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ENHANCING CIRCULAR ECONOMY PRINCIPLES THROUGH ENVIRONMENTAL IMPACT ASSESSMENT: A FOCUS ON WASTE MANAGEMENT AND RESOURCE REUSE

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Abstract

The transition from linear to circular economy requires the development of frameworks supporting the implementation of circular economy principles. This study's aim is to propose an approach to incorporate circular economy into the process of project environmental impact assessment through the inclusion of a life cycle thinking perspective. At the operational level, these objectives concern the implementation of life cycle thinking principles in waste and resources reuse evaluation, by adapting the steps already comprehended in the Environmental Impact Assessment procedure. A practical example shows the application of the proposed approach to a qualitative case study, specialized in the used natural cork stopper industry. This sector has an ambitious environmental sustainability objective: the preventive management of cork stopper waste is intended to create a virtuous context of increased cork stopper recycling, so as to avoid the disposal of this product in obsolete landfills. The identified criticalities show that life cycle thinking is a valuable paradigm to guide evaluation activities on waste management systems, in order to facilitate the movement of the analyzed waste up the waste hierarchy.

Keywords: *Life Cycle Thinking, Waste Hierarchy, Circular Economy, Natural Cork Stopper Industry, Environmental Impact Assessment.*

1. INTRODUCTION

The transition to a circular economy is recognized as one of the most viable pathways to address the sustainability challenges driven by the growth of the human population, increasing urban development, and the methods by which work is performed. It contributes to long-term climate change targets and sustainable development objectives. The promotion of circular activities through policy, innovation, technology, and collaboration has been the subject of numerous economic studies and initiatives. To date, most studies focus on the economic, environmental, and societal impacts of circular economy activities, which have made it possible to identify the priority sectors and resources for improving the main approaches and strategies. Conversely, one innovation framework to drive circular economy transitions and understand cascade effects is Environmental Impact Assessment. [1]

EIA's ability to systematically consider circular issues, such as reuse, recycling, and recovery, among others, is virtually unexplored. Specifically, the reuse of soil and construction waste management is mentioned as something that can be conducted by EIA. Nonetheless, detailed and coherent multi-criteria tools considering circular economy principles together with other social and environmental criteria are not in place, and well-executed EIA studies tend to focus more on sectorial and impact categories such as noise pollution, air quality, and landscape modification. While office investigation is available and includes several aspects related to both traditional EIA and circular economy, scant information is available about the link between the two domains. Information gaps exist that limit our understanding of how to promote and implement circular economy strategies. We explore EIA's

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potential to systematically promote the circular economy, with a focus on waste management and reuse of different resources. We collect a dossier of EIAs that do so, and we use the survey to deduce some lessons learned and identify implications for theory and practice. [2][3]

1.1. Defining EIA and Circular Economy

Environmental Impact Assessment (EIA) is a widely used tool across the world to assess the likely significant effects of development proposals on the environment. EIA checks that potentially adverse effects of proposed major developments, such as waste facilities, are considered before planning authorities decide whether to grant permission. While EIAs consider a wide range of environmental topics, including human health, the focus of this text is the relatively underexplored area of the role of EIAs in helping achieve well-considered resource management decisions, leading to more circular economic systems. The term 'circular economy' refers to a production and consumption model that aims to use and reuse resources in a way that minimizes secondary materials waste generation, maximizes economic value, and contributes to saving and preserving nature and natural resources. [4]

Separating fact from fiction notwithstanding, the EIA Directive's ambition is to reconcile economic growth with improvements in the environment through promoting sustainable development and using and redistributing throughout the European Union the best available techniques for the implementation of projects likely to affect the environment. Typically, a waste project developer will employ a third party to carry out an EIA. This work is summarized in an Environmental Statement, which is submitted to the planning authority in support of the planning application. The expectation is that the public, stakeholders, and the regulator will use and refer to this information, in combination with their own perspectives, to decide whether or not to grant consent for the project. [5]

1.2. Paper structure

The paper is divided into six sections. This introduction is the first section, while the subsequent section explores the relationship between EIA and Circular Economy, highlighting their synergies. Section three delves into waste management within EIA, emphasizing sustainable practices. The fourth section focuses on resource recycling and conservation. Section five assesses cases and presents strategies to enhance EIA's efficiency, effectiveness, and sustainability. The final part summarizes findings and offers suggestions for future research in integrating EIA with Circular Economy.

