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RETURNING ORGANIC RESIDUES TO AGRICULTURAL LAND (RORAL) – SCENARIOS CO-CONSTRUCTION ON REUNION ISLAND

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SUMMARY: Rehabilitating disrupted nutrient cycles through organic residue recycling in agriculture represents a win-win lever, particularly in urban-agricultural areas, with benefits at both ends of the food chain. It carries the promise of enhancing agriculture's eco-efficiency and resilience while reducing environmental pressure in urban and downstream areas. After several decades of largely unsatisfactory attempts to promote recycling practices through ad hoc transfer-of-technology approaches, this paper proposes an epistemological base for RORAL research. A proof of concept case study involving implementation of the RORAL approach in Réunion is presented. This isolated territory with very limited natural resources, particularly arable land, and increasing demographic pressure represents one out of two types of high-potential areas.

Keywords: organic residue, soil, recycling, INRM, system modelling.

INTRODUCTION

The practice of returning organic residues to agricultural land (RORAL) is as old as agriculture itself. But industrialisation, agriculture's subsequent green revolution (particularly synthetic fertilizer use) and globalization largely disrupted this habit and therefore local nutrient cycling and soil preservation. While allowing for major increases in agricultural production and expansion of the producing area, the environmental boomerang effect of these profound changes has put the recycling of organic residues progressively back on the political agenda. Reintroducing an old practice into a now very different world is, however, a serious challenge requiring substantial research and development. The adoption of 'innovations' by increasingly complex, integrated and globalized production systems is far from straightforward, but still more daunting is the definition of new practices adapted to the multiple (economic, social, societal and environmental) constraints of today's world.

Despite its relevance, RORAL research, as well as organic matter management research in general, are still rather ad hoc and lacking a clear epistemological base and well defined paradigms. The limits of the 'transfer of technology' paradigm to enhance RORAL have been acknowledged since well over three decades (Greenland, 1980). Initial attempts to enhance organic recycling in agriculture by adding a 'systems' research dimension were made in the 1990s (e.g. the network approach, as reported by Lefroy & Santoso, 1999) but did not gain momentum in the face of a 'transfer of technology' approach (Chambers and Jiggins, 1986) that continues to thrive.

At CIRAD we develop an approach that represents a shift from the 'conflicting' paradigms of reductionism and holism, positivist-realism and constructivism (Douthwaite et al., 2002) towards one centred on the need for both. We briefly comment the approach in the following section before presenting its application to the situation of Reunion Island.

RORAL AND INRM

Following the observation that the green revolution paradigm underestimated the complexity of systems in which producers operate (Sayer and Campbell, 2002), the Consultative Group on International Agricultural Research (CGIAR) concluded on the need to carry out types of research and intervene in very different ways to the yield improvement work that has been CGIAR's mainstay in the past (Douthwaite et al., 2002). They define integrated natural resource management (INRM) as "the responsible and broad-based management of the land, water, forest, and biological resources base needed to sustain agricultural productivity and avert degradation of potential productivity." Douthwaite et al. (2002) proposed the 'follow-the-technology' (FTT) approach as an alternative to the 'transfer-of-technology' approach. The FTT approach would "use technology as an entry point into a complex situation to determine what is important". The motivation for stakeholders to participate is a 'plausible promise' made by the R&D team to solve a real (farming) problem.

The successful INRM cases are invariably built around very specific intervention possibilities that achieve adaptation and uptake (Hagmann et al., 2002). RORAL can be such a specific intervention. It pursues the same goal as INRM, which claims to put "more emphasis on management of risks, reduction of dependence on agricultural inputs, avoidance of long-term depletion of productive potential, and more careful control of environmental externalities". Technology, i.e. the application of knowledge to the practical aims of human life or to changing and manipulating the human environment, should clearly not be put aside, but rather used as the value-based input of research to INRM.

