

Review

# Investigation of Ecosystem Services and Circular Economy Interactions under an Inter-organizational Framework

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**Abstract:** Nowadays, the conceptualization of circular economy is an attractive managerial tool among governments and businesses throughout the world, while ecosystem services are a contentious issue due to the particular needs of humans' well-being. At this review the interactions between the principles of ecosystem services and the circular economy were investigated in the light of inter-organizational systems. This evaluation was based on more and more complex processes, while the integration of the growing circular economy concept within the shrinking parent ecosystem unveiled challenges and constraints for products' end of life and quality. It was argued that: (a) The existence of social and people-related barriers can be considered under three groups, namely, the "sustainable provision and modeling schemes", "socio-cultural appreciation and payment schemes", and "regulatory and maintenance schemes", (b) The impacts of circular economy–ecosystem services toward an inter-organizational functional stream model associated with distinguished proactive and post treatment risk values (c) The functionality and the accountability of the technosphere are the two critical components to support the restorative and the regenerative perspectives of the biosphere. The aforementioned findings unveiled new emerging paths to be further investigated, offering a deeper appraisal of circular economy under the inter-organizational perception.

**Keywords:** energy flows; ecosystems services; circular economy; inter-organizational functional stream model; technosphere; biosphere

## 1. Introduction

In the relevant literature a typical circular economy (hereafter, CE) framework necessitates a transformation of both production and consumption systems into marketable products and services [1–4]. In such production and consumption systems, design and engineering are marketable factors of the utmost importance. Specifically, design influences the sustainability of a global-value chain management, while engineering influences the manufacturing routes of production and commercialization [2,5]. It is noteworthy that in an environmental appreciation of CE, this can be associated with multinational enterprises that are organising their processes and production strategies under a variety of environmental aspects, like the tackling of climate change and the development of novel approaches to support the closure of the procedural loops. Besides, the economic appreciation of ES is mainly determined by a wide spectrum of patterns, such as the accomplishment of environmental sustainability, the re-thinking education, and the eco-engineering [5].

CE is also considered a vital asset of “anthropogenic material stock” of wealth [6]. It is noteworthy that large-scale infrastructure works could be considered as future capital stocks due to the embedded value of secondary raw materials. Thus, “anthropogenic material stock” can be considered as a model to close the loop of flows, to support policies of raw materials supply and to effectively explore the norms of ecosystem services (hereafter, ES) values and the anthropogenic appreciation of CE [6]. In applying the CE concept at free markets and open competitions, process resource efficiency is distinguished from the product resource efficiency [7]. CE value is considering the scarcity of resources and the taxes’ imposed, thus, implying social and environmental externalities.

In valuing the ES – CE coordination it is important to appreciate the availability of resources and materials in terms of site and time of application [7]. It is also noteworthy the sporadic literature production is devoted to address and unify various institutional theories upon CE. In such a literature study, Fischer and Pascucci [8] stressed out transition tools in structuring CE and in achieving effective management of circular material flows at a textile industry in the Netherlands [8].

ES-CE coordination is especially effective at those industrial plants where common methods of wastewater are detrimental to the local environment. Specifically, at the pork industry in Catalonia (Spain), Noya et al. [9] adopted a Life Cycle Assessment (hereafter, LCA) approach and concluded that both fodder production and transport activities were identified as the critical parameters of the system controlled. Besides, in such a closing-loop production system, resources efficiency and wastes valorization are prioritized over final disposal choices [9]. Coordination between ES and CE values is fostering feasible green production practices of eco-industrial park firms, being also related to complex chain management of large-scale socio-environmental systems [10–12].

Therefore, the integration of CE with supply chain management is needed, in order companies to achieve an optimal balance of economic, social, and environmental benefits [13]. The attribution of economic value to environmental patterns is no new. It is indicatively noted that an attempt to control environmental pollution and mitigate climate change has been made by establishing a global carbon emissions trading. This form of trading is a comprehensive regulatory tool adopted from various countries and groups of organizations, which gathers information on mandatory carbon trading schemes in the world. Particularly, a carbon emission trading can control pollution by providing economic incentives to accomplish emissions reductions from human-born pollutants [14].

The contribution of the literature review at this study is to provide the mainstream research on ES during the last 20 years of analysis, thus revealing the gradual evolution of ES research and the appreciation of environmental sources under the principles of CE. Moreover, this literature production revealed the significant role of organizations in asserting economic attributes to environmental patterns, being perceived as spatially-driven tradable goods of financial background and monetary value, thus, they should be considered as vital components to circulate the global CE.

The scopes of this study are, firstly, to investigate the developing inter-organizational linkage between the ES and CE systems, secondly, to determine the key-parameters of the ES-CE functionality and, thirdly, to contribute at the better understanding of the divulged conceptualization upon the ES and CE systems, in alignment with their functionality, challenges, and uncertainties developed under this ES-CE framework.

The innovative aspects of this study is the proposition of an integrated socio economic scheme of ES – CE in alignment with a functional stream model (hereafter, FSM), while the critical components of technosphere and biosphere as well as the concurring risks were also stressed out. Under this research orientation, not only traditionally environmental issues of global impact –such as trading of global carbon emissions and the inclusion of external costs in pricing electricity production– but a wider context of multi-dimensional aspects ES-CE under inter-organizational patterns were determined [15].

## 2. Materials and Methods

Over the past 20 years, the increasing reports in both the number of studies and the number of services make the valuation methods upon ecosystem services more inclusive. Therefore such a

dynamic case pace is revealing important lessons for ES values practice during the time reference of last 20-years examined. The search criterion was the key-phrase of “ecosystem service valuation” under the last 20 years period of reference. This literature outcome was grouped in reverse chronological order and in alphabetical list, being presented on the authors’ name, accordingly. The relevant literature search was undertaken through the Scopus database and it unveiled the multifaceted approaches of economic appreciation on ES. Specifically, during the last two decades of literature analysis, this literature production was collected and classified into the following three groups, which correspond to Tables 1–3, respectively: “sustainable provision and modeling schemes” (Table 1), “socio-cultural appreciation and payment schemes” (Table 2), and “regulatory and maintenance schemes” (Table 3).

**Table 1.** Literature overview of ES under the thematic classification of “sustainable provision and modeling schemes”.

| Ref# | Authors (year)                | Conceptual Framework   |
|------|-------------------------------|--|
| [16] | Gerner et al. (2018)          | Authors examined the suitability of a structured ES at the case study of estimating the impact of the restoration of the Emscher River, Germany. This large-scale restoration project entails immense temporal and financial efforts to assess the values generated by this restoration. Therefore, the ES framework is quantified by the regulation and maintenance upon “self-purification capacity”, “maintaining nursery populations and habitats”, and “flood protection”. Authors concluded about the successful application of their structured evaluation framework in practice.   |
| [17] | Livingstone et al. (2018)     | The research objective of this study was to examine ES by Rouge National Urban Park (NUP) users, Canada, as well as perceptions of the impact of the invasive vine <i>Vincetoxicum rossicum</i> . Furthermore, it was investigated how those valuations and perceptions are affected by “ecological engagement” (EE). Authors conducted a social survey of Rouge NUP users and found that valuation of most ES was significantly greater for EE users. The examination of EE can reveal differential ES valuations and perceptions of invasion impact. Moreover, such examination can inform conservation management plans and public engagement strategies.   |
| [18] | Tolessa et al. (2017)         | At this study authors assessed the land use/land cover (LULC) dynamics and its associated changes in ES for the Toke Kutaye district (ca 72,700 ha) at the central highlands of Ethiopia. The analytical procedure included four satellite images of the study area along with the use of the Arc GIS software to assess the LULC changes of the area. Specifically, six LULC types were identified in the study area (forest, shrub/bush land, grassland, cultivated land, settlement, and bare land). The analysis improved researchers’ understanding of deforestation trends in the study area, showing that overall ecosystem services value reduced by 68%, mainly due to deforestation. Overall, by applying this methodology, better information to land managers and policy-makers in their decision-making processes, was accumulated. |
| [19] | Schaubroeck et al. (2016)     | This study quantified the environmental impact (on human health, natural systems, and natural resources) in physical units and uses an ES based on monetary values, towards a sustainable management of human, industrial, and environmental systems to be achieved, via modelled and predictable evaluation modes.  |
| [20] | Colombo et al. (2013)         | This study investigated the sensitivity of choice experiment values for ecosystem services to “attribute non-attendance”. The authors developed a number of models in considering the following classifications of attendance –when people may always, sometimes, or never pay attention– to a given attribute in making their choices.  |
| [21] | Plantier-Santos et al. (2012) | The Gulf of Mexico Ecosystem Service Valuation Database (GecoServ) was developed to support the distribution and sharing of information regarding ES, and to further identify gaps in the ES literature. The GecoServ tool enabled researchers to retrieve information for varied study sites that are related to value transfer methods, supporting managers taking reasonable and feasible decisions.  |

Table 1. Cont.

| Ref# | Authors (year)                | Conceptual Framework  |
|------|-------------------------------|---|
| [22] | Villa et al. (2002)           | The Ecosystem Services Database (ESD) was considered as an integrated, web-accessible base that links a relational database with dynamic-simulated models.  |
| [23] | Sutton (2003)                 | This study described an Environmental Sustainability Index (ESI) derived solely from the ratio of two classified satellite images with global coverage. The advantageous features of this ESI were its simplicity, global coverage, and comparability easiness with other ESIs.   |
| [24] | Zong et al. (2006)            | In this study, the theoretical basis on ecosystem services valuation was discussed from the viewpoints of energy and economy, while indicative improved methods and means for ES were summarized, including the adjustment of unit value by biomass, identification of different spatial scales, improvement of contingent valuation method, and application of dynamic simulation models.  |
| [25] | Lienhoop and Völker (2016)    | These authors developed one-shot survey upon monetizing unfamiliar, to respondents, ecosystem services in unknown or hypothetical markets. In this survey the authors concluded to this deliberative choice experiment, in order to reveal well-rationalized value estimates and advisable policies.  |
| [26] | Richardson et al. (2015)      | In this study the generation of monetary value estimates upon ecosystem services was examined. To this end, benefit transfers and summarized advancements tools were facilitated.   |
| [27] | Sarkki and Karjalainen (2015) | The authors of this study examined how local-level practitioners (including state forestry enterprise, tourism entrepreneurs, reindeer herders, local NGO and local hunting association) performed ES through argumentation to promote certain interests in practical governance in the context of a forestry debate in Northern Finland. In this framework, monetary valuations may escalate disputes instead of providing neutral information, whereas, increasing transparency could gain an understanding of the links between the strategic partiality of knowledge production and perceived ESs and trade-offs across stakeholder groups; enabling a common view on various ESs and governance solutions. However, special provision should be taken to practices of denying and questioning certain ES values. Better understanding of how stakeholders perform ESs through argumentation can shape the governance options for and against particular ESs. |
| [28] | Sinha and Mishra (2015)       | The contingent valuation method (CVM) was used for calculating willingness to pay (WTP) for different ecosystem services in a Hariyali Sacred Landscape (HSL) of the Indian Himalayas. WTP for the conservation of the landscape was the lowest among the nearby villagers.   |
| [29] | Whitham et al. (2015)         | An ES for the National Nature Reserve in southwest China across different management zones, was implemented under six assessments approached. This methodology included two different land-use land cover (LULC) maps and development of three economic valuation techniques, using data from global or local sources. ES outcomes across varied management zones were differentiated to each other, since these were predominately influenced by forests and farmlands classification with credible valuation coefficients.  |
| [30] | Gowdy et al. (2013)           | This study investigated the apple-tree pollination in Maoxian County, China, where the positive economic benefits do not justify eliminating the natural processes. This study denoted the danger of leaving the fate of nature to the whims of the markets even if prices are “corrected”.   |

