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Preliminary results for a tool-based approach for indicators supporting circular economy projects

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A tool-based participative approach to support indicators definition was developed in a previous study. Both the use of the indicators and the approach aim to support decision-making in projects of transition to a circular economy, with a systemic vision and in a strong sustainability perspective. The approach was tested in laboratory, without participants, on a project of food-processing design (micro scale). Here, first results about its implementation in 3 case-studies at a meso scale, with participants, are presented. Participants' support for the approach tends to validate its value in responding to problems in the field. While some adaptations were required between the cases, the main steps of the approach and the tools are similar. It demonstrates their genericity in these contexts. However, in the three case-studies, participants initially did not have the systemic vision expected. Adaptations of the approach and tools have been necessary, including multiple iterations, a meeting to link the project and the circular economy framework of the approach, and the co-construction of a map of the system. Based on these first encouraging results, the case studies are still in progress to verify the assumptions about the approach. In the medium term, it should be associated to a co-modelling process to provide a more complete decision-making support.

* 1. Introduction

A growing number of circular engineering projects are being developed. They propose to reduce, reuse, recycle or recover resources. Their aim is to contribute to the transition to more sustainable systems. However, they are embedded in an economic, social and environmental context. This context will impact the project (e.g. social acceptability), which in turn will impact it (e.g. CO2 emissions). Depending on the context, the project will not necessarily improve the global sustainability. It may be necessary to rethink elements of this context, particularly socio-economic ones. In this case, the project is part of a transition to a circular economy, going beyond the scope of circular engineering. A question to be asked in engineering project management is: How to support the development of projects really contributing to a transition to a more circular economy, and thus to more sustainable systems?

Models are useful decision-making tools. Stakeholder participation in the model development improves both the consistence between the model and the context, and its usage in decision-making (Roth et al., 2021). However, indicators to include in such model should first be defined. While there are numerous indicators relating to the circular economy, most of them are specific, biased by an aggregation method and incomplete (De Pascale et al., 2021). So, what aspects should the indicators represent to support the transition? How? And how can they be adapted to the specificities of a given context?

As for models, developing indicator sets with the stakeholders is of special interest, including to consider the specificities of the context and improve their usage (Bauler, 2012). It is also a way to co-define which system to aim for and how to get there. Such participation seems then necessary for real and desirable transitions. But how to support this participatory process?

A previous study (van der Werf et al., 2025) proposes a tool-based participatory approach for developing indicators aiming to support decision-making on projects of transition to a circular economy. The central tool is a database of indicators classified in a framework, both deduced from the literature. The categories of the framework present what can be considered to get a systemic vision of the circular economy, and the indicators are examples of how to represent that. The approach was applied in laboratory, to have indicators assessing if a specific project of development of a food processing unit was anchored in a circular economy, with a systemic vision.

The main perspective was to implement the method on projects in other contexts, with participants, to discuss the following assumptions. The approach and the tools are supposed to be generic (scale, sector, context). The set of indicators are supposed to be case-specific and present a systemic vision of the circular economy. Both the participative process and of the use of the co-defined indicators are supposed to influence the participants, their vision of the circular economy and of the system studied.

The method is being implemented on three case studies, in three contexts, with participants, to verify the assumptions. Case-studies are (i) a public project aiming to improve the reuse in building sector in a French metropolis; (ii) a waste management joint association wishing to improve the reuse in a French metropolis; (iii) a waste management joint association wishing to understand and improve the value chain of used textile in a rural French department. A first section about material and methods presents the approach of indicator sets development and the three case-studies. A second section describes the first adaptations of the method which were necessary, discuss its genericity and interest. It also outlines of reasons for these adaptations, including about the systemic vision expected.

