Environmental Consequences Assessment: Towards a Comprehensive Appraisal

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Abstract
Local stakeholders' cooperation is of primary interest in order to recycle organic residues in agriculture. It is also plausible that environmental burdens occur by such recovering. However in most of environmental assessment methods, actors' perception regarding: What is the environment and What are the environmental consequences to be assessed, are rarely questioned. That may lead to misunderstandings between the actors and scientists, and hinder projects aiming at building such recycling at a territory-level. The aim of our work was to overtake this issue. We conducted an interdisciplinary research that we first present. Then, after describing a case study that is a project aiming at recycling organic residues in agriculture in Reunion island, we base on the framework previously described, in order to express plausible environmental consequences to be assessed. We finally come back to some limits of our work that we put in perspective.

Introduction

Recycling organic residues in agriculture is a challenge that could be approached worldwide at different levels. At local scales, integrated natural resource management can be envisaged by involving territorial actors. While recycling organic residues can present solutions, it can present environmental problems as well. However, scientifically correct answers can be perceived as irrelevant by participating stakeholders, when their perspectives and concerns are ignored [1].

In the case of a territorial management that involves several actors, we can face to different environmental concerns. These concerns emanate from differences in individual perceptions and representations of the environment. However, it seems little research has been conducted to estimate what environmental consequences should be assessed from the perspective of local agents.

The aim of this research was to develop a framework taking agents' perceptions into account, for sketching environmental consequences of a territorial management recycling organic residues, in order to enhance their participation.

Framework description

Epistemological basis

Environmental concerns can differ quite a lot, depending on the perspectives one chooses. One commonly refers to climate change, agricultural impacts, environmental risks, ecological risks, environmental impacts and so on. Then, since the concept of environmental assessment is used for a broad scope of approaches, it seems necessary, in a multidisciplinary case of study, to seek the interdisciplinary basis of what is the "environment to be impacted".

We thus started to seek those basis in fields of research that somehow study the relations between modern societies and nature. We thus choose the three fields of research: economics, geography and sociology-anthropology. From these fields we extracted three key points of actors' perception with the environment, that should be expressed in an environmental consequences assessment. These are:

- involvement of components of the biosphere;
- futurity of actors, i.e. their action's causality is placed in the future;
- degree of proximity (DoP), which reflects actors' feelings about the environment.

We distinguished three DoP:

a) support to anthropogenic activities;
b) physically close to the population;
c) outside the living territory even global.

These are the basis of three distinct environments we call:

a) the *functional environment*:

This relies on biophysical components that support the local economy. This environment is in line with the supporting ecosystem services described in the Millennium Ecosystem Assessment [2].

b) the *environment of the population* on the living territory:

It refers to a sensitive environment, lets say the well-being, ie. related to what one can smell (odours), hear (noises), see (visual amenities), drink and eat (health). This environment, in relation with the local population, is especially propitious to mobilize the inhabitants [3].

c) the *global environment*:

This corresponds to "symbolic relations" [4] one keeps with an environment outside the living territory, ie. on other areas, or at a global scale. The scope of this environment that includes all scale levels can be treated with a global perspective [5]. This perspective is the one used in life-cycle assessment with midpoints and endpoints indicators [6] and deals with impacts on natural ecosystems, climate change, human health, and natural resources.

Assessment of consequences

As we sow, an environmental assessment in a multidisciplinary standpoint, may not be expressed from a sole perspective. Such an assessment should present several types of indicators linking society and the perceived environments along environmental mechanisms. That kind of approach is used by, for example, the European Environment Agency with the DPSIR framework [7] (**D**riving forces apply **P**ressures to environmental medias, that change the **S**tate of environmental compartments and **I**mpact the society, human and ecosystems). In line with the guideline made with that framework, we should consider several indicators of environmental consequences, ie. changes of states and impact.

Application and results

Identification of sources of pressures

In Reunion island, most of organic residues are up to now viewed as wastes and not as products. The research project GIROVAR (Integrated management of organic residues recovered in agriculture in Reunion island) aims at building an alternative management for those residues than the common end-of-pipe practice. With the cooperation of local stakeholders, agricultural needs on the one hand, and sources of organic residues on the territory on the other hand, were highlighted and characterized. These are presented in table 1. In order to fit each others, composting processes to transform the organic matters were added into the management network.

Table 1. Sources of residues and agricultural needs on the territory

Organic residues available	*Agricultural needs*
Vinasse	Fertilization of sugar cane at planting
Aches from bagasse burning	Fertilization of sugar cane at growing
Sewage sludge	Fertilization of meadows
Crushed green waste	Fertilization and amendment for market garden
Pig manure	Amendment for municipal green spaces
Poultry manure	Horticultural growing medium
Aches of residues of slaughtering	

Technical meetings and studies allowed to identify three main organic products that would result from composting processes: granulated organic fertilizers; organic amendment; solid organic fertilizer.

The recovering management directly induces three industrial processes: 1) transport of residues; 2) composting; 3) spreading of the organic products. The recovering also avoids the use of chemical fertilizers. The processes directly induced by the management system with corresponding pressures are summarized in table 2. The pressures emitted along the global supply-chains that correspond to the life-cycle inventory of the processes mentioned, are synthesized by "emissions and extractions in cradle to gate supply chain". Nevertheless there are a lot and they are emitted in different compartments.