**Table 2.** Literature overview of valuing ES under the thematic classification of “regulatory and maintenance schemes”.

| Ref # | Authors (Year)                | Conceptual Framework  |
|-------|-------------------------------|---|
| [31]  | Miller et al. (2017)          | This study described this new governance structure to understand the potential benefits to communities and federal land management agencies for protecting watershed services. Particularly, institutional design and governance structures aimed at maximizing community strengths and stressing out several advantages over traditional federal land management models, including increased collaboration and institutional support, financial security, and public approval.   |
| [32]  | Zhang et al. (2017)           | The proposed method can realize the rapid ES valuation of nine ecosystem service types of six different terrestrial ecosystems at services in the Sanjiang Plain, China, was deployed. It is noteworthy that variations among the contributions of the different ecosystem services were considerable, where the regulation function was the highest at the hydrological and climate regulations.   |
| [33]  | Hackbart et al. (2017)        | These authors emphasized upon the valuation of water ecosystem services (ESw) among ES contexts. Particularly, they defined five types of valuation and five major theoretical principles that can be classified under 14 indicators that were used in the ESw studied. It is noteworthy that the current knowledge about ESw carried the false impression that the ES is sufficiently consolidated to support decisions about payments for ESw.  |
| [34]  | Greenland-Smith et al. (2016) | These authors introduced the ecosystem goods and services (EGS) model and deployed a survey, determining mostly recognized wetland- and pond-related services, proposed measures to improved wetland conservation.  |
| [35]  | Li et al. (2016)              | Since the generation, transmission, consumption, and reproduction of the wetland ecosystem services are cycle processes, in case that researchers only evaluate the value by simple classification, the accuracy of the results would be affected, easily leading to double counting. In case that this double counting problem cannot be removed appropriately, the credibility of the evaluation results would be subsequently reduced. The authors of this study developed a flow chart of energy and analyzed the three basic mechanisms- “separation”, “feedback”, and “co-product” in the wetland ecosystem services to avoid the double-counting error. The authors denoted that associating energy with the preconditioning analysis of the system it could remove the double counting effectively and result in accurate evaluation. |
| [36]  | Li et al. (2015)              | In this study the ES perspectives were investigated in the Napahai Wetland, as a typical plateau wetland in the Hengduan Mountain Area, China, with characteristic geography and abundant biodiversity. The authors investigated ESs in this region by using the methods of: market pricing method, replacement cost, shadow engineering, cost expenditure, and contingent valuation.   |
| [37]  | Quoc Vo et al. (2015)         | In this household-based survey a remote sensing data was utilized to assess mangrove ecosystem services in the Ca Mau Province, Vietnam. The authors concluded that remote sensing is significant in ES upon the regional mixed mangroves and aquaculture examined.   |
| [38]  | Brooks et al. (2014)          | Inclusion of non-monetary stakeholder priorities is an underdeveloped issue in ES practice. To this end, the authors deployed four site-scale wetland ESs in Asia by exploiting non-monetary participatory stated preference techniques from various stakeholders, and compared these prioritizations to those obtained from the large/ global-based monetary assessment of the Ecosystem Service Value Database (ESVD). In this context, the diversity of values among stakeholders to incorporate site scale management issues, particularly was related to poverty alleviation.  |
| [39]  | Chen and Yao (2014)           | This study summarized connotation, classification and assessment methods of wetland ES. Authors proposed that more attention should be paid to the systematic, integrity evaluation system establishment of wetland ecosystem service in the future wetland ES and management in China.   |

Table 2. Cont.

| Ref # | Authors (Year)        | Conceptual Framework  |
|-------|-----------------------|---|
| [40]  | Comello et al. (2014) | The authors of this study developed a new comparative framework for natural and engineered systems. This ES was based on international accounting standards, which were in alignment with biological ecosystem service valuation.   |
| [41]  | Li et al. (2014)      | The middle-lower Yangtze River region, with its lake groups and river systems, is one of the important wetland regions in the world. In this study, physical dimension measurement and monetary evaluation were conducted to estimate the value of wetland services in this region. Results revealed that the total value of the wetland ecosystem services in the middle-lower Yangtze River region is the US \$162.5 billion per year, which reflects the irreplaceable importance of wetlands in this region.  |
| [42]  | Pang et al. (2014)    | The Chinese wetland in Zoigê Plateau and its ES was the research objective of this study. The existing literature production was based on the classification of the Millennium Ecosystem Assessment (MA), which can lead to double counting. Wetland ecosystem services were divided into intermediate services and final services, and the value of final services was the total ES. The intermediate services were similar to the supporting services of MA, through combined ways to provide final services. Final services were similar to the cultural services and provisioning services of MA, with direct effects on human welfare. Benefits of external things were referred as the impact on human well-being, such as more food and less flood. The only criterion to determine final services was that the services have a direct contribution to human well-being. |
| [43]  | Chen et al. (2007)    | Sanchahe Wetland is located at Huaishang region of Bengbu city, which lies in the middle reaches of Huai River. A long time ago Sanchahe was a canal for human beings and many weeds distributed around it. In this study, among weeds accommodated were consisted of <i>Phragmites australis</i> and <i>Scirpus triquetus</i> . Wetlands resource was abundant and various in the region examined. The authors applied the ArcGIS9.0 software in order to survey area data of different wetland types, whereas some economic methods were quoted for ecosystem services valuation. The main functions of Sanchahe Wetland were water regulation, product provision, and carbon fixation. Direct use value including product provision, tourism, and scientific research took 48.35% of the constructed wetlands.   |

Table 3. Literature overview of ES under the thematic classification of “socio-cultural appreciation and payment schemes”.

| Ref # | Authors (Year) [Ref.]       | Conceptual Framework  |
|-------|-----------------------------|---|
| [44]  | Oleson et al. (2018) [Ref.] | The transition from a monetize-based ES to an integrated valuation paradigm represents a more diverse set of the values of nature, and beyond, to a more fully realized conception of the island social–ecological systems. ES should signify the developed interconnections between ecosystems and between human and environmental systems, while more integrated valuation methods that better capture the diverse values of nature can be drawn. Besides, knowledge and decision-support tools should be co-created with decision-makers and stakeholders.   |
| [45]  | Toledo et al. (2018)        | Authors applied an ES framework to a legal case in the Anchicaya region of Colombia. Besides, several valuation methodologies were used including direct valuation, replacement costs, and benefit transfer. Particularly, the quantification of ES framework upon the material and non-material damages, it was recognized under the Colombian legal framework. The total value for the valuation of material damages approximated to \$100 million USD, while for the non-material damages, which were classified as cultural ecosystem services, it was argued that the loss was high as the victims lost something invaluable and critical for their identity and their well-being. |



Table 3. Cont.

| Ref # | Authors (Year) [Ref.]           | Conceptual Framework  |
|-------|---------------------------------|---|
| [46]  | Anderson et al. (2017)          | Authors applied ecosystem service values from The Economics of Ecosystems and Biodiversity (TEEB) valuation database to appropriate datasets via benefits transfer methodology upon spatial resolutions. It was estimated the change in ES that has taken place in South Africa over 24 years, estimating that total ES is roughly 1.5 times larger than South Africa's GDP (\$350 billion) for the reference year 2014.  |
| [47]  | Mavrommati et al. (2017)        | Authors deployed a Deliberative Multicriteria Evaluation (DMCE) method that combines the advantages of multicriteria decision analysis with a deliberation process, allowing citizens and scientists to exchange knowledge and evaluate ecosystem services in a social context of the upper Merrimack River watershed in New Hampshire. Research focus was given on structuring a more reliable assessment of trade-offs among ecosystem services, as well as an explicit consideration of the future by both presenting specific socioeconomic scenarios and asking participating citizens to serve as "trustees" for future generations. Particularly, eleven panels of residents were tested with the goal of assessing the relative value of 10 different ecosystem services in the form of trade-off weights. The vast majority of the groups tested were satisfied with the outcome of the deliberation, while all groups except one were able to reach internal consensus on the relative value of these ecosystem services. |
| [48]  | Sangha and Russell-Smith (2017) | An integrated ES framework was applied to assess ES for an Indigenous savanna estate in northern Australia. Two scenarios were explored, Business as Usual (pastoral land use) and ES-based economies (implying customary land use, particularly through fire management) to project plausible broader benefits for the community over a longer term. This research unveiled the ways under which inclusion of Indigenous peoples' capabilities and socio-cultural values are critical for ES assessments, indicating that an integrated approach is essential for appropriately informing local, regional and global development policies.   |
| [49]  | Van Riper et al. (2017)         | Deeper understanding of how less tangible and non-material values shape management and stakeholder decisions, it is proposed at this study. Therefore, it was conducted a framework that characterizes a suite of socio-cultural phenomena rooted in key social science disciplines that are sporadically addressed at the ecosystem-services literature. The main complexities in individual and social functioning, the perceived benefits of nature, and the distinctions among alternative value concepts, they were examined.  |
| [50]  | Calvet-Mir et al. (2016)        | In this study the authors investigated the relationship between gender and environmental perceptions. Particularly, the authors analyzed the ways in which values and ecosystems services are perceived by women and men at home gardens in Vall Fosca (Spain). The study concluded that women expressed higher ecosystems services appreciation than men, whereas gender socialization determined peoples' interaction with personally managed environments, such as home garden.  |
| [51]  | Preece et al. (2016)            | The authors investigated the Cape York Peninsula's world-class landscapes and continuity, stressing out that contest between socio-cultural and economic interests is not considered in valuations of ecosystem services (ESs). Besides, due to regionally excessive land degradation, a policy framework towards cultural ESs was proposed.  |

