patterns.
- The primary container consists of a custom-made "pouch" for cosmetic use coated with a special paper that provides a better grip and a pleasant tactile experience; the format of the secondary packaging, a parallelepiped with a square base, is designed to easily place the primary container on the store shelf or in home environments.

The project implements:

- Circularity strategies R0, R2;

[8] https://unired.it/insights/eco-piping-bags-tra-i-vincitori-del-best-packaging-2020/

- the R-AD dimensions of Responsiveness, Anticipation, Inclusion, Time, and Care.

A transversal analysis shows that more could be done on the dimension of Reflexivity, thinking about forms of active consumer education to make the paradigm shift understood in a positive way, and on Transparency, highlighting the process and connections within the supply chain.

Fig. 4.1 Eco Piping Bags by UNIFARCO in collaboration with UNIRED.

Algramo

Founded as a startup in 2012 in Chile, Algramo[9] is a product-service system based on refill stations for bulk products. Its mission is to create a solution that responds ethically to the environmental and social needs of a cross-section of people who want to make conscious purchases and care for their own well-being and that of the planet, but with limited economic capability. In addition to moving towards social justice, this product is also concerned with the impacts that packaging has on the environment. The main features of this system are:

- buying food, personal or household products in bulk to get away from the logic of large-scale distribution, reducing waste, optimizing the cost of purchasing by consumers;

[9] https://algramo.com/

- combining in the same system the dispensing of a precise quantity of a product and payment through a vending machine;
- supporting a local economy (at neighborhood scale).

Currently, Algramo is implemented in several countries around the world, and it is based on a reusable and consumer-desirable smart packaging that, through the integration of an RFID chip, allows the consumer to be recognized, monitoring the number of reuses, and awarding them for each reuse.
The project implements:

- Circularity strategies R0, R1, R2;
- the R-AD dimensions of Responsiveness, Anticipation, Inclusion, and Care.

A transversal analysis shows that more could be done on the dimension of Responsiveness, bringing the project also to an immaterial dimension that also pushes it to be a lever to educate the community to a more aware and sustainable type of consume. In addition, work could be done on the Transparency dimension by also making the origin of the product visible.

Fig. 4.2 Algramo refill stations for bulk products.

4.3.3.2 Extend Lifespan of Product and its Parts (R3 > R7)

This category groups the strategies of Reuse, Repair, Refurbish, Remanufacture and Repurpose, meant to retain finished goods and their parts in the economy for longer,

while maintaining or improving their value. For this category, the projects selected for analysis are Brown Lift Lock (Italy) and Green Glass (Chile).

IFCO Brown Lift Lock 6413

Brown Lift Lock 6413[10] is the design of a range of Reusable Plastic Containers (RPCs) made by IFCO for bread and bakery products. It is collapsible and suitable for low and high temperatures; it is designed to ensure maximum quality and freshness from bakery to point of sale, and several benefits in terms of environmental impact. The main features of this product are the following:

- significantly reduced CO2 emissions and water and energy consumption compared to single-use packaging, as well as less food waste and the generation of less landfill waste;
- IFCO RPCs are reused up to 120 times, cleaned and disinfected and, at the end of their life cycle, granulated and used to produce new IFCO RPCs;
- ventilation holes that keep the bread at the right temperature while reducing waste, and a robust structure that prevents damage and crushing;
- a smooth base and inner walls that protect the contents, as well as an interlocking design that allows for safer palletization;
- a mechanism called Lift Lock, designed to close and open quickly and safely;
- ergonomic design ideal for automated systems and equipped with handles for safe manual picking;
- compared to standard disposable packaging, it has good cold storage characteristics in the freezer and is not affected by moisture;
- IFCO RPCs produce up to 60% less CO2 and 86% less solid waste; they also save 64% energy and recover 80% water compared to single-use packaging.
- with its 28 mm height when closed, the Brown Lift Lock 6413 boxes makes maximum use of available space in trucks or storage compared to stackable or rigid bakery boxes;
- finally, it allows an economic advantage for retailers in their fresh produce supply chains: the adoption of this standardized packaging system enables a 25% reduction in handling, storage, and equipment costs.

The project implements:

- Circularity strategies R3, R4, R5, R6;
- the R-AD dimensions of Care, Anticipation and Responsiveness.

The analysis of the case study shows that to make the product more responsible, more work could be done on the Transparency dimension of the entire supply chain and the type of relations activated with suppliers and consumers, e.g., using enabling technologies already incorporated on the product.

[10] https://www.ifco.com/it/soluzioni-alimentari/pane/

Fig. 4.3 IFCO Brown Lift Lock 6413.

Green Glass

Green Glass[11] is a company that recovers waste products, specifically glass bottles, which, thanks to a rethinking process, take on a new form and a new purpose within a different sector. The main features of this project are:

- recovering containers that were so far seen as waste and transforming them into an everyday object: the glass, a product that no longer has the function of a "disposable" container but increases its life cycle because it retains a function of use within the context in which it is placed;
- generating employment for the most fragile sectors of the population such as the "cartoneros" or people working in the process of transforming the product from bottle to glass;
- maintaining the characteristic of a means of communication through the graphitization of the surface of the glasses. In fact, the glass also becomes a tool for telling stories;
- promoting environmental and social sensitivity and awareness. For example, for every purchase a tree is planted, or part of the proceeds are donated to charitable projects. This type of activity increases the social responsibility of the company.