Table 2. Sources of pressures of the recovering management system

Processes directly induced	*Sources of emission*	*Pressures*	*Compartment of emission*
Management of residues	Use of trucs	CO2, CO, SO2 and sounds emissions	Local air
	Fuel consumption/production	Emissions and extractions in cradle to gate supply chain	Global
	Trucs manufacturing	Emissions and extractions in cradle to gate supply chain	Global
Composting	Composting processes	NH3, N2, N2O, CO2 emissions	Local air
	Building composting plants	Emissions and extractions in cradle to gate supply chain	Global
	Energy consumption	Emissions and extractions in cradle to gate supply chain	Global
Spreading of organic fertilizers	Organic fertilizers in agricultural soils	Minerals, trace metal element, organic matter, pharmaceutical compounds	Localized agricultural soils
	Soil biophysical processes	NH3, N2, N20, CO2 emissions C sequestration	Local air
	Spreading process	CO2, CO, SO2 and sounds emissions	Local air
	Fuel consumption/production	Emissions and extractions in cradle to gate supply chain	Global
	Spreading materials manufacturing	Emissions and extractions in cradle to gate supply chain	Global

Another aspect of an environmental consequences assessment is the avoided pressures to the environment. In our case of study, the use of chemical fertilizers is avoided. Then the industrial processes occurring upstream their use are avoided, ie. shipping, production and extraction of nitrogen from air, mining of phosphorus and potassium, including the energy and sources of energy employed. All these industrial processes occur in a global market, thus the emissions occur at global scale.

Results

The *functional environment* was defined as supporting the local economic activities. In the case recycling organic residues in agriculture, it may refer to a support to agricultural productions. In term of impact in that environment, it then refers to the soil fertility. In term of change of state, it refers to soil properties on which relies the soil fertility, lets say organic matter content, trace metal concentration, mineral content, soil moisture, density and pH.

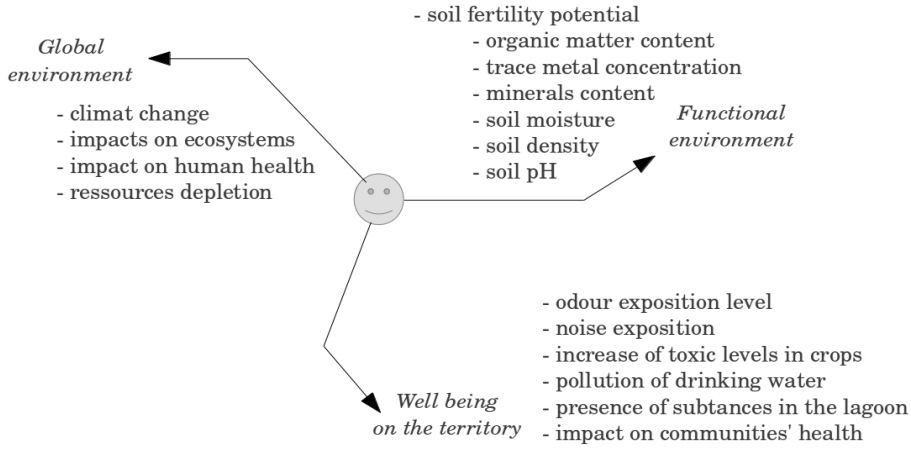
The *environment* (well-being) *of the population* was presented with regard to what one can smell, hear, see, eat and drink. Referring to table 1, it relies on local emissions to air and agricultural soils.

- Odours can be emitted by spreading and the composting processes regarding the levels of emissions of ammonia.
- The transport of the residues and spreading may emit sounds by means of the use of trucks. These emissions can be a source a noise to surrounding populations.
- Excess of nitrate and phosphate may run-off and infiltrate to surrounding soils and localized groundwater. It may present a risk of pollution to drinking water and the lagoon and thus present a risk to human health and surrounding communities.
- Trace elements are naturally present in the volcanic soils of Reunion island. Spreading organic residues in excess in agricultural soils may present a risk to human health in term of concentration (toxic levels) in crops (sugar cane and market garden).

The *global environment* refers to environmental mechanisms occurring outside the territory. This scale of study is developed with the framework of life cycle assessment. The Recipe method [6] enables to assess impacts on ecosystems (species.year), human health (DALY: disability-adjusted life years), abiotic resources depletion (cost increase in $) and climate change (W.yr/m² in CO2 equivalent) of

thousands of substances emitted at a global scale. Regarding the climate change, the global impact in completed with local emissions of greenhouse gases and carbon sequestration in the agricultural soils.
The figure 1 illustrates the conceptual representation of the three environments and the plausible environmental consequences to be assessed. As this conceptual representation tries to illustrate, the consequences are mutually exclusive and totally exhaustive.

Figure 1. Conceptual representation of plausible environmental consequences



Conclusion and perspectives

Our framework can be useful on the one hand for defining the scope of the method that would aim at assessing environmental consequences of local cooperative actions, and on the other hand as a basis for exchanges between stakeholders. Although such work may encounter some challenges in term of understanding between scientists and actors [8], this approach on the crossroad of different disciplines, that was still lacking, may be an answer to such challenges.
Nevertheless biophysical particularities, regarding the case study we present, increase issues on computational aspects. Indeed, we face to a management system at a territory-level that is spatially and temporally distributed. The different sources of pressures emitted to the environmental compartments will thus be equally spatially and temporally distributed. The broad differences in fate and impacts of the different types of environmental pressures, need then further research in terms of modeling, in order to combine them in a simulation tool.

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