Table 3. Cont.

| Ref # | Authors (Year) [Ref.]     | Conceptual Framework   |
|-------|---------------------------|--|
| [52]  | Taylor and Bennett (2016) | The authors of this study investigated teaching ecosystem services, as a means that provides an ideal opportunity to use inquiry-based learning to support students make connections between ecological, geological, and social systems. To teach ecosystem services to the next generation of geoscientists, inspired authors to develop inquiry-based learning exercises in which students utilized the ecosystem services approach to assign a monetary value to varied ecosystem services. The authors concluded that geoscientists should be especially interested in integrating the concept of ecosystem services into their courses, enabling future geoscientists to contribute to the interdisciplinary field of ecosystem services. |
| [53]  | Scholte et al. (2015)     | In this study the socio-cultural approach for the valuation of ecosystem services was deployed. Socio-cultural values were determined by social and ecological factors.  |
| [54]  | Evans et al. (2014)       | The key-parameters of this study were the investigation of multiple anthropogenic pressures upon ecosystem functions; In this respect, “biodiversity” as considered an intermediate factor under which anthropogenic pressures are evolving changes in flows of ecosystem services. The challenges of this perception involve the spatial scale and configuration of anthropogenic pressures, as well as the uncertainties derived from the lag between anthropogenic pressures and ecosystem responses. This research orientation enables to draw policies upon land management and a more quantitative, multi-parameter approach to the valuation of ecosystem services to be optimized.   |
| [55]  | Fanny et al. (2014)       | In this study, the authors argued that monetary valuation of ES should represent only one component of valuation. Therefore, the authors provided tools of integrated approach upon ES and its positive contribution to preserve cultural and biological diversity. The authors suggested that acknowledging boundaries to resource exploitation and building on the various interests and socio-cultural values of all stakeholders, can strengthen public awareness for biodiversity conservation and environmental understanding.   |
| [56]  | Mukherjee et al. (2014)   | The authors denoted that ES is a complex process as it includes varied dimensions (ecological, socio-cultural and economic), but not all of them can be quantified in monetary units. In this study an ES for mangroves ecosystems was conducted in order that information governance and management of mangroves to be derived. The Delphi technique was adopted to identify, categorize and rank the various ecosystem services provided by mangrove ecosystems at a global scale.   |
| [57]  | Johnson et al. (2012)     | The authors of this study stressed out that uncertainty about the biophysical production of ecosystem services is implying uncertainty about the value of services. Therefore, uncertainty associated with the ES in agriculture affects the evaluation ranking of land use alternatives in alignment with the social net benefits incurred.   |
| [58]  | Liu et al. (2012)         | This study examined changes in ES in response to land use changes caused mainly caused by anthropogenic activities in Taiyuan City, China. The authors introduced ways in which sustainable urban development can be developed in sensitive ecological environments of rapid urbanization in the Chinese context.  |
| [59]  | O’Farrell et al. (2011)   | In this study the authors investigated ways and values that could be used to promote conservation in the arid Succulent Karoo biome in western South Africa through the adoption of sustainable land-use practices which have human welfare benefits. The authors argued that major welfare effects can be derived while effectively linking ecological and social factors.  |

Based on the aforementioned literature overview the ES framework is especially applied to developed or developing economies, being based on the ecosystems sensitivity for all endangered species accommodated on them. Besides, it is noteworthy that ES can be particularly perceived to natural water sources. Indeed, water resources have been widely cited as a prime example of ES,



especially when the issue is valuation [38]. Because of the importance of water ecosystem services (ESw), they are being effectively evaluated in at least three aspects: clarity about the type of valuation employed; adoption of a strong theoretical basis guided by ecological knowledge; and the inclusion of analytical elements, map-modeling and imaging, which ensure social control in decision making [38,44]. Moreover, it can be noted that the scientific ecosystem services valuation (ESV) was evolved from the “ES under modeling, regional mapping, and geomorphologic imaging” conceptualization, to: “ES under water sources, wetlands, and aquifers”, “ES under social contexts, anthropogenic activities, cultural traits, and public awareness” and (presently) “ES under economics background and governmental policies”, thus satisfying the transition from one conceptual statement to another [17,31,33–35,43,47].

On the basis of this literature overview it is noteworthy that the cognitive gap between the predictions provided by theoretical schemes and the corresponding outcomes in practice, it impedes the ability researchers to develop and to regulate ES in a sustainable manner. The main challenging issues of such anthropogenic appreciation of ES are [60]:

- Firstly, payment schemes upon ES often lack financial sustainability unless local entrepreneurs utilize the new networks developed in creating innovative markets for environmental goods. Therefore, there is an imperative need a shift of policymakers to focus from regulation to innovation in projects and policies designed to ES.
- Secondly, policies regarding payoffs upon ESV are perplexed, since they are commonly regulating unsustainable environmental changes in developed countries, whereas they fail to achieve sustainable environmental changes in developing countries. Therefore, such policies are based on the implicit assumption that there is a trade-off between economic development through technological change (in supporting provisional services of ecosystems) and the conservation of natural resources (in protecting regulatory services of ecosystems).
- Thirdly, emerging economies are coping with the many social and environmental challenges of economic growth which are undoubtedly challenging by trade-offs between economic development and the conservation of natural resources. Such emerging economies are commonly investing in technological changes, in order to cope with the payment appreciation of ES. Such payment appreciation schemes into national policies are profoundly challenging in developing countries where governments cannot afford to dispense large payments for the provision of ES.
- Fourthly, in developed economies the economics appreciation of ES has been perceived under the national agricultural and environmental policies, but the high payments have often undermined incentives to actively improve the quality of ES while being economically viable.
- Fifthly, a comprehensive and differentiated theory on the effective provision of ES can be based on the ground to invest in new markets for environmental goods and services in generating positive welfare effects for society and the environment.

The design of ES-based programs requires an understanding of how stakeholders perceive environmental characteristics, in alignment with the cost and benefits anticipated. Besides, it is noteworthy that the determination of those most recognizable wetland- and pond-related services it is a complex task since wetlands, ponds, and other environmental hallmarks are not equally valued by observers, visitors, or farmers.

The need for economic valuation in the decision process of selecting ES is apparent, but yet controversial. Following a review of numerous papers, Lopez et al. [61] conducted a meta-analysis to investigate which factors affect the willingness to pay (WTP) for biodiversity conservation. The contingent evaluation method analyzed internal factors –such as benefits, payment mechanisms, elicitation format and timing of payment– and recommended that a careful contemplation is needed due to the interdisciplinary effects of the anthropomorphic and anthropocentric parameters on ES species [61].

From the CE side, an extensive analysis has been conducted by Ghisellini et al. [15] who were focused on the origins, the roots, the principles, and the limits of the CE concept. The classification

in micro-, meso-, and macro- levels is an evolutionary analysis which indicated the continuous advancements in the research of the topic. From this review, and taking into account the shortage of inter-organizational framework impacts on ES-CE conceptualization, it was analysed a plethora of articles which refer and describe the evolution of the implementation of CE in the meso-level, the waste markets and the policies, namely the eco industrial parks, the industrial symbiosis districts and the networks, in a life span time period of the last 20 years. A worldwide classification with geographical distribution and policies attempt to quantify the impact of the ES – CE interaction and, in this context, to shape an integrated conceptual framework of the CE context [62]. The indexing methodology research [63,64], the CE in different sectors, such as the supply chain, the built environment, and manufacturing [3,12,65] the development and implementation of Product Service Systems [66–69] are some of the latest research approaches regarding the CE determination and functionality, being further analyzed at the next sections.

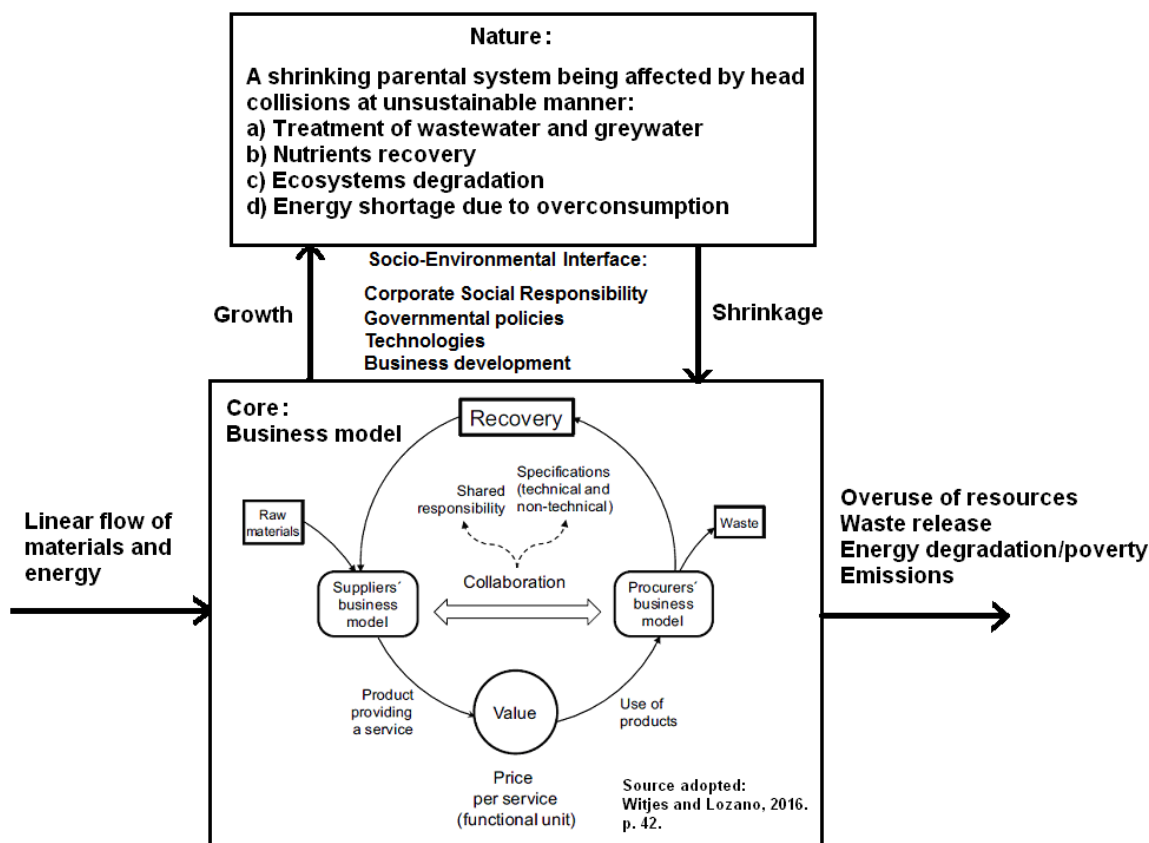
### 3. Results

#### 3.1. Functionality of the CE – ES Framework

Korhonen et al. [70] developed an integrated biosphere-technosphere system, in which the natural sources are shrinking (biosphere) and the economy aspects are growing (technosphere). The shrinkage of the biosphere is attributed to the fact that natural sources—including land use for occupation, hospitality, accommodation; as well as places for leisure, transportation and work—are all considered as inelastic goods of certain capacity and commercial value, especially in developed economies. This economic appreciation of finite natural sources is causing political disputes in sharing and benefiting from these sources, mainly between wealthy-developed economies and poor-developing ones.