2. THE INTERCONNECTION BETWEEN EIA AND CIRCULAR ECONOMY

The importance of a circular economy is attracting greater attention. Waste management and resource reuse are crucial aspects of a circular economy. Environmental Impact Assessment exists to prevent or at least highlight potential pitfalls and to create added value in terms of sustainability through the proposed developments of which these aspects are inherent since the early phases. Nevertheless, when the link between Environmental Impact Assessment and circular economy is addressed, only a few studies have been observed that have investigated the potential of Environmental Impact Assessment to be used to enhance circular economy principles. This paper aims to look at the interconnections and explore the area between Environmental Impact Assessment and the circular economy by placing increased focus on waste management aspects of Environmental Impact Assessment. [6]

Understanding the Relationship

The logic of why resource use and waste production should be linked with their impacts and accounted for in the same way in an impact assessment process is that they all occur over time and cause stress

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on the environment and natural resource base. Resource use and waste formation both require an input of materials and energy, and the loss of both during use or through the formation of waste requires that these resources be managed so that the outputs do not impact the environment in an unacceptable way. Minimization of these impacts is carried out by a set of stakeholders, including both public and private sector institutions. Many of these, such as local authorities, industry, regulatory authorities, and citizens, will take part in an EIA through the information given in the assessment process and through the feedback on results and proposed improvements. [7]

As the principal program implementing this management system, an EIA directly addresses the environmental component of these impacts, and degrees of indirect interventions across the system of operation of the resources and waste depend on the assessment process used and the authority of the process to control impacts. When the EIA is directly prescribing measures to monitor these externalities, the improvements occur quickly. When they are indirect, such as through public opinion or the disciplinary authority of the organs that finance the EIA, it may take a little longer to see improvements. The main EIA objectives relate to the protection of human health and the quality of the life support functions of the environment. These functions include the preservation of terrestrial, marine, and aquatic ecosystems, richness of biological diversity, the workings of natural biogeochemical and climatic mechanisms, non-depletion of soils and resources on which human survival depends, and exposure to historical and cultural elements inherent in a component of the local or regional environment. [8][9]

3. KEY COMPONENTS OF EFFECTIVE WASTE MANAGEMENT IN EIA

The effectiveness of how an activity's waste is generated, managed, and ultimately reaches its end state is a key area of scrutiny within the EIA process, given the implications of inadequate performance in this area. Interventions requiring all EIA-investigated activities should efficiently manage waste, encompassing upstream interventions, which help limit the volume and variety of waste being generated, typically through the application of extended producer responsibility schemes in line with the objectives of the Waste Framework Directive, and downstream requirements, ensuring a need to separate those quantities and categories of waste that are generated as inevitable, to prevent the shade, and ultimately reduce the release of byproducts of human activity to the environment and to recover raw materials and energy that are lost, for sustaining productivity in the economy at the highest possible level. [8][7]

The management of waste through EIA primarily relates to activities' operational phases, with a primary focal point on waste arising in the short to long term. This therefore relates to both residual waste from treatment processes and other end-state waste from the implementation of waste management activities, as well as potential unforeseen consequences from these end-state activities. Such failures can have impacts on the generation of reactive pollutants that damage the global and regional atmospheric environment. Traditionally, waste management has categorized issues under two key categories of waste control and the broader sustainability of waste management within a circular economy context, and its associated link to appropriate pricing across the various stages of the waste hierarchy. [10][11]

Waste Classification and Characterization in EIA

When identifying waste streams and how these can be directly influenced through a project, a project proponent or EIA practitioner can look at the preliminary project design and identify point source emissions, volume and nature of waste streams, and understand how these can be avoided, promoted, and enhanced for waste prevention and management. Project components, such as plans, processes, and technologies already known or identified during the screening and scoping phases,

