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TEST OF THE STEP-BY-STEP DESIGN APPROACH TO STUDY THE TRANSITION OF AN ORGANIC FARM LOCATED IN A MARSHLAND AREA (FRANCE)

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Introduction

In French Atlantic marshland, farming systems are operating in a complex socio-pedo-climatic environment characterized by grazing livestock systems on wet meadows but also cropping systems on drained heavy clay soils. Managing farming systems supposes to manage trade-offs between key ecosystem functions of wetlands : food production, biodiversity conservation, water quality regulation and flood buffering. Therefore, switching from conventional to agroecological cropping systems is a major challenge in these areas. This transition is constrained by the limited numbers of days with adequate soil conditions (constraint exacerbated by the greater climate variability, especially high levels of winter rainfall events). It is also due to weed species adapted to the hydromorphic conditions of these environments. The aim of this study is to test a theoretical framework for the progressive design of farming systems (Meynard et al, 2023), applied to an entire organic farming system seeking to diversify its food production. Here we present the learning feedback loop during the implementation of this farming system after 5 years of cultivation. We focus on analyzing the pathway to move from the initial situation to the targeted one.

Methods

This study is conducted in an experimental farm (INRAE) located in the marchlands of Rochefort-sur-Mer (France) in a temperate oceanic climate (coldest month above 0°C; heaviest precipitation in winter, fairly distributed throughout the seasons). The soils, calcareous fluvisols, have high clay content (50-60%) and over 90% fine elements, with no textural differences between horizons. The farming system experiment, called Transi'marsh, design and implement an organic mixed crop-livestock system with 45 suckler cows and is composed of 100 ha of grasslands and 60 ha of arable land (Durant et, al., 2020). Arable land comprises 50 ha of drained heavy clay with surface (10 ha) or subsoil (40 ha) drainage, and 10 ha of sandy loam. Since 2019, the experiment aims to achieve four main goals: 1) restoring wildlife biodiversity, 2) producing local staple foods, 3) reducing the impact of climate change and 4) being profitable. This cropping experiment constitute a major challenge in such environment, as there is few, if none, comparable example in commercial farms. The learning feedback loops consist of four steps from the initial diagnostic to the assessment (Figure 1). In our case, we analyze the decision, practices and outcomes that emerged during each steps of the loop.

Results

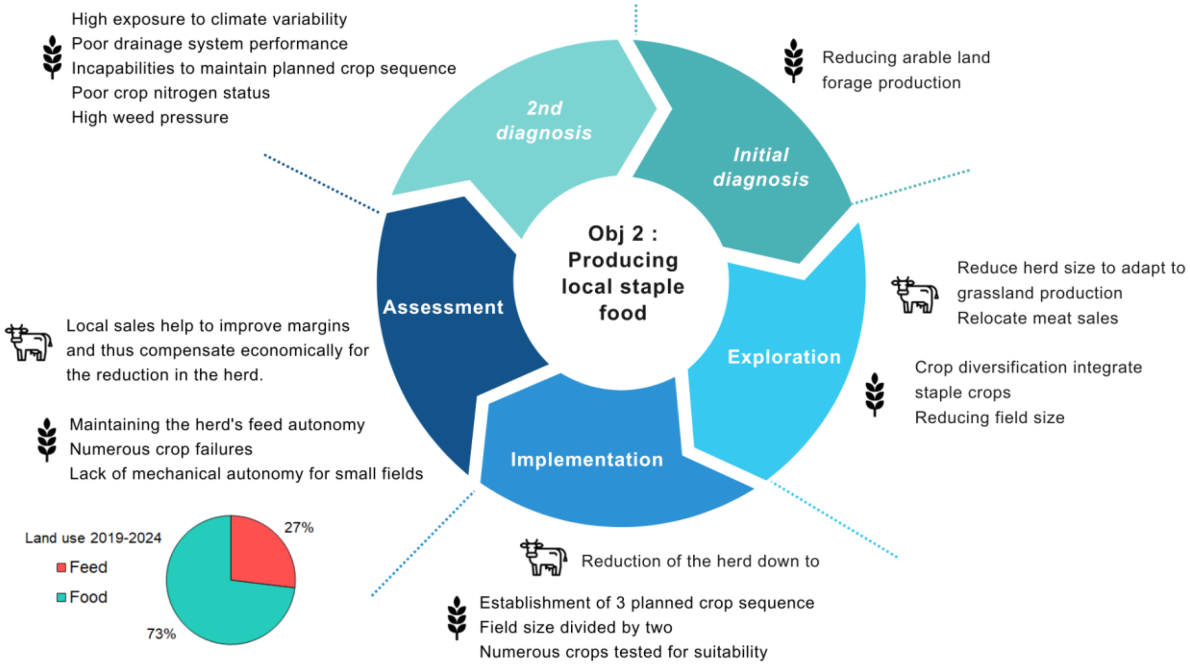

Figure 1. Steps of the learning feedback loops and the key decisions, achievements or learnings that emerged during the process.