Besides, the expansion of technosphere is attributed to the fact that in satisfying socialization needs and pursue national economic growth, there is an imperative need of drawn policies upon the: development of domestic, industrial, and social infrastructure; economies of scale achievement; ongoing needs for urbanization, housing and nutrition; intensification and autonomy of energy production. Therefore, the conflicts aroused from the expanding technosphere and the shrinkage of biosphere are balanced out through the reasonable utilization of anthropogenic assets and natural wealth. Critical aspects that determine the aforementioned biosphere-technosphere conflicts are that of: linear flows of materials and energy; greywater and wastewater treatment; nutrient recovery; pricing of services; ecosystems degradation; businesses' development; as well as the intervening governmental policies to control, reconcile, and alleviate the consequences of these conflicts, as depicted in the following Figure 1.

At the “Core: Business model” frame that was signified by the ProBiz4CE framework of Witjes and Lozano [71], a key-issue in better understanding the conceptual interface of ES-CE coordination is the development of an appropriate methodology relevant to the closed loop material. The main duties of a closed-loop supply chain are, firstly, to be responsible for value-added processes in order to satisfy customers' demands and, secondly, to collect the end-of-life, or returned, products from customers and determine the best accountability of them [72,73]. Besides, Witjes and Lozano [71] signified the fact that the transition to a functioning CE regime requires a systemic multi-level change, including technological innovation, new business models, and stakeholder collaboration. These authors bridged the gap among sustainable public procurement (SPP) and sustainable business models (SBMs). Under this stochastic framework, Figure 1, the entities of SPP and SBMs to ES-CE, can be reciprocally interchangeable and conceptually correlated to each other [71].



**Figure 1.** Diagrammatic representation of the linear flow of materials and energy in coordination to: a) the growing business modeling, b) the shrinking parental system, and c) the socio-environmental interface developed. Sources adapted: Korhonen et al. ([70], p. 38); Witjes and Lozano ([71], p. 42); Liu and Cote ([74], p. 7).

The socio-environmental interface depicted at Figure 1 signified that Korhonen et al. [70], delineates the economic subsystem in operating within the parental ecosystem. It uses physical flows of materials and energy, while—at the same time—it develops head collisions. These collisions are imposing that inward-inflow directions are superior in aesthetic, quality, and quantity terms, whereas the outward-outflow directions are of inferior aesthetic, harmful, and degraded nature, comparing to the inflow ones.

The competitive nature of the socio-economic interface developed between the shrinking-natural and the growing-economy interactions can be resolved, or at least alleviated/smoothened, by the following actions: a) corporate social responsibility schemes planned and implemented by large multinational companies to protect the local ecosystems and the endangered species accommodated at the hosting countries b) governmental policies which emphasize to the reinforcement of central governmental policies in improving the performance evaluation upon the governmental authorities and ecosystems' surveillance, c) technologies which are oriented to technology research and further business development [75].

Moreover, the natural characteristics presented at the aforementioned Figure 1 can be furthered analysed into the following classification subcategories, namely the greywater and wastewater treatment, the nutrient recovery, the energy production and the ecosystem services [76]. Therefore, in this study it is argued that the conflicts aroused from an ES-driven shrinking nature and a CE-bounded growing economy are (or should be) eventually balanced out by compromising the needs for personal development and economic wealth, with the inelasticity and the scarcity of natural sources, raw materials, energy production, commercial goods, and labour units, under an inter-organizational context of analysis.

The coordination of humanistic, anthropogenic, technical and environmental entities has been attracted the global literature from the early decade of '70. It is indicatively noted the study of Milsum [77] who presented some suggestions as to how humans can bring a systems approach to bear on analyzing-and perhaps optimizing human-borne problems in the broad areas of the geosphere, biosphere, technosphere, and sociosphere. This interdisciplinary approach of the aforementioned entities implied that our society becomes more and more complex. At such an early study it was noted that while humans enjoy the advantages of energy (nowadays being effective by the environmental-driven renewables) and information (nowadays, being effective by the technological advancements in computer sciences, analytical techniques, and bio-engineering) revolutions, readers make sure that the structures of each society throughout the life-span are, or have to be, flexible enough to adapt to technological changes. In another study, Allen et al. [78] signified the fact that the interrelated disciplines of technosphere and biosphere are firmly associated with the principles of eco-techniques.

Since the nineties, the applicability of technosphere to biosphere was examined. In such a context the ES was framed by the emissions of metals into different environmental media, thus, the pools and flows in the biosphere can be introduced and compared with the anthropogenic pools and emissions. At that time the disciplines of technosphere were not directly determined by economic criteria, but were actively based on the metal concentrations in the sludge at the main waste water treatment plant and in storm water. In more recent studies, Bousquet [79] introduced the entity of post-anthropocentric international relations that determined the entities of biosphere and technosphere in a global complexity. In such a complex context the technological priorities were evolved from the wastewater treatment towards the CE imposed at various biosphere-derived functions. Similarly, Rugani et al. [80] broadened the existing human-nature nexuses and the ecosystems-technological knowledge towards an integrated biosphere-technosphere model that advanced the assessment of ES-CE perspectives.

In the relevant literature it has been stressed out that CE can reduce the total wastes' volume, while reducing the share of dumped and incinerated waste. The successful implementation of CE contributes to all the three dimensions of sustainable development, but it is limiting to a level that nature tolerates and utilizes ecosystem cycles in economic cycles by respecting their natural reproduction rates. Such waste reductions, in association with the substantial increase of renewable energy utilization, can positively impact the environment and its biological and developmental processes, in joint cycles, using representative approaches such as "cradle to grave" industrial ecology or inter-systems ecology applications. The so called "biological nutrients" within industries provide an effective vision with dual service to support both biosphere and technosphere [70,81].

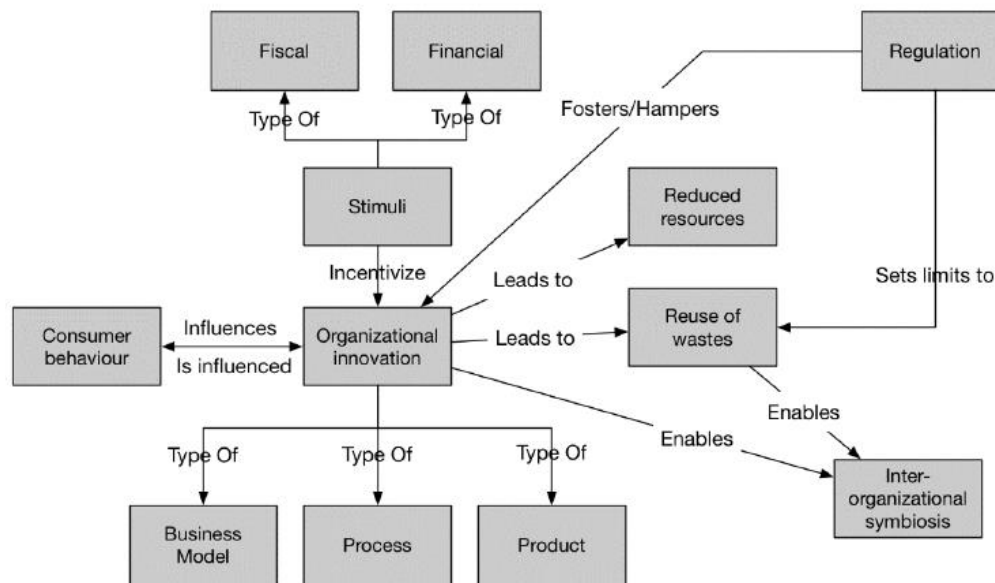
In this respect, Masi et al. [76] developed a systematic approach in achieving biodiversity in nature by combining diversity in urban-based systems, being the major task of sanitation for all waters working as an urban fabric [76].

ES-CE functionality is also determined by the transition phenomenon from one socio-environmental context to another. This dynamic behavior was further reported from the transition towards "zero waste" and CE. Ruggeri et al. [82] suggested that this function can be alternatively utilized against the dominant linear model of production, as well as a feasible approach to cope with climate change using the Global Reporting Initiative (GRI) guidelines. Moreover, a step-by-step holistic meta-model analysis of the CE implementation is presented as follows:

- Determine factors and interactions of impacting CE principles and applications among industrial processes.
- Reconstruct the production process and manipulate the environmental impact of such industrial activities.
- Identify the production steps, in alignment with utilization of raw materials used, and manipulation of wastes production.
- Investigate viable recycling strategies of materials and wastes within the same or among coordinating business organizations.

- Discuss the possible measures and policies that increase the CE applications within industries, under the principles of wastes reduction and exploitation of their residual value. In this framework, potential inter-organizational cooperation opportunities can be also effected/involved.

