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Recycling urban organic waste in agriculture: a case study of peri-urban areas around Paris.

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Abstract

The increasing world population and the improvement of waste collection and treatment are leading to a significant increase of urban waste production. In this context, agricultural use is considered as the most interesting option for the disposal of urban organic waste but little is known about it. Through a case study of two peri-urban areas around Paris, this thesis aims to identify and understand the strengths and weaknesses of the existing networks of agricultural recycling of urban organic waste at the local scale. The work focused on green waste compost and sewage sludge from wastewater treatment plants. Multiple methods were used, including a literature study, interviews with different actors, within-case analyses and cross-case synthesis. Results led to the identification of (a) existing actors and networks, (b) farmers' interests and motivations, and (c) factors influencing their decisions in using urban organic waste. In France, sewage sludge recycling is much more difficult than green waste composting, because regulations are complex and unstable, and its management raises many questions and debates. In the end, farmers' decisions are influenced by a variety of agronomical, economical and ethical factors. To conclude, suggestions are proposed to further develop agricultural use of urban organic waste.

Key-words: urban organic waste, agricultural recycling, sewage sludge, green waste compost, case study

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List of acronyms

ADEME	Agence de l’Environnement et de la Maîtrise de l’Energie (French environment and energy control agency)
APPVPA	Association Patrimoniale de la Plaine de Versailles et du Plateau des Alluets (Heritage association of Plaine de Versailles and Plateau des Alluets)
CEC	Council of European Communities
EPA	Environment Protection Agency
EU	European Union
GMO	Genetically Modified Organisms
Ha	Hectare
IAU	Institut d’Aménagement et d’Urbanisme (French institute for urban planning and development)
Inra	Institut National de la Recherche Agronomique (French national institute for agronomical research)
Insee	Institut National de la Statistique et des Etudes Economiques (French national Institute for statistics and economic studies)
NIMBY	Not In My Back Yard
pH	Potential of Hydrogen
SIAAP	Syndicat Interdépartemental pour l'Assainissement de l'Agglomération Parisienne (Interdepartmental Syndicate for Decontamination of Parisian Agglomeration)
UN	United Nations
US	United States

1. Introduction

1.1. Context

According to the United Nations (2014), the world's population living in an urban area is expected to increase from 54% to 66% in the next 35 years. An increasing population means an increasing volume of urban waste. Moreover, many countries are improving their waste collection and treatment, which in turn increases the volume of urban waste to be disposed (Hofmann, 2013; Kelessidis and Stasinakis, 2012). A significant part of urban wastes are organic wastes, including sewage sludge coming out of wastewater treatment plants, solid municipal and household waste, and green waste[1] (Ayuso et al., 1996). Disposal options include landfilling, incineration, agricultural use, composting, and to a lesser extent storage, reuse in green areas and forests and exportation to other countries (Kelessidis and Stasinakis, 2012). Due to the high environmental and economic costs of landfilling and incineration of urban organic waste