1. Initial diagnosis, exploration and implementation

At the farm level, the aim was to diversify food production by growing organic crops and therefore to reduce the area of arable land producing fodder (Figure 1). The transition from a forage-based farming system to an organic food system was explored by reducing the size of the cow herd to reduce feed requirements and relocating meat sales to increase margin. Three principles were applied to the cropping system : 1) diversifying the crop sequence and introducing staple crops, 2) improving biological soil fertility by incorporating straw, cover crops and applying cow manure and 3) reducing soil mechanical management (i.e. deep tillage, subsoiling). Crop diversification led to the implementation of three planned crop sequence. One sequence was made to feed the cows composed of 2-3 years perennial legumes – cereals/grain legumes intercrop. A second crop sequence with 2-3 perennial legumes followed by 5 years of alternance of winter and spring summer staple crops. A third sequence with a cereals/grain legumes intercrop followed by 4 years of alternance of winter and spring summer staple crops (Tricheur et al, 2022).

2. Assessment and learnings

On average, 73% of arable land were devoted to the production of staple crops, with variations from year to year. The high climate variability limited crop production during those 5 campaigns. In particular, heavy rains leading to high soil water content in 2019 and 2024 has prevented from sowing autumn and winter grain crops. This is reflected by the high variability of the date of last sowing of winter crops (i.e. last possible entrance in the fields) and of spring crops (i.e. first possible entrance) (Table 1.).

Table 1. Last winter and first spring sowing date (Transi'marsh farming system experiment).

Crop operation	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024
Winter last sowing	11/10/19	30/11/20	30/10/21	07/11/22	12/09/23
First spring sowing	03/04/20	29/03/21	08/03/21	13/04/23	25/04/24

Crop production was also limited by summer droughts particularly during the 2021-2022 campaign. This climatic variability prevented the implementation of the planned crop sequences. In particular, the date of sowing variability was found to be a high constraint as it prevents key management practices such as 1) maintaining the alternance of winter-spring crops, 2) choosing appropriate crop species in the crop sequence (legumes), 3) increasing the risk of late summer harvest and 4) preventing late seeding to reduce grassy weeds density. In response, we decided to stop implementing the planned crop sequence but to conduct an opportunistic cropping system based on agronomic principles and soil conditions (Figure 1). With an average wheat yield at 2.5 t/ha (min-max: 0.8 – 4.0 t/ha) and sunflower at 1.0 t/ha (min-max: 0.3 – 1.8 t/ha), these results highlight the relative potential of this agronomic context but also the remaining constraints that limit crop production. The combination of a high climate variability, poor nitrogen supply at key crop stage and high weed pressure led to numerous crop failure. These five campaigns also emphasized the lack of drainage efficiency in our fields and the need for rehabilitation in order to reduce waterlogging and improve soil structure and fertility. Numerous crop species were tested (9 forage species and 22 food crops), such as millet and sorghum, which appeared to be well adapted to these soil conditions. The cow herd was reduced progressively from 65 cows in 2017 to 45 in 2024. The herd feed autonomy was maintained during almost the five campaigns. In 2024, the autumn-winter climate conditions prevented the cultivation of cereals-leguminous intercrop and leguminous forage, forcing the farm to rely on stocks, which coupled with the poor quality of the natural grassland hay did not allow us to be completely self-sufficient. Consequently, to maintain the herd feed self-sufficiency, it may be necessary to increase the target of 25% devoted to animal feed.

Discussion and perspectives

The step-by-step design framework was found to be a relevant research approach to study the transition of the farming system while maintaining a high level of flexibility in the design and implementation of the cropping system. This conceptual approach permitted to 1) stimulate the process of adaptation and generate many learnings (e.g. crop choices, crop sequence), 2) highlight pitfalls and blockages and fostered a systemic understanding (e.g. drainage performance, feed-food ratio, crop nutrient efficiency) and 3) was source of technical and systemic changes (e.g. reduction in the size of the herd). In particular, improved drainage performance, crop nitrogen supply and weed management have emerged as key objectives for the future. This is to be achieved through dynamic management of the cropping system to ensure adaptability and responsiveness to this marsh farming context, while striving for a higher level of production and better performance (Tanaka et al., 2002).

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