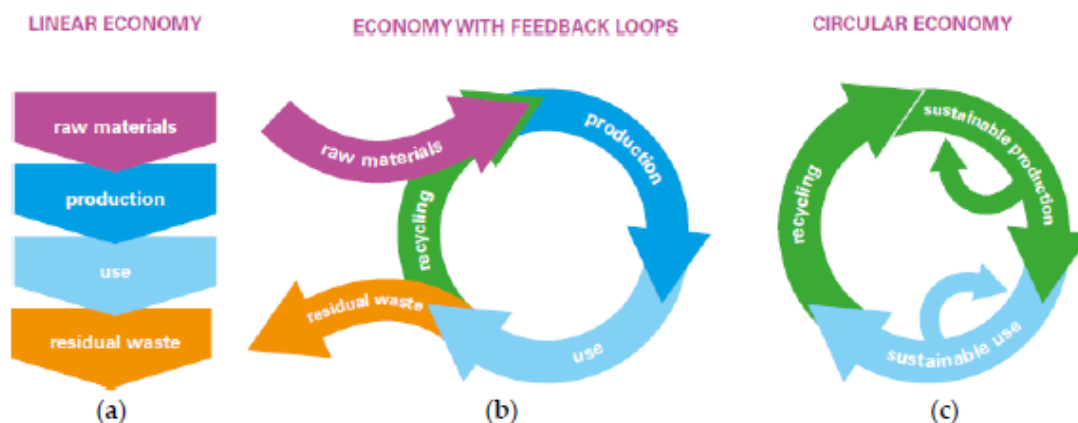
The main components of the inter-organizational ES-CE meta-model impacts are depicted in Figure 2. This meta-model defines the determining parameters of the inter-organizational interplay in the context of the functionality of the legislatives, the financial motivation, the consumers' behavior and the innovation procedures. Much more have to be done from the perspective of the mechanisms that enhance the continuity and the stability of the circular symbiosis over time [82].



**Figure 2.** A meta-model scheme of inter-organizational cooperation and ES-CE coordination.  
Source: [82] p. 12/17.

Another feature of the CE is referred to the effective adaptation to the energy-consuming industrial processes, such as in the steel industry. In such energy-consuming processes, CE integrates the component of the model, by promoting appropriate policies and introducing an improved design of products in recycling and reusing, thus, reducing the need for extraction of primary raw materials [72,83]. Furthermore, such a re-structural adaptation to CE is directly related to product designers who close material loops by recognizing and addressing challenging issues at the start of the design as well as the supply chain process [84]. Such an approach is linking to existing systems for resource recovery and further development of feasible CE, while the perspective of good economic earnings always plays crucial role of transition, through collaboration and corporate strategies to optimize the business ecosystems [81,83]. Three barriers identified in this framework, namely, the lack of investment power, the insufficient challenge of producers and the vested interests. The increasing rate of contracts and collaborations needed in the production–consumption chain, the higher management costs along with the more complex planning of CE that the producers confront, as well as the difficulty to change the status of established preferences are mentioned as the main barriers [81]. The most prevailing inflows and outflows processes of economic systems are gathered and presented in the following Figure 3.





**Figure 3.** Inflows and outflows diversifications among the schemes of (a) linear economy, (b) economy with feedback loops, and (c) CE. Source: adapted from [85], p. 4/17.

In the relevant literature production it was stated that worldwide, a portion which exceeds the 80%, is still discharged without adequate treatment, thus, open disputes on different concepts are arousing, such as centralization vs. decentralization [76]. Environmental performances and economical aspects are challenging issues that are attributed to the rather insufficient WTP perception, or in low treatment costs technologies with sufficient reliability and robust performances [76]. Another contentious issue at the energy sector is the food vs. fuel debate upon land use for energy crops [85].

A significant critical approach of ES-CE is the consideration of a wide spectrum of marketable products, including fertilizers, bioplastics, soil conditioners, and biofuels. Under this research context Masi et al. [76] clarified that the resource-oriented, and ecosystem services approaches, for future orientation of sanitation perspectives will be significant within the CE context. To this end, the global transition to future research upon sustainable water and biogeochemical cycles is needed, comparing to conventional wastewater treatment schemes. In this transition, the ES-CE coordination is an inseparable managerial tool [76].

In a similar study it was stated that special research can be applied to link ES to the CE [74]. In this context, the expansion of CE values is revealed in order to include restoration and regeneration of ES and to determine the appropriate parameters to support valuation. Liu and Cote [74] concluded that there are many opportunities and challenging issues to apply the framework to China's EIPs. In the Chinese context it is also noteworthy the study of Zhang et al. [32] who argued that the ES values is a booming tool for sustainable development of decision-making. Therefore, the social and economic dimensions of ES offer promising perspectives [86]. In such ES-CE co-valuation the critical parameters are that of: population, economic factors, regional environmental settings and norms, which all compose the basis for spatial allocation between different regional areas within a country of wide geomorphology diversification (such as China). It was concluded that both the ESV per capita and per GDP are effective indices [86].

In a critical research overview, Zhang et al. [32] introduced a regional revision coefficient and developed an index system for the equivalent value factors to better valuate the Sanjiang Plain in China ES. The variations among the contributions of the different ES are considerable; unveiling that there is no an absolute accepted method in which the ES could be measured in CE terms [32].

Finally, in the context of Mediterranean coastal areas, the urban sprawl and the reforestation incidents were detrimentally affecting the traditional agrarian profiles and the natural resources profiles, including beach areas and freshwater streams. Under this context, severe negative consequences on the biodiversity, ecological states, and terrestrial ecosystems were reported [87]. In evaluating the economic impacts of ES, the reconstruction of the landscape at El Maresme County (Barcelona Province, Spain), was studied by Dupras et al. [87]. These authors classified the three historic times of 1850, 1954 and 2010 to estimate the changes of land-uses, being affected by the ES non-market and market values.



These values were provided by distinct land-use through market prices and benefit transfer methods. It was pointed out the land planning policies, such as those of beaches and coastal systems, played a pronounced role of valuing non-market ES; and signifying the natural systems into decision-making processes [87].

### 3.2. Key Parameters Impacting the ES – CE Framework

#### 3.2.1. Uncertainty upon the End-of-Life Phases of Production

Product development from waste is directly determined by the accurate prediction of the composition of the waste streams available in differentiated phases of products' end-of-life [83]. Furthermore, the volumes of waste streams are changing seasonally, being time- and regionally-dependent from the sources of collection. End-of-life uncertainties can be flexibly addressed when product design uses industrial waste, rather than post-consumer waste, since industrial waste have commonly attributed to a well-known composition [83]. However, challenging issues of new products' design is the integrated approach of consideration cultural values, information sharing among global markets, and the limited influence upon products' discarding [83].

In our better understanding the optimization routes of used raw materials or generated waste the linear framework, product process (PP), has been introduced. According to the processes included, raw materials and waste are defined, obliging suppliers to be aware of resources efficiency and the life cycle of the products' delivered [71]. Further, once the raw materials have been extracted, refined and reused, make sense the gain of the value of the products that already have been lost and the longevity of the applications, as far as possible, coming back in the flow [70].

#### 3.2.2. Uncertainty upon Products Quality and Costs from Recovered Materials

Products designers have to make their product attractive but there is no specific market for such products, necessitating them to be completed within the existing markets. Therefore, the same quality standards of products must apply to both conventional and recycling-based products. Under this perspective products cost is an important issue, especially when recovered and virgin materials have no significant pricing differentiation to each other, as well as monetary incentive to justify the recovery motives [83].

Besides, rapid technological innovations increased significantly the complexity of production [83]. In this context, the profitability of recovering materials is only achieved through scaling up the collection of such products. In this respect, Extended Producer Responsibility (EPR) proposes a sustainable framework of product design, in which producers are responsible to reuse, recycle and finally disposal of the products and components they manufacture [83]. On the other hand, there are several cases in which producers outsource the responsibility to other organizations [83]. Producer Responsibility Organizations (PRO) can provide economically efficient ways to recover and recycle products, sustaining plentiful operations. PRO is not determined in reintegrating discharged products back to the industry, due to the complexity of the whole organizational system incurred [83].

Moreover, in the context of defining “value” under a business model, it is based on three main elements: (a) value proposition; (b) value creation and delivery; and (c) value capture. Therefore, the selection of activities, the development of an activity system structure, and the definition of actors performing these activities are inseparable components of such business models [72]. Specifically, the entity of “value” is determined under the following framework:

- Resources' recovery process ascertains that the economic value is gained, but it is questionable whether the materials' quality was improved, or not [83].
- In a CE system materials can be recovered and reused almost endlessly. Therefore, the entity of “value” (one component of which is so-called “resources”) prevents it from just exiting the economy [81].

- The concept of product-service systems (PSS) can reduce the total environmental burden of consumption, enabling more efficient use of resources and productive collaboration between producers and consumers [71]. The adaptation of novel approaches for products and services can eliminate the adverse environmental impacts and continue meeting users' satisfaction upon the products and services offered [68].

### 3.2.3. Uncertainty upon Environmental Changes

The main uncertainty issues upon environmental change are literature considered the timing of any climate change, the magnitude of the physical and biological changes, the relationship between the physical and biological changes to social costs, and the social discount rate used to put a value on current carbon releases relative to distant carbon costs. This brings up the concepts of sunk costs, sunk values and the discount rate as espoused [88–92]. Based on these studies it was denoted that carbon pollution creates very long run damage to the Earth, such that the environmental damages transfer across decades and, even, centuries. However, the link between carbon build-up and the climate system is non-linear, making unclear the determination of the magnitude of quantities, ways, and time of carbon build-up and geo-climate changes occurred. Similarly, the relationships developed between climate and biological systems as well as the link between climate and the world's economic system are, likewise, non-linear [88,91].

Actually policy makers upon environmental planning never really know what the benefits from reduced environmental damage will be, or even the amount of environmental damage that will be reduced by a particular policy. Worse yet, policy makers cannot precisely know what those benefits will be even exerting a lot of hard work to find out. For example, modern meteorological science interpret that the relationships developed between greenhouse gas (GHG) concentrations, regional or global temperatures, and climate patterns, are all inherently stochastic, thus, partly random. Again, supposing that policy makers knew what those changes in temperatures and climate patterns are likely to be, even less are known about their economic and social impact, in part because it is unknown of how humans will adapt to the issue of global warming (such as by growing different crops or living in different areas), since there is very little agreement as to just how bad this environmental change it is [89,90].