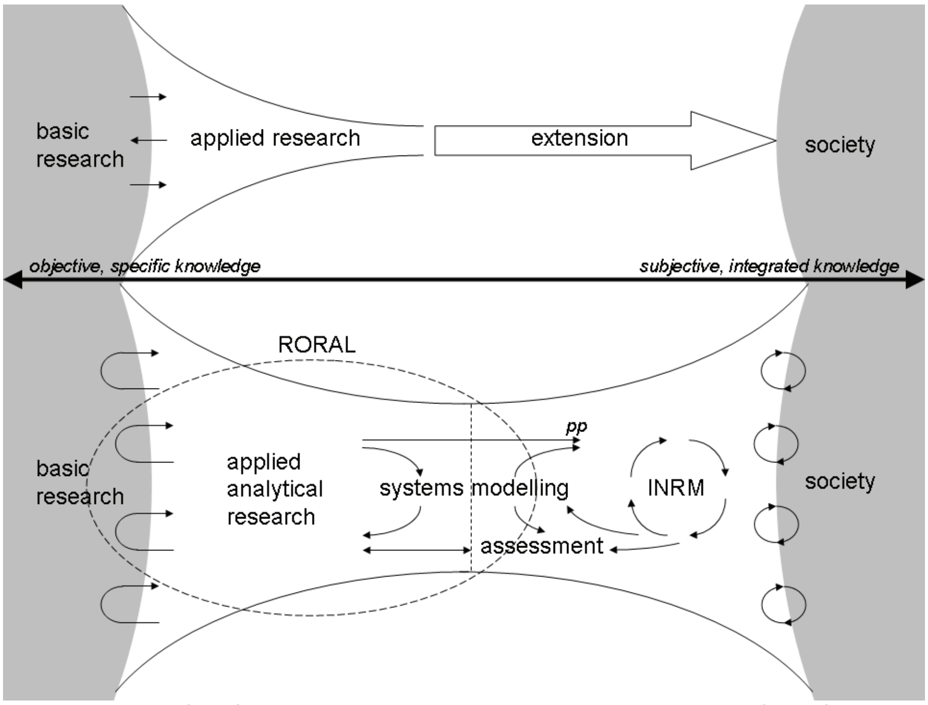

Fig.1. Top: the linear transfer-of-technology research-development continuum, for reference. Bottom: the proposed epistemological basis for a solid science-society bond in the agricultural development context. All research types and related knowledge are required and complementary, but **generating innovation starts at applied research** by initiating the generation of the plausible promise (pp). The example of the RORAL research group projected onto this proposed generic FTT implementation (dashed oval) illustrates our view on effective research organization: this 'hard' science group, while being part of the INRM process where it interacts with 'soft' sciences, extends back into basic research.

A continuum from fundamental to systemic 'hard' science covered by CIRAD's Recycling and Risk research unit, internalizes a number of 'boundary crossings' (Klein, 1996), thereby removing barriers to interdisciplinarity allowing interaction to emerge and persist (Fig. 1). Though not spanning the full continuum of 'wholeness-oriented research' (Alrøe and Kristensen, 2002), it covers the range from specialized fundamental research, through applied research to systems modelling (from a high degree of reduction and a low degree of involvement to a low degree of reduction and a high degree of involvement). Such a 'hard' science group, specialized in a core problem area geared to providing system information, kicks off an integrated assessment process involving stakeholders representatives, led by a facilitator. The 'hard science' group then becomes a constituent of the participatory process 'following' its own technology (promise). The latter is progressively consolidated by an iterative dialogue between theoretical scientific knowledge and empirical and enacted knowledge. Non-thematic INRM research groups focusing on facilitating 'soft' participatory research like CIRAD's GREEN research unit (http://www.cirad.fr/ur/green) master participatory modelling approaches such as Companion Modelling (ComMod: Etienne

2010), which can make use of tools such as agent-based models and role-playing games, well tuned to socioeconomic variables, and other soft systems methods.

For RORAL, soil science, agronomy and research on residue transformation processes constitute the core applied research area. From this core, the required continuum is obtained by links with systems modelling and environmental assessment capacities on one side, and with fundamental research capacities on the other (Fig. 1). On the basic research side, geochemistry and biochemistry are considered as core expertise areas and partially internalised (as illustrated by the dashed oval intersecting the basic research sphere in Fig. 1). On the modelling and assessment side, the field level, resilience enhancement oriented, plausible promise issued by the applied research core area is translated into a systemic promise at the scale of the research area at hand. This translation constitutes a core methodological RORAL research area. Translation at the system level and subsequent simulations seek to add the eco-efficiency gain pursued by RORAL, based on the paradigmatic vision of a sustainable system, as advocated by the emerging scientific field of industrial ecology (Erkman and Ramaswany, 2003).

High-potential areas for implementation are those where, on the one side, organic residue concentration induces critical environmental and human health risk levels while, on the other, long-term intensive conventional agriculture provides a significant potential for ecological intensification (Doré et al., 2011). Such situations are rapidly becoming more frequent. They can be divided into two main types: (1) isolated territories (e.g. islands) with very limited natural resources, especially arable land, and increasing demographic pressure, and (2) peri-urban areas of fast growing large cities in emerging countries, inducing changes in consumption patterns, resulting in spatial shifts in agricultural production and related organic material flows.