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with regard to handling waste streams, can provide more detailed information regarding the nature of the waste. They can also enable an assessment of risks to the project and the environment, should the waste not be properly handled or managed during project operations. This will enable the design and strategy development for waste management, treatment, and disposal measures, particularly should the projected waste quantity or quality exceed waste treatment capacity. [12][9]

The nature of the project will determine the specific waste classifications of interest. For this regulatory review of interest in this study, the focus is on priority waste streams; specifically, activity-specific priority waste. These carefully selected waste priorities would predominantly need an obliged operator. The project proponent or EIA practitioner may categorize the volumes of waste likely to be handled or produced by the project. Typically, predictors for waste classification are the phase of the project, project location, or type of project. The site inspection, where possible, should provide full details regarding the type and nature of the waste that is likely to be handled, generated, and disposed of at the project site, and which could have a direct negative impact on the project and surrounding environment if not properly regulated and enforced. [13]

The figure below illustrates the classification and characterization of different waste categories in Environmental Impact Assessments (EIA), highlighting the proportion of each waste type.

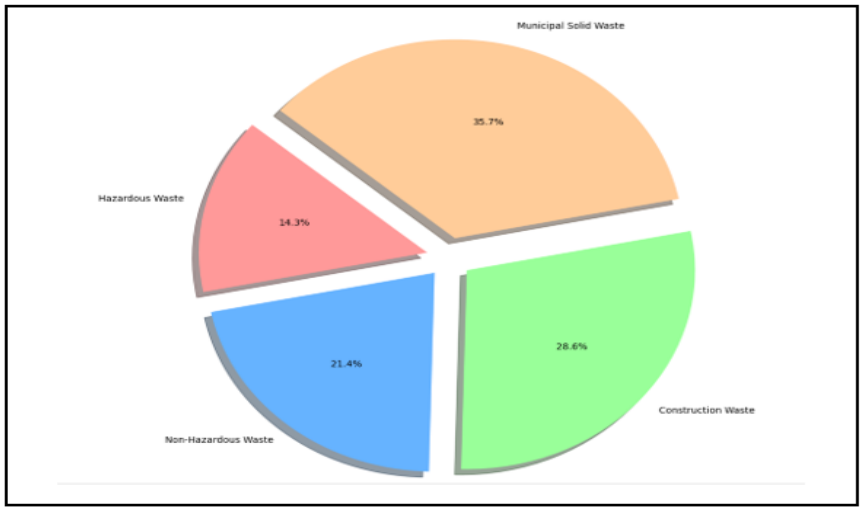

Figure 1: Waste classification and characterization in EIA

4. RESOURCE REUSE INITIATIVES WITHIN EIA

EIA is an important tool used by virtually every country in the world. Environmental assessments that are used today have evolved to identify potential environmental issues based on what we currently understand and concern. As such, outside of a few jurisdictions, the practices and tools that are being applied are based on historical policies, knowledge, and experience. Despite the ability of the EIA process to identify environmental impacts and provide recommendations or conditions to reduce or compensate for these impacts, few proposals promote the reduction and controlled handling of resource loss resulting from the process, or specifically identify opportunities for resource recovery and reuse. [14][15]

4.1. Circular Economy Concept

The concept of a Circular Economy has been defined in a number of ways, but there is general agreement that we are currently living in a linear economy where products are manufactured, used, and disposed of in landfill or incineration, which promotes high levels of waste generation. This

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process produces, both from direct manufacturing processing waste and post-consumer waste, a high number of pollutants and waste that are often not managed in a consistent manner and then frequently end up in the environment. The Circular Economy model can contribute to assist in society's transition to policies intended to be restorative and regenerative by design, which preserves and enhances natural capital, optimizes production, and presents opportunities to reuse materials. [16]