Another issue is the uncertainty on ways to put a value on future geophysical environmental changes since: (a) Citizens usually do not know what the current and future costs of a policy will be, and, (b) There is disagreement among economists regarding the “correct” rate that accounts properly for social time preferences. Therefore, it is risky to select those discount rate (or rates) which should be used to calculate the present values of ES. Under this uncertainty, ESV can be attributed under the context of a broad set of uncertainties over future changes in the: demographic makeup of the countries of reference; incomes; savings rates; costs of living for different demographic groups; as well as changes in disease prevalence along with medical and social inclusion costs involved. It is noteworthy that these uncertainties are greater and more crucial to policy design and evaluation, since important complications arise that are often crucial for environmental policy, but are usually much less important for most other private and public policy decisions [90,91]. Such environmental-sensitive complications: nonlinearity, irreversibility, and timing-sensitivity, are outlined below:

- (1) Environmental cost and benefit functions tend to be highly nonlinear. Subsequently, the cost of pollution abatement may be very low for low levels of abatement but then become extremely high for higher or total abatement. This fact implies that one cannot simply use expected values. The expected value of the cost or benefit function will be very different from the function of the expected value. The aforementioned uncertainties imply that environmental policy should be “precautionary” in the sense of favoring earlier and more intense interventions.
- (2) Environmental damage and policy costs are often irreversible. As a result, it can be misleading to base policies on expected values of costs and benefits. Environmental policies usually involve important irreversibilities, and those irreversibilities are occasionally functioning under a

complicated way of uncertainty. Environmental damage can be irreversible, and this can lead to a more “conservationist” policy than would be optimal otherwise. Irreversibility will affect current decisions if it would constrain future behaviour under the following plausible presumptions, (a) and (b):

- (a) Policies aimed at reducing environmental degradation almost always impose sunk costs on society. These sunk costs can take the form of discrete investments, or they can take the form of expenditure flows (such as a price premium to be paid by a utility that has committed to burning low-sulfur coal). If future costs and benefits of the policy are uncertain, these sunk costs create an opportunity cost of adopting the policy, rather than waiting for more information about environmental impacts and their economic consequences. This implies that traditional cost-benefit analysis will be biased toward policy adoption.
  - (b) Environmental damage is often partly or totally irreversible. It is exemplary noted that atmospheric accumulations of GHGs are long lasting; even if policy makers were to drastically reduce GHG emissions, atmospheric concentration levels would take many years to fall. Likewise, the damage to ecosystems from higher global temperatures, acidified lakes and streams, or the clear-cutting of forests may be permanent, thus, adopting a policy now rather than waiting has a sunk benefit, that is a negative opportunity cost. This implies that traditional cost-benefit analysis will be biased against policy adoption.
- (3) Environmental policies often involve very long time horizons. Indeed, while NPV calculations for firms’ investments are commonly ranged at 20–25 years, the costs and especially the benefits from an environmental policy can extend for a hundred years or more. Besides, a long time horizon exacerbates the uncertainty over policy costs and benefits, making hard enough to predict the impact of pollution or the costs of abatement. A long time horizon also makes discount rate uncertainty much more important. The determination of the optimal abatement policy for any realistic climate-economy model, one must solve a complex stochastic dynamic programming problem. Therefore economists’ debates are not so much over the need for some kind of GHG abatement policy, but rather whether a stringent policy is needed now, or instead abatement should begin slowly or be delayed for some time. Under this uncertainty, it is recommended that the “beginning slowly” approach is plausible since, by beginning slowly, it is likely to be dynamically efficient because of discounting (most damages will occur in the distant future) and because of the likelihood that technological change will reduce the cost of abatement over time [91]. Furthermore, it has been argued that this optimal timing uncertainty of policy implementation is effected in the case where sunk costs of implementing the policy –or the environmental damage from having no policy in place– is at least partly irreversible. Depending on the particular situation, it may be preferable to defer the implementation of an environmental policy until policy makers learn more about benefits and costs, or to speed up the implementation while avoiding irreversible damage. It is noted that while researchers have a good understanding of the economic theory, they may suffer from poor understanding of implementation in environmental practice [90].

### 3.3. Challenges Impacting the ES – CE Framework

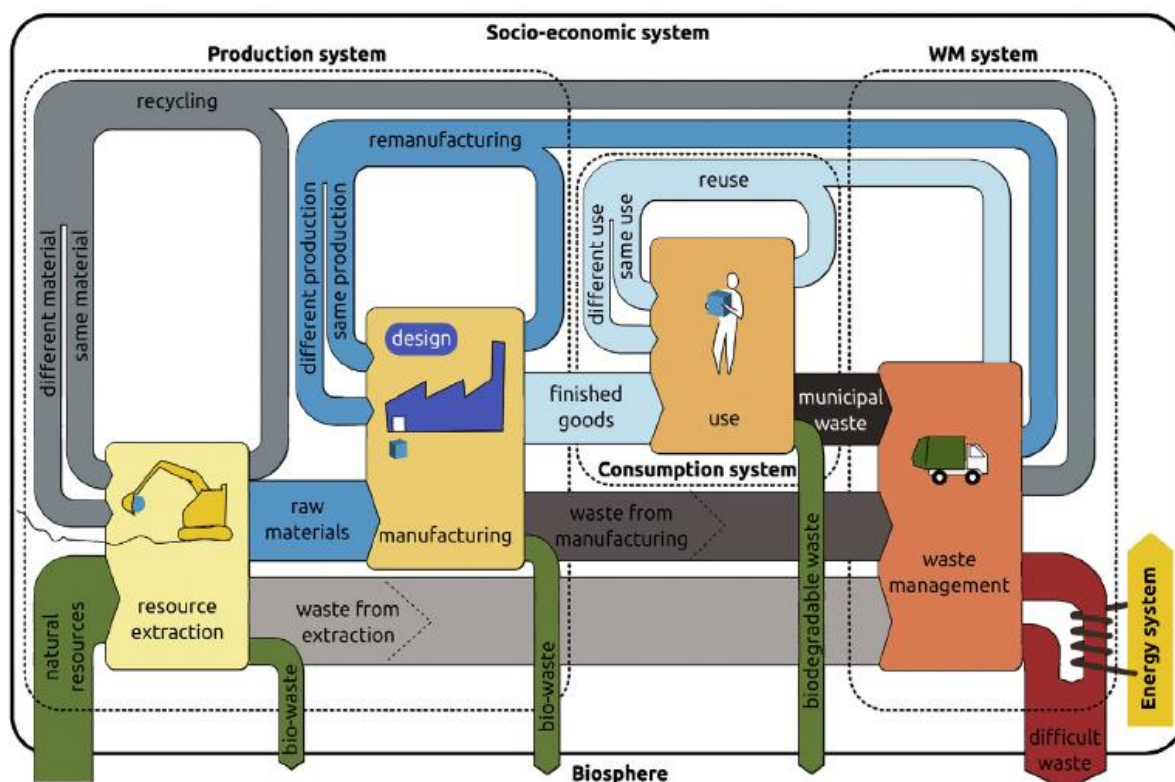
#### 3.3.1. Challenges upon the inter-Organizational Appreciation of the CE – ES Framework

In the relevant literature it was argued the necessity of transition from the linear business models: extract→ manufacture→discard, toward circular business models where products’ life cycle is including the steps of: repair →reuse→return→recycle [72]. In this CE approach the “capital” is broadened to include: financial, manufacturing, human, social or natural sources [72]. Subsequently, the deployment

of a lifecycle approach that involves social, economic and environmental impact of a product, from raw material extraction to end-of-life (EOL) recycling or disposal could be a quality criterion [72].

Even though the “conventional” CE concept requires manufacturing companies to recover their own products to secure the material stocks, it has been also reported that CE value is flexibly adaptable to a wider waste management orientation [83]. The wider concept of waste management also anticipated social, economic and environmental challenges in products designing to realize the goals of CE. The conceptual interface terminology among the ES – CE impacts can be framed under a set of definitions and questions upon the product type, the value, the production process, the waste type, the recycling system and the biodegradability [83]. Redesigned products and recovered materials—in alignment with the type of these products, the commercial value of these products, the possible inclusion of linear production processes, the identification of waste materials as industrial wastes or post-consumer wastes—are all routing the CE idea from the closed technical manufacturing system to the biosphere [84].

Indicative reuse-recycle-resale schemes referred to telecommunication sector (mobile phones) in US revealed a high retention rate of mobile phones by owners or second-hand users, as well as the fabrication industry in Sweden where there was reported high potential to reuse or recycle clothing material, in case that it was collected separately, by non-commercial second-hand stores [83]. In such an integrated socio-economic approach the CE and ES principles are treated under the flows and routes deployed at Figure 4. Singh and Ordoñez [83] interrelated the main contributors of the CE and ES principles, which are framed as: Reuse, Maintenance, Remanufacture, Recycle, Biodegradable, and Energy Recovery. Under this framework the main social-economic points are perceived as the human intervention to redirect the linear flow of materials and energy to a looped/cycling mode of actions, thus, adding value to –otherwise– waste flows of trivial significance.



**Figure 4.** A modeled scheme of CE and ES routes, under an integrated flow-chart of inter-organizational processes. Source: [83], p. 348.

In another integrated research approach of ES-CE impacts, van Buren et al. [81] determined a distinction between various gradations or options for circularity. This starts with “refuse” and

ends with “recover energy”. Different gradations or options (often referred to as the nine Rs) can be determined as follows [81]: Refuse; Reduce; Reuse; Repair; Refurbish; Remanufacture; Repurpose; Recycle; and Recovery of energy.

### 3.3.2. Challenges upon Labour, Time Preference, Liquidity Constraints, and Cultural Constraints

When businesses face input price increases or demand decreases, they tend not to suddenly change their labour, capital and supply chains. First, a business may have a large amount of sunk cost and sunk value invested in its existing human capital, real capital and suppliers that compel it to continue operating in its existing state in order to gain as much of that sunk value as possible. Second, the business cannot be sure that input prices or demand might not revert back to previous levels making a wholesale change in its business practice a loss making venture. Third, the business cannot be sure what new technologies and business environments will emerge such that if it tries to change too fast now, it will miss a better investment opportunity in the future. Therefore it refrains from changing. [88].