APPLICATION TO REUNION

The island of Réunion is one such high-potential area. This volcanic island, a French territory situated in the Indian Ocean, has a population of about 850 000 in 2012, which is growing by over 10 000 a year, and an area of 2.5 thousand km^2. Arable land represents only a tiny and slowly decreasing 17% of the cragged, mountainous land. Dependence on imports to the island, i.e. inputs for agricultural production or food for consumption, is strong and increasing. On the one hand, this means that smallholders depend on increasingly expensive inputs (e.g. fertilizers) from the global market, thus threatening the competitiveness of their produce. On the other hand, this situation, exacerbated by stringent EU regulation, leads to a pressing need for solutions to rapidly increasing organic waste management problems. Increased efficiency of the island-level organic ‘metabolism’ would unlock the development potential of sectors concerned (crop production, livestock production and produce consumption) while increasing the system’s resilience.

The essence of the initial ‘promise’ is that different residues (e.g. livestock manure, agro-industrial waste, municipal green waste, sewage sludge) could be complementary, whereas their collective management could lead to synergy (e.g. economies of scale leading to profitable treatment processes generating better suited fertilizers as well as energy co-products). This is presently being explored by a project focusing on the administrative western coastal territory, i.e. about a quarter of the island’s surface area and population. A project team including all major stakeholders (e.g. waste producers, collectors and processors; fertilizer industries and consumers) was convinced to participate through the proposed conflict-avoiding shift of paradigm from a ‘waste disposal’ logic in favour of an agricultural demand centred approach.

The initial ‘plausible promise’ development involved: i) assessing fertilizer and amendment needs of the various crop-soil-climate situations; ii) gathering information on prevailing practices and farmer preferences; iii) creating a detailed inventory of available organic residue properties (in qualitative, quantitative, spatiotemporal terms); iv) convene and participate in expert panels to list desired properties for products adapted to different situations; and v) analyse these products for similarities and compare them with the raw residue properties and theoretical residue processing (locally suited technical variants of aerobic and anaerobic digestion, vermicomposting and pyrolysis) outputs. These various stages mobilized a major part of the generic as well as locally specific knowledge generated by the RORAL research team. The INRM process then elaborated detailed descriptions (incl. governance and organization) of production chains for selected organic products. A territory-wide, dynamic and spatially explicit system model was then designed in order to simulate the functioning of the overall scenario, constituting a basis for subsequent logistical, environmental and socio-economic assessments.

RESULTS AND DISCUSSION

The study area is composed of markedly different situations. From about 800 to 1500m altitude the landscape is dominated by extensively managed pastures on fragile soils with marked andic properties. These under-fertilized, acid soils of low exchange capacity would clearly benefit from organic fertilizer/conditioner application. But although interested, cattle farmers have strong practical and sanitary constraints limiting the scope. Below the landscape is dominated by sugar cane. Until about 3-400m altitude one finds brown cambisols of reasonable quality. At lower altitudes the shallow stony soils highlight the strong physical soil conditioning potential of organic amendments. Because of practical constraints and a long tradition of using chemical fertilizers, sugar cane farmers are nearly exclusively interested by the nutritional value of fertilizer. As a consequence only about half the population might adopt organic fertilizer. Although of limited spatial extent, market gardening is of interest because of its intensive fertilizer use. Currently already opportunistic users of raw agricultural residues, market gardeners have a marked interest for concentrated organic fertilizer for manual application. Due to internal variability, the agronomic analysis led to the conclusion that fertilizer composition requirements are not significantly different among the different crop-soil-climate situations, creating perspective for a generic fertilizer.

On the supply side, poultry litter and pig slurry appear to be the only agricultural waste sources available for integrated management, the former under logistic conditions. Among the agroindustrial residues, sugarcane filter cake is of limited agronomic value and kept under the control of the industry. Due to its particular composition, vinasse is of great interest, but only seasonally available. A small amount of feather and blood meal is produced in the area. Grinded municipal green waste and waste water sludge are available in relatively large quantities. A database tool simulating transformation output characteristics of a large number of raw material input combinations and transformation processes supplied the INRM process with information. Co-composting is for now the only process selected, resulting in green waste to become the limiting resource. The theoretic production potential would nevertheless be sufficient for three co-composting installations envisaged to be viable and to meet local demand.

Logistical feasibility issues, in particular temporal adequacy of supply and demand, are being explored through the agent-based simulation model. Ongoing environmental assessment suggests substantial benefits in terms of the overall eco-efficiency balance as well in terms of risk reduction. The level of nuisance the scenario may represent for the local population remains to be assessed, just as the broader socio-economic balance.

CONCLUSIONS

Within the proposed framework, RORAL research does not claim to come up with the solutions alone. It typically generates knowledge and tools to help generate and assess integrated solutions to complex problems. The Réunion proof of concept shows that it takes more expertise and parties to be able to identify effective and acceptable solutions favouring local recycling of organic residues in agriculture, representing a gain in sustainability for the concerned territory without harming any of its constituent parts.

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