4.2. Promoting Reuse and Repurposing Strategies

Stimulating conditions to promote the market for reused goods and repurposed materials within EIA can be handled by including the associated approaches within the option generation phase. Indeed, numerous reuse support instruments can be adopted to promote the production and consumption of reused goods and to support companies in their transformation into organizations able to realize new business models through process innovation. Economically oriented instruments may support the development and commercialization of reused products, promote the market for reused end-products, ensure favorable tax treatment, and encourage the market of goods produced from recycled materials and the exploitation of unwanted waste by creating job opportunities. Moreover, new official green claims can be used to target environmentally conscious consumers, certifying the real sustainability performance of the products in focus, and thereby promoting the market of reused goods and repurposed materials. [17][18]

Among the non-economic tools, environmental protection requirements for companies taking on public contracts or grants have been proposed. Furthermore, the inclusion of specific green public procurement criteria for reused products in the technical specifications of any calls is encouraged. Alongside these proposals, reuse potential could be assessed in the product life cycle and potential target markets addressed. Europe-wide standards across the product design process would need to be created to refine the identification of optimal customized solutions, while also displaying any thresholds to consumer acceptance and technological aspects to the development and testing. Finally, innovative companies should be incentivized to further experiment through either small-scale piloting in new innovative ideas or sets of demonstration projects replicated throughout the territory. [19][20][21] The figure below highlights the focus levels of Environmental Impact Assessments (EIA) and Circular Economy initiatives across key factors, including waste management, resource reuse, pollution reduction and sustainable practices.

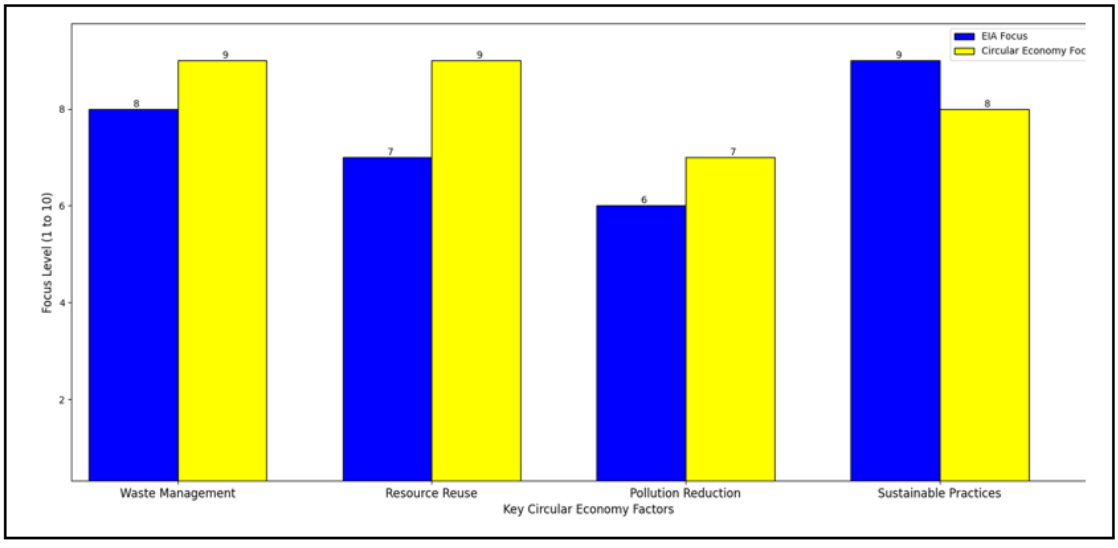

Figure 2: A visual summary of how EIA and circular economy principles interact

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5. CASE STUDIES AND BEST PRACTICES

There seems to be a general acceptance that resource management and sustainable development ideas should become increasingly central in the total evaluation of projects and activities, similarly to the fact that landscape and other cultural issues are being assessed through the EIA procedure, particularly in some specific contexts and under specific rules. The connection between these concepts and the EIA itself is therefore thought to be twofold: on the one hand, the assessment of the consequent impacts, influenced by a more attentive reach of social and governing issues, can better take into consideration the comprehensive principle that sound development processes are characterized by a satisfactory use of different kinds of resources; on the other hand, the process itself, which might be developed in association with the EIA, supports the implementation of projects according to the best available technology, instead of selecting the environmentally feasible option among contrasting ones. The primary objective for it resulted in an attempt to contribute to identifying the conditions under which the EIA, properly realized, could take into consideration circular economy principles and key elements of the resource efficiency system, plus contribute to their implementation and hence offer them strong support. [22][23]