This implies that the world’s current fossil fuel based technologies should not be radically changed as that will reduce the sunk value that the world can continue to reap from its current fossil fuel technologies. By exploiting that sunk value now, new and better knowledge and technology, such as nuclear fusion, can be had in the future that ultimately might work better than the current batch of renewable technology on offer. Besides, the social rate of discount needs to be viewed from the perspective of the poorest two thirds of the world, in developing countries, rather than from the perspective of the richest one third of people, which suggests a social rate of discount much higher than 10%. That means the social cost of carbon emissions could be very low or even zero [89,92]. Generally, “discount rate” is nominated as marginal rate of substitution, not pure rate of time preference. Conceptually, the impact of liquidity constraints on time preference is theoretically ambiguous. Similarly, one expects intuitively that use of an interest rate that is too low, it will produce a time preference rate that is too low. Since liquidity constraints raise the household’s consumption growth rate, the household appears more patient than it actually is. Although no direct evidence is available, tests of the models’ over-identifying restrictions are potentially providing indirect evidence regarding the prevalence of liquidity constraints.

Under a microeconomics/organizational level of analysis, it is noteworthy that a significant negative correlation of a family’s current disposable income and its future consumption growth, are consistent with liquidity constraints. Consequently, it could be assumed that liquidity constraints, while they may affect some households in some years, are not so concentrated in a particular permanent income group as to seriously bias the results. [89,92].

It can be assumed that high rates of time preference may reduce investment household expenses, thereby producing a negative relationship between time preference and permanent income. In parallel, time preference may have a cultural viewpoint. These assumption sustain important policy implications, since, poor households are likely to possess relatively high rates of time preference and, consequently, relatively high marginal propensities to consume. As a result, transfers to poor households may adversely affect private savings and capital accumulation [89].

Under a microeconomics/organizational level of analysis, a negative correlation between time preference and labour income has two possible interpretations. Firstly, since it is difficult to borrow future labour income, impatient individuals may prefer jobs with flat wage paths, as opposed to careers that promise high wages only after a period of training or education (a period during which very low wages are earned). If the constraints are severe enough, impatient individuals will prefer the former kind of jobs even if their long-run earnings potential is reduced. Moreover, capital market imperfections can explain a negative correlation between time preference and permanent income. Actually, time preference is culturally-attributed, having sound sociological evidence supports this view [89]. This author signified that the negative relationship between time preference and a family’s permanent income could reflect, at least in part, deep-seated cultural differences. Under this argumentation, there



are assumed that the only preference parameter that differs across households is time preference, and that socioeconomic variables vary with time preference in the same way for all households. For the low-income households, age and family composition are the only significant predictors of consumption growth [89].

### 3.4. Integrated Biosphere – Technosphere Conceptualization under the CE – ES Framework

So far, the main socio-economic characteristics of such ES-CE co-evaluation are associated with the reduction of the materials and energy flows, the socio-cultural perspectives, and the higher value and quality of product cycles. The reduction of production and consumption system by applying cycles and cascades to close the flows loops, offers new market opportunities and risks related with the sharing economy, increased employment, participative democratic decision-making and a cooperative and community user (user groups using the value, service and function) as opposed to a consumer (individuals consuming physical products) culture. In a socio-cultural perspective of ES-CE coordination, the cooperation of a range of disciplines across sectors changes the users' behaviours and adapts to a new system. These ES-CE changes of attributes are best community driven. The contribution of CE is summarized, firstly, in the highlighting of high value and quality material cycles and secondly in the sharing economy regarding the sustainable production and consumption culture, although there are several issues related with the limitations and challenges, such as thermodynamics, systems boundaries, management of inter – organizational symbiosis, intersectoral relationship, governance and energy flows, all regarding with the actual environmental impact [70]. For these reasons CE –equipped with critical sustainability assessment– it can play a decisive role for global net sustainability.

There are two critical components that related with the CE in an inter-organizational grid, the functionality and the accountability. Taking into account the distinguished risks regarding the proactiveness and the post treatment underlying values, a FSM is considered to accelerate the industrial symbiosis towards the restoration and regeneration of ecosystem services. Table 4 depicts the integrated systems' framework. Based on this, it can be noted that the first-step processes of CE contain all (two-boxes) components of the main procedures of "renewables management" and "stock management of finite materials", which are following a linear order of implementation, but these main procedures have both the manufacturing process, as the common ending component. Subsequently, the second-step processes contain the restoration and regeneration of ES, both of which are following a linear order of implementation.

In a scaling-up viewpoint, the second-step processes are leading to the three-step process, which reflects the quality and quantity of restoration and regeneration processes applied. Whatsoever this linear process is satisfactorily effected, or not, it is noteworthy to conceptually recognize CE as "*one (entity) that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles*" [2]. Based on the aforementioned conceptual map it is noteworthy that though the linearity of processes are prevailed while examining the ES and CE in isolation, under the principles of inter-organizational functionality the significance of looped processes is predominated over the linear ones.

At this study it was further proposed an integrated approach of linking the ES and the CE entities under to comprehensive development of an inter-organizational grid. As it is schematically represented in Table 4, the interrelated partnership between the ES and CE –in the light of an inter-organizational grid– is perceived in terms of proactiveness and post-treatment, towards a restorative and regenerative interplay. The role of organizations in balancing the ES-CE system is of paramount importance since both public-owned and private-owned organizations are able to sustain the appropriate economic funding and the know-how diffusion, in order to act proactively or post-treated upon ES-CE discordance. Other determining parameters of the ES-CE inter-organizational grid are the bilateral agreements developed under wider governmental allies, or private-owned organizational collaborations, as well as the technological, vocational, and environmental orientation of education curricula in order to reinforce the personal development of environmentally conscious and alarming citizens.



**Table 4.** Integrated biosphere–technosphere conceptual map implemented into inter-organizational grid. Sources adopted: [74], p. 5/20; [53], p. 69.

| Biosphere   |   |   |
|---|---|---|
| <b>RESTORATION AND REGENERATION OF ES:</b>  | <b>SOCIO-CULTURAL VALUES OF ES:</b>   |   |
| <ul style="list-style-type: none"> <li>• Use: How do beneficiaries use and benefit from ESs?</li> <li>• Perception: How do beneficiaries perceive ESs?</li> <li>• Information: What do beneficiaries know about ESs?</li> </ul>                       | <ul style="list-style-type: none"> <li>• Group values: Social network; Institutions</li> <li>• Individual values: Cultural background; Willingness to Pay (WTP); Location of residence; Education level; Income; Age; Gender</li> </ul> |   |
| <b>RENEWABLE MANAGEMENT:</b>  | <b>Environmental Services (ES)</b>  | <b>STOCK MANAGEMENT OF FINITE MATERIALS:</b>  |
| <ul style="list-style-type: none"> <li>• Biochemical feedstock</li> <li>• Extraction</li> <li>• Digestion</li> <li>• Collection</li> <li>• Biogas production</li> <li>• Ecosystem service supply (quantity, spatial scale, temporal scale)</li> </ul> |   | <ul style="list-style-type: none"> <li>• Collection</li> <li>• Share maintain prolong</li> <li>• Reuse</li> <li>• Refurbish</li> <li>• Recycle</li> <li>• Landscape characteristics (land use change, configuration, composition)</li> </ul>                                      |
| INTER ORGANIZATIONAL PATTERNS LAYER   |   |   |
| <b>PROACTIVENESS PROVISION AND DESIGN UPON:</b>   | <b>Circular Economy (CE)</b>  | <b>POST-TREATMENT REGULATORY AND MAINTENANCE UPON:</b>  |
| <ul style="list-style-type: none"> <li>• Bilateral agreements</li> <li>• Technology</li> <li>• Education</li> <li>• Lessons learnt from past/historic environmental disasters</li> <li>• Large scale infrastructure</li> </ul>                        |   | <ul style="list-style-type: none"> <li>• Bilateral agreements</li> <li>• Know how diffusion</li> <li>• Education</li> <li>• Public and Private owned funding</li> <li>• Governmental interference</li> <li>• Environmental restoration</li> <li>• Healthcare budgeting</li> </ul> |
| Functionality of CE/Accountability of CE  |   |   |
| Technosphere  |   |   |

Under the aforementioned context, Scholte et al. [53] introduced an integrated socio-cultural approach to value ecosystem services in interpreting the ES-expanded fulfillment criteria of importance to the human well-being, regarding the ES principles about monetary values and socio-cultural perspectives. This integrated socio-cultural approach was enriched at this study in order to reveal the relative positioning of inter-organizational patterns into a wider technosphere-biosphere grid, shown at Table 4, below.

Based on the aforementioned Table 4, the extension of functionality and accountability of CE-side accelerates the restoration and regeneration of ES-side through the underlying risk values of proactive and post treatment operations analysis. Transformation is proposed into a FSM. Besides, the inter-organizational patterns are positioned as an intermediated layer among technosphere and biosphere. Moreover, and based on the literature viewpoint of Tables 1–3, this layer is predominately determined by the underlying proactiveness aspects of provision and design on environmental systems, as well as the post-treatment policies of regulatory and maintenance interest on environmental systems. Subsequently, the inter-organizational patterns' layer is directly determining the main processes of renewable management and that of stock management of finite materials. Based on this framework it is noteworthy the pronounced importance of such an inter-organizational patterns to the conceptualization and functionality of a robust and sustainable technosphere-biosphere grid.

According to Scholte et al. [53] cultural ESs are further attributed to both material and immaterial well-being and landscape, while ecosystem characteristics are also linked to management practices and valuation. However, limitations of ES values are recognized, firstly, regarding the individual motivation

upon environmental behaviour without reviewing contextual factors and secondly, referring to the difficulty of experiencing private-owned firms which are adopting sustainable practices in management decisions [53]. These limitations are originated from companies' inability to balance out on the one hand the environmental value of conserving ecosystems and, on the other hand, the potential profits captured through their organizational development [53]. Another critical issue that is related to ES is their restoration and regeneration perspectives given that the ES are perceived as subgroups each one of which is further determined by descriptive indicators. Under this framework, Liu and Cote [74] proposed the subgroups and description of ES. They analysed the ESs in provisional, regulating, cultural and supporting services, referring to the products obtained, the benefits gained from the processes, the cognitive and aesthetic perceptions, as well as the participation for the production of other ecosystems services, respectively. Interrelated descriptive indicators have been also proposed [74].