The project implements:

[11] https://www.greenglass.cl/

- Circularity strategy R7;
- the R-AD dimensions of Time, Inclusion, Responsivity, and Care.

The analysis of the case study showed how the Inclusion dimension could be enhanced within the product itself, particularly in the graphic image, which could become a vehicle for narrating the concept of social responsibility.

Fig. 4.4 Recovered and repurposed glass by Green Glass.

4.3.3.3 Useful Application of Materials (R8 > R9)

This group of strategies (Recovery and Recycling) covers solid waste otherwise destined for landfill or burned without heat recovery. For this category, the projects selected for analysis are Rinascimento (Italy) and TheUpcyclingco (Chile).

Rinascimento

Rinascimento[12] is a circular economy project of Icma Sartorial Paper that provides a high value-added service for the company-user, the end consumer, and the environment. It transforms pulp waste recovered from companies into recycled creative

[12] https://www.icma.it/rinascimento/

papers for new packaging projects by the same companies. The project is a virtuous example of material reuse:

- at all production stages, waste materials are tracked to ensure their identification;
- the production chain is shortened: waste is directly used as raw material to produce new paper, eliminating the intermediate step of virgin or recycled pulp production, a process that uses chemicals, energy, and water;
- material handling is reduced due to both the shortening of the process and the design of the service: the company itself designs the circularity chain tailor-made for the customer and chooses partners based on the geographic location of the pulp mill and on the characteristics of the creative project;
- this process management results in less CO2 production.

The project implements:

- Circularity strategy R8;
- the R-AD dimensions of Transparency, Responsiveness, and Care.

Again, the project analysis shows that significant action could be taken on the dimensions of Anticipation and Reflexivity by having several actors of the territorial eco-system collaborating in the design.

Fig. 4.5 Rinascimento circular papers by Icma Sartorial Paper.

TheUpcyclingco

TheUpcyclingco[13] is a project born in 2019 that works on responsible plastic recovery and recycling. It transforms plastic waste, from different collaborations with Chilean communities, organizations, and universities, into new home and play products made of 100% recycled plastic. The project is characterized by:

- a local supply chain from material recovery to its processing; the startup follows the complete cycle from the collection of the plastic material to its revaluation;
- a system of valorization of the partner companies by proposing the development of new products to be returned in a new version to the company; this also supports a form of collaborative environmental awareness that emphasizes how one's own waste can also generate new life within one's own institutional or entrepreneurial reality;
- a policy of also raising consumer awareness by sending a recycling guide with the purchased products.

The project implements:

- Circularity strategy R8;
- the R-AD dimensions of Reflexivity, Inclusion, and Care.

Here it emerges that the dimensions of Anticipation and Responsiveness are minimally considered in the project development phases and could be enhanced.

Fig. 4.6 Responsible plastic recovery and recycling by TheUpcyclingco.

[13] https://theupcyclingco.cl/

4.4 Conclusions

From the research and the synthesis overview of the case studies, it emerges how the R-AD model integrated with the circularity framework allows projects to be observed through a filter that not only investigates the stages of a product's production process, but also focuses on the relationships among the actors in the system, the social and cultural impacts of the product-service, and the intangible principles implemented to achieve sustainability.

Table 4.1 Overview of the analysis of selected case-studies

Selected Packaging Case Studies	Circularity Main Category [from 9Rs Framework]	Circularity Specific Strategies [from 9Rs Framework]	R-AD Dimensions
Eco Piping Bags	Smarter product use and manufacture	R0, R2	Responsiveness Anticipation Inclusion Time Care
Algramo	Smarter product use and manufacture	R0, R2	Responsiveness Anticipation Inclusion Care
Brown Lift Lock	Extend lifespan of product and its parts	R3, R4, R5, R6	Care Anticipation Responsiveness
Green Glass	Extend lifespan of product and its parts	R7	Time Inclusion Responsiveness Care
Rinascimento	Useful application of materials	R8	Transparency Responsiveness Care
TheUpcyclingco	Useful application of materials	R8	Reflexivity Inclusion Care

Finally, the application of R-AD to the analysis of existent cases can contribute to promoting three actions:

- mapping and systematizing good practices, design, production, and distribution systems that in some way already respond to these above-mentioned principles, useful for further implementations of the model;
- consolidating the idea that an interactive and integrated approach between Advanced Design, Responsible Innovation and Circularity can be a line of action to deal the needs of the complex systems that are around us today;

- bringing out critical issues and gaps in current product-service systems (e.g., lack of gender equality, inclusion, or other ethical aspects, etc.) by verifying through the conceptual model which R-AD tools can respond to process change and improvement.

To increase the practical and theoretical value of the R-AD model enhanced with the dimension of circularity, it is necessary to continue the ongoing process of investigation and mapping and to experiment with it in other contexts of intervention. It is hoped that these future actions can outline guidelines and a set of semi-processes to achieve, with a holistic approach, regenerative sustainability throughout a product's value chain.

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Fig. 4.1 Eco Piping Bags by UNIFARCO in collaboration with UNIRED.

Fig. 4.2 Algramo refill stations for bulk products.

Fig. 4.3 IFCO Brown Lift Lock 6413.

Fig. 4.4 Recovered and repurposed glass by Green Glass.

Fig. 4.5 Rinascimento circular papers by Icma Sartorial Paper.

Fig. 4.6 Responsible plastic recovery and recycling by TheUpcyclingco.