In the paper, three case studies were considered, part of some European funded projects, respecting different application contexts of the EIA procedure but characterized by some common features among them: matching a context of a more and more urbanized coastline, characterized by a growing population, which is accompanied by an increase of local activities and practices on a large variety of impacts not well known or predictable by a conventional or traditional content of an EIA process. In the case of flood risk assessments, for example, to assess the impacts of individual proposed options, account has to be taken of a not-just geometric approach with determining the hydraulic conditions that will arise in the different situations examined. This means that to carry out flood risk assessments, a full description of the planned development options is required, both with regard to the physical planning and use of land and the operations related to the hydraulic task. Likewise, with respect to the Integrated Coastal Zone Management or coastal area enhancement proposals, a full description of the impacts of activities or similar Integrated Action Plans should be presented with their various alternatives. Besides the more traditional issues described above, the process has to take into full account the very specific contexts and conditions within which the areas examined at each planning stage reside, such that the effects considered are truly relevant to the direct and indirect impacts of planned developments. [24]

Successful EIA Projects in Circular Economy

Bearing these points in mind, it is possible to demonstrate via a series of successful EIA projects in Finland how the principles of CE support the task of achieving successful projects in environmental protection. One such striking EIA exemplar can be found in the recent completion of Helsinki's West Metro Project. This subterranean overhaul commenced after the construction of the first line in the Helsinki Metropolitan Area turned harmful when leaching metal from the tunnel began contaminating an aquifer that served 600,000 customers with drinking water. The pollution meant costly upgrading and waste-plugging before reinstatement reversed western Helsinki's precious groundwater quality. At this stage, environmental authorities wondered whether a similar problem would mar the excavation of further forest and calcareous wetlands to bring the Metro to a new population center, Otaniemi. Consequently, EIA was initiated.

The assessment aimed to develop sustainable alternatives that would give the most added value to the entire West Metro Project by performing the least harm to human welfare and the environment. It spotlighted alternatives that would inflict the least noise impact while causing the least stress to residents and the rare amphibians whose biosphere lay above the mine. The selected Otaniemi vicinity

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option comprised a one-stop and 12-hectare car park facility combined with efficient provision for cycling, walking, and heavy rail connections. This phase of the West Metro EIA communication cycle involved dissemination of relevant, contemporary project information. Stakeholders had the opportunity to introduce new knowledge that would improve the sustainability of the project whose influences touched them. The current generation of EIA was not only well-timed and well-argued, it also helped authorities state and restate the making of facilitated changes that improved communications and trust regarding the salient alternatives. The EIA report revealed residents' need to assess the credibility and reliability of human health expenditure assumptions expressed in company assurances. All things told, the communications surrounding the State of the Environment and the identified potential problems and spatially explicit proposals for mitigation form a single master plan of regional infrastructure and service facilities. [25][26][27]

6. CONCLUSION

The comprehensiveness of Environmental Impact Assessment (EIA) procedures makes it a potentially significant policy instrument for enhancing and embedding circular economy principles. However, responsibilities surrounding the examination of impacts may not always be sufficiently comprehensive to broaden how impact is accounted for, as they are inherently responsive to conventional methods. Guided by an improved regulatory framework, the requirement for the 'use of best available techniques' in the treatment of waste challenges the continued dominance of technology-focused EIA practices. While striving to accommodate the open-ended nature of the circular economy, new evaluation procedures must further their own specific characteristics into EIA operations and highlight the location, life cycle, and planetary boundaries of activities. Critically, EIA has an essential role in informing priorities and balance in the implementation of circular economy shifts by identifying potential benefits and adverse effects that may arise. Where there are thresholds above which impacts need to be controlled, legislative or regulatory frameworks can include these thresholds. The examination of the circular economy concept within EIA is both normative and forward-looking. The notion of circular economy merits attention within differing evaluation methodologies. It opens a broad array of environmental consequences—the circular economy does not consider environmental aspects as costs but as beneficial effects nurturing sustainable economic systems.

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