The inter-organizational patterns at Table 4 are framed as enablers and barriers. Enablers of such a multi-parametric inter-organizational grid can be the economies-of-scale achievement upon properly structuring and operating large-scale infrastructure of environmental restoration. On the other hand, barriers of such a multi-parametric inter-organizational grid can be the complexity of manipulating globally-burdened environmental issues, such as accidents at nuclear power stations, transboundary pollution on air—including firestorm, industrial smog, and chimney effect—and in wastewater inflows from countries-crossed rivers and bonds. Besides, other challenging barriers are the complexity in calculating the environmental externalities of anthropogenic-intensive activities, such as electricity use, as well as the abiding huge costs in healthcare treatments after the environmental malfunctions divulged. Moreover, it is noteworthy the following critical issues (based on interpreting Table 4):

Firstly, proactive funding is commonly less costly than post-treatment funding, since the latter always involves not only the cost of environmental remediation itself, but also the non-monetary calculated environmental deterioration caused as well as landscapes' degradation, habitats' malfunction, and endangered species' extinction. Nevertheless, the strategic planning of operating companies of a meso-level of analysis it is directly determined by proactive or post-treatment philosophy. To this point, it is an imperative need of clear governmental policies and a powerful legislative system to regulate the marketplace and to reconcile the competitive interests of maximizing business profitability (that is one of the CE-principles) at a low cost, against unavoidably costly environmental protection (that is a core perception of the ES-principles).

Secondly, the role of organizations in balancing the ES-CE inter-organizational grid is badly affected by the regional segmentation of regulatory directives, educational background, funds' budgeting, and traditional peculiarities applied at developed and developing economies, as well as the inherent subjectivity in accounting environmental and economic aspects in a common basis, especially considering the uneven influential power of stakeholders and the conflict of interests in sharing the common good of environment under monetary appreciation.

#### 4. Discussion

In an integrated research context, this research study highlights the necessity of a new value-based indicator to assess the performance of inter-organizational systems, in terms of "resource efficiency", "environmental services valuation" and "circular economy". Particularly, in this research work under the term of "inter-organizational system frameworks" there are not merely included entrepreneurial contexts, but an integrated function of influential environmental, social, economics, and cultural patterns. Under these research objectives, the determining issues that are stressed out in this study regarding the feasible impacts between CE and ES are as follows:

- The inherent difficulty to standardize and a product and make product from something (such as wastes management) that it is not standard. Therefore, a marketable product can be drawn under the strategic-planned constraint that never mass-production from recycled materials can be precisely scheduled, due to inherent uncertainty upon the possibly adequate components

available to produce a new product, since the less value for the products implies the less value for recyclers.

- The fact that even though the prospected cooperation parameters among organizations in cases of absence of symbiosis are identified and discussed with practitioners, future research orientation can develop paths of ES-CE inter-organizational symbiosis among businesses, valuing also quantity and quality of resources exchanged in these symbiosis schemes.
- The fact that there is an inherently related limitation to the operability of some industrial products, such as in the steel industry where only a rough estimation of the steel stock available for recycling can be estimated. This limitation is also apparent to properly sorting out all scrap-prone stocks, ensuring the higher possible quality of reused material.
- Monitoring complexity upon the overall recyclable stock is retarding large-scale applicability of CE. Singh and Ordoñez [83] exemplary indicated that a large portion of post-consumer goods can be placed as stock, thus, there are non-traceable stocks, making their reuse potential highly randomized, whereas remanufacturing has to be further developed, too.
- The context of Global Reporting Initiative (GRI) guidelines, as well as other standards' codification are offering standardized indicators to measure waste reduction through various methods, whereas these methods are mainly measuring outputs versus the socio-cultural impacts of: source reduction, reuse, corporate social responsibility, sustainable production-consumption chains, innovation, and the principal inclusion of the "Res" modes, such as: Reform, Refuse, Reduce, Reuse, Repair, Remanufacture, Recycle, Recover. This integrated consideration of CE – ES impacts implies a dynamic transition from one socio-environmental context to another, such as the transition towards "zero waste to landfill" and CE.
- The fact that ES - CE impacts in contemporary urban contexts of developed economies implies that multifaceted factors are determining the future of urban systems. In this respect, treatment of wastewater can be replaced by production of goods and an optimized system can achieve multiple targets altogether, instead of having a separate infrastructure for any purpose [76].

The impulse of transformation is based on more and more complex processes, while the integration of the CE concept within the shrinking ecosystem services is an utmost importance factor to achieve an optimal balance of economic, social, and environmental benefits for the inter-organizational grid. To this end, the proposed FSM orientation, incorporates the risk values of proactiveness and post-treatment, and accelerates the restorative and regenerative pulse, to provide a strategic planning advantage to the new entries and existing organizations. In a scaling-up perspective it can be denoted that, for an integrated ecosystem management, its operationalisation is mainly hampered by the lack of agreed evaluation instruments upon appreciating cultural environmental system (ES) –such as aesthetic, recreational, educational, and existence– values. Monetizing of ES through economic methods –including "damage costs avoided", "contingent valuation", or "benefit transfer"– could precisely estimate a market value or direct economic impact per year, as a result of the restoration. However this financial appreciation is neither convenient nor worldwide achievable [16].

It is noteworthy that neither the ES-bounded renewables' management –along with the stock management– should be straightforward perceived as costless choices, nor that CE-centered procedural choices of proactiveness and post-treatment are ensuring the economic profitability of a business and the wellness prosperity of its workforce and ownership. This study framed a generic flow-chart of coordinated procedures, which are determining the exact positioning of CE services and ES operations into a wider inter-organizational context of development. Whatever the managerial philosophy could be in an organization, policy makers cannot undermine the issues of economic recession, educational background, economic liquidity, technological maturity, scarcity of bank loans offered, thread of companies' or national economies' bankruptcy, as well as the non-always regulated governmental supportiveness of entrepreneurship. Moreover, it is important to signify that human thought is inherently functioning into a linear manner of thinking, when decisions have to be taken among alternative choices, whereas the looped-perceived processes upon socio-economic and environmental

issues are appreciated as radical and complex by managerial-, energy-, and environment- planners. Therefore, the CE and ES coordination is a case-sensitive strategic decision undertaken from a company, not a panacea that can ensure businesses' economic growth. Besides, followed by social cohesion and personal prosperity at developed and/or developing economies, it is particularly interesting to viewpoint the CE – ES framework in the light of a SWOT analysis. The main components of such a SWOT analysis are as follows:

- Strengths consist of the biosphere contribution to technosphere functions. Particularly, the main biospheric features of applicability are the use of renewables and particular the utility of solar, wind, hydro, geothermal energy as well as the land use for energy crops' cultivation. In an industrial context the biosphere serves as deposit of wastes disposal, while in a commercial/services context the natural hallmarks serve as tourist destinations of high quality/attractiveness's leisure services at the tourism industry.
- Weaknesses, are the barriers aroused in a socio-cultural context, such as the lack of investing power and capital, the lack of interest of CE endeavours due to complex terms of bilateral contracts imposed and the increasing costs concurred, as well as the vested interests incurred against greener economies. Other weaknesses valued upon the ES-CE frameworks are that the economics appreciation of variable ecosystem service types of different terrestrial ecosystems at the same area, they may be considerably varied. In such an index system, the contribution attributed to regulation function was the pronounced from the hydrological and climate regulations [32].
- Opportunities, being unveiled under the internationalization and extroversion of SMEs of agricultural, services, or trading interest, under reciprocally-signed bilateral trading agreements, as well as the technological development running under innovation-driven advancements' spur. Interestingly, in the literature it has been also reported that non-“ecological engagement” users tended to give at the cultural-oriented ES value of recreation the highest importance value. Therefore, by understanding stakeholders' valuation of ES, and perceptions of threats to their conservation, can improve planning for urban protected areas [17].
- Threads, aroused under the economic pressure, the depletion of natural sources, the social exclusion and marginalization, along with opportunistic workforce units –being powerless to shape their own prosperity paths under the socio-environmental restrictions divulged. Another critical issue for further consideration is the provision of a broad classification of valuation methodologies of ecosystem services that can, and has been, aptly used within a legal framework. Especially among developing economies it is important to note that a valuation of a CE – ES framework is directed to a subsistence economy, where communities are operating outside monetary markets, much like many other remote communities rich in supporting and regulating ecosystem services. Here the ES-CE framework is appreciated through stakeholders “(not to lose) *something invaluable and critical for their identity and their well-being*” [45], since “biophysical and socio-cultural ES benefits play a vital role for peoples' wellbeing” [48].

Under this socio-environmental orientation of the aforementioned SWOT analysis, major research orientations should be focused on the causes and the likelihood of severe or catastrophic outcomes, thus, involving collaboration between economists and physical scientists. In appreciation of global-driven environmental issues which reflect the biosphere-technosphere system, such as global warming, more work is needed on other problems that may eventually turn out to be even more pressing, such as the depletion or degradation of water resources, acid rain, toxic and nontoxic waste disposal, as well as the loss of wilderness and wildlife [90].

## 5. Conclusions

ES valuation in monetary conditions can be proven effective to attract the proactive responsibility and environmental consciousness of citizens. The latter could further promote the transformation from traditional economy towards the integrated economy-environment integrated calculation systems.

In this respect, a CE framework upon inter-organizational systems should play a critical role in an organizational and strategic planning context.

It can be also pointed out that resource efficiency within CE can be achieved by keeping the added value through the prudent use of raw materials and energy consumption throughout all stages of the value chain, and by using products for as long as possible, thereby eliminating waste. The multifaceted impacts of inter-organizational grids directly affect the company's business model components and activities that ensure a fair distribution of costs and benefits. This fully integrated process of redesign categories should support the sustainability of jointly triple layer business models taking into account both vertical and horizontal dimensions in a multilayer consideration.

Besides, the redesign of business models can move from fully product-centered to include service-centered operations, involving other important stakeholders throughout the life cycle of the product itself, or for the whole society in general. Subsequently, the social reflection of ES-CE impacts increases public awareness and drives consuming behaviour to actively contribute to such ES-CE schemes. Moreover, under this socio-emotional context CE may come across with the product – service systems, thus, not conveying the conventional values of ownership.

Conclusively, while the ES-CE boundaries are reviewed the concept of the inter-organizational grid cooperation among different business organizations is perceived, in which these partners are exchanging resources towards circularity of production processes and industries. Therefore, an organization can be symbiotic with another one or more. This form of symbiosis is applicable to either reduce resources overuse, resulting in costs reduction and the creation of new working opportunities by reusing waste as secondary raw materials. The research paths of future ES and CE coordination are promising to creatively activate the inherent strengths and organizational capacities to reciprocally coordinate to each other. The study unveiled the prosperity of this process, to be technically feasible and socially accepted in a near future time-frame. Nevertheless, further research and codification are yet to be made upon the degradation and the quality of secondary materials, while clearly indentifying distinguishable indices against the conventional models.

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