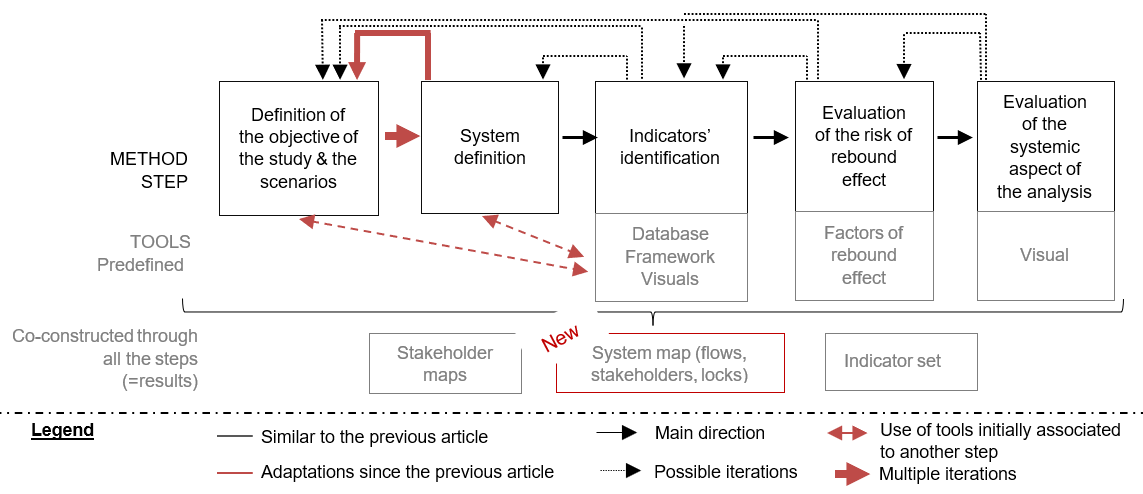


Figure 1: Overview of the method and associated tools to develop indicator sets. In red the adaptations since the previous article, with the case-studies.

* 1. Material and method
     1. Indicator set development approach

A previous paper presents a participative approach to develop sets of indicators for projects linked to circular economy (van der Werf et al., 2025). It includes five main steps, supported by tools (Figure 1). The purpose of the study is defined in step 1, i.e. what use of indicators is expected, to which question they would answer, which scenarios they would compare. In step 2, the scope of the study is defined in terms of stakeholders, scales, spatial and temporal limits. Stakeholders’ identification is supported by visuals and definitions from stakeholder theory (management sciences, (Girard and Sobczak, 2010)) and school of proximity (economy, (Colletis and Rychen, 2004)). Both steps are supported by maps of the stakeholders and of the system studied. First indicators are also identified during these steps. In step 3, the complete set of indicators is developed, supported by a data base of 379 not aggregated indicators classified in a framework deduced from the literature, summarized in section 2.2. Categories of the framework show what can be considered in indicators related to the circular economy, while indicators show examples of how to represent that. Steps 4 and 5 aim to verify that the indicator set and the maps present a systemic vision. In step 4, the risk of rebound effect is discussed, based on (Metic and Pigosso, 2022) and (Castro et al., 2022), who identified the main factors initiating or developing rebound effects in circular economy projects. In step 5, the indicator set developed is assessed, using a visual based on the framework of step 2 and the system definition of step 1. Indicators should provide a global vision of the system and of the circular economy.

* + 1. A framework to support a systemic vision

The approach is supported by a framework deduced from a multi-disciplinary literature analysis and workshops, presented in a previous paper (van der Werf et al., 2025). It was developed in a strong sustainability and systemic vision (Vivien, 2009). It considers that humans extract and reject matter and energy flows from/to the nature. They transform and exchange flows through various technic and economic systems. Societies’ structure deeply depends on the economic system adopted, on the technics employed, and on the nature state. Actually, the structure of each dimension (i.e. nature, society, economy, socio-economy, technic, flow) depends on the one of the others. However, the dependency between them is not equivalent. While nature can still exist without humans, even in a modified state, humans require a certain level of nature integrity to exist.

A system is presented as a network of elements associated to each dimension, at various scales, i.e. nano (product, person), micro (organism), meso (network of micro) and macro (environment). Circular economy is considered as aiming at increasing the sustainability of this whole system by various strategies, grouped in 5 categories in this order of preference: rethink, reduce, reuse, recycle, recover.

Concretely, indicators were associated to the categories of this framework (dimensions, circularity strategies and scales). Dimensions were decomposed in subcategories, presenting meta-criteria. A systemic vision would consider the various categories and the interests of the stakeholders.

* + 1. Case-study in laboratory

In the previous paper, the approach has been applied on a project previously studied by the authors: the implantation of a food processing unit in a peri urban area of Abomey Calavi, Benin. The unit processes cassava roots and sweet potatoes into flours and starch powder. There is currently no such scale of food unit in this area. It raises many problematics, including around raw material, devices availability, and social impact on the current processor and local population. The objective was to define indicators which could have been used to ensure the adequation between the design of the unit and the circular economy. It mainly focused on the micro scale. Each step was conducted by the authors out-of-field, based on their knowledge of the context. The indicators selected present all the dimensions of the circular economy identified in the framework, the scales, and the (supposed) interests of all the selected stakeholders.

* + 1. Three case-studies with participants

The approach is being implemented to support decision-making in three case-studies with participants, leading to the development of three projects. Table 1 presents their context. They were selected for their topic and diversity. According to the projects’ initiator, these projects aim to contribute to the transition of systems to a circular economy. They all mainly focus on the reuse of objects or materials, at the meso scale (network of organisms). They were initiated by public institutions, in rural and urban areas of a French region. Table 1 underlines the diversity of maturity of the sectors studied, of expectations from the participants about the study, and of proximity between the stakeholders. The following paragraphs present each case.

Case “used textile”: In a French rural department, waste management has been entrusted to a joint association. The joint association sees room for improvement in the used textiles sector at the scale of its department, but knows neither the sector nor the stakeholders. Stakeholders of the sector present in the department are mainly involved in the reuse. They are not federated, critic about the current value chain, and suffer from a lack of support from the joint association. The joint association would like to bring them together to define a common strategy. Indicators are a means of exchange, and will enable the strategy to be monitored.

Case “reuse in waste collection centers”: In and around an important French metropolis, most waste collection centers are managed by a joint association. It delegates the operation of some of them to a company. Since 2024, reuse zones have been deployed in most of these waste collection centers. Individuals drop off their reusable items there, and reuse actors collect, prepare and sell them. Reuse actors are associations and social companies working on reinsertion. The joint association aims to bring reuse actors and waste collection centers operators together to improve the reuse and support the establishment of these zones. Indicators are a means of establishing a common strategy.

Case “reuse in the building and public works sector”: The reuse value chain in the building and public works sector is not structured. The economic service of a French metropolis leads a project to increase the reuse of this sector by initiating and boosting a change of practice for all the actors of the sector in the metropole, to make the reuse a habit. They want indicators to defined the conditions required for this habit change, and to follow the project.

Currently, the steps 1 and 2 of the approach are being implemented in the three case-studies (i.e. definition of the objective and the scope, see section 2.1). In the case “used textile”, meetings have been organized with the stakeholders separately for now. As the project initiator did not know them, it was necessary to identify them, pre-define a scope for the problematic and invite them all to a first structured meeting. For the case “reuse in waste collection centers”, the main stakeholders have already met three times leading to a relatively clear definition of the project outlines and the main scenarios to be explored. In the case “reuse in the building and public works sector”, four meetings with the project initiators have been necessary to clarify their purpose and invite other stakeholders.

* + 1. Data

The analysis is qualitative, anchored in a constructivist epistemological paradigm. It is based on recording and notes of 8 meetings, 17 interviews, 4 visit of sites, public communication of the stakeholders (e.g. website, status reports), and literature about the sectors of the case-studies.

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| Table 1: Comparison of the three case-studies   |  |  |  |  | | --- | --- | --- | --- | |  | Case “used textile” | Case “reuse in waste collection centers” | Case “reuse in the building and public works sector” | | Sector maturity | Existing, possible restructuring | Recently structured | In creation | | Project initiator  (= first participant) | Joint association in charge of waste management | Joint association in charge of waste management | Economic activity department of a metropolis | | Typology of territory | Rural area | Metropolis | Metropolis | | Participants | Being defined (Joint association, ecoorganism, associations and social companies selling used textile) | Joint association, company operating some waste collection centers, the main social company in charge of the reuse | Currently only people from the economic activity service of the metropolis. Other stakeholders will participate | | Relationships between participants | Stakeholders (future participants) do not know each other, or very few. | Participants know and appreciate each other. They know less the other stakeholders. | Participants are colleagues. Only one knows the stakeholders of the sector. | | Initial expectations of the project initiator | Understand the sector to improve it | Personal curiosity; way to valorize its activities in the joint association | Defining scientifically-based indicators assessing policy efficiency | | Current expectations of the project initiator | same | Same, and redefining performance indicators for the stakeholders; actions to improve the current system | Same, and process to support the structuration of the sector; indicators to follow the structuration | | Purpose of the study defined by the current participants | Being defined | “How to increase the tonnage collected that will actually be reused  on the network of waste collection centers  over a 4-year period?” | “Conditions and timeframe for a desirable shift in the construction industry towards more reuse” | |

* 1. Results and discussion

The approach has been applied in laboratory on a micro-scale project, and is being implemented in three cases on field, on a meso-scale, with participants. The initial vision of the circular economy and of the system by the participants is first analysed, to explain then the adaptations of the method between the case-studies. It provides first elements about the genericity and the interest of the approach.

* + 1. Difficulty of a systemic vision

The framework of the approach (2.2) classified five strategies of circularity, by order of preference: rethink, reduce, reuse, recycle, recover. Project initiators desired to focus on one of them (reuse). However, each case-study is anchored in a wider strategy, involving other strategies. For example, for the case of waste management centers, other projects with other actors focus on recycling, recovering or reducing waste by rethinking the waste vision. All these projects aim to implement the global strategy defined by the joint association. This fragmentation is presented as necessary to treat operational question, while it is in contradiction with the framework proposed.

Participants consider the reuse as an objective, while in the framework it is considered as one of the strategies possibly leading to the objective of the circular economy, i.e. a system more sustainable. This difference is partly due to the lack of consensual definition of the circular economy, as underlined by the 221 definitions collected by (Kirchherr et al., 2023). It also reveals the difficulty to perceive the links between the dimensions (nature, social, …) and the strategies of circularity, necessary to consider possible direct or indirect impact of the reuse. Impact consideration could lead to the choice of another strategy (e.g. rethink), or to actions to limit them (e.g. formation). Furthermore, their vision of the circular economy, focus on flows, limit the expression of some stakeholders for whom reuse is not the personal objective. For example, for some social companies the reuse is a means to reach their own objective, which is the reinsertion of people far from the employ.

Furthermore, the sectors studied being recent or in creation, they are not central in the activity of the participants. Participants have then not a complete knowledge about the system studied, complicating the access to a systemic vision.

* + 1. Generic approach requiring adaptations

It is expected that the set of indicators developed presents a systemic vision of the problematic, anchored in a strong sustainability perspective. In concrete terms, it should reflect the dimensions of the circular economy and of the system identified in the framework (2.2). This is quite straightforward if the participants' projects and visions are initially systemic and close to the framework. It has thus not been a problematic for the case-study in laboratory, while it required adaptations of the approach for its implementation on field (Figure 1). However, adaptations remaining slight, it does not contradict its genericity in these various contexts.

The use of the tools was adapted. Figure 1 differentiates the tools predefined, developed in laboratory, from the ones co-developed with the participants. Predefined tools were too conceptual to be used with the participants. It is partly due to the gap between the systemic vision supported by the tools and the fragmented one from the participants. Researchers, in the role of facilitators, used them to support discussions. Co-developed tools were both discussion supports and results, as they capitalized the shared knowledge and could be used further to support the system transition. The set of indicators is one of them, developed during all the process.

One co-constructed map of the system has been added to the approach. Inspired by the co-modeling approach (Roth et al., 2021), it represents the flows, the operations, and the actors. It was necessary to share each one knowledge and support the multiple iterations to define the purpose and the scope of the studies. Iterations also allowed participants to take a step back from the project, and begin to adopt a more systemic vision.

While the same method steps and tools were implemented in each case study, three elements have been adapted to the specificities of each case: the iterations between the steps; which stakeholder use or develop which tool; and the duration of the study. Iterations, duration and tools use depends including on the maturity of the project, the maturity of the value chain, the proximity between stakeholders, and the stakeholder at the origin of the project.

* + 1. Interests of the approach

The first meetings are encouraging for the assumption that both the process of indicator definition and their use support decision-making. Indeed, change in the discourse of some participants could yet be observed, in their relationships and knowledge about the system. Some possible shared strategies also emerged, in particular during the mapping of the system development. They will be associated to indicators about their implementations and impacts. Such indicators revealing desirable “rethink” strategies are intrinsically case-specific. It is another interest of the approach. Interests and limits of the approach will be deeper discussed when the case-studies would end. The time required to develop such indicator set can yet be seen as a limit.

* 1. Conclusion

A previous paper presents a tool-based approach to define indicators to support decision-making in projects linked to circular economy, and applied it on a case-study in laboratory. The approach and the tools aim to be generic. The indicator sets should be case-specific and represent a systemic vision, in a strong sustainability perspective. The approach is being implemented in three case-studies to discuss these assumptions. First, the approach seems interesting both in a micro-scale project without participants, and in meso-scale projects in different contexts with participants. Participants saw it as an opportunity to respond to one of their problematic. Second, there is a gap between the vision of the circular economy from the participants -focus on one flow circularity strategy-, and the one supported by the approach -more systemic-. Moreover, projects focus on value chains recent or in development, only partly known by the participants. It has then been straightforward neither to define the objective and the scope of the study, nor to adopt a systemic vision. Slight adaptations of the approach have been required. Knowledge about the systems have been shared around a map of the flows, operations and stakeholders. Researchers, in the role of facilitators, used the framework of the circular economy developed in the previous study to guide the scope definition. Moreover, a meeting will be developed to link the projects to this framework.

The main perspective is to continue the case studies to verify the assumptions and improve the approach. A mid-term perspective is to propose a more global approach to support decision-making, including a co-modeling process (Roth et al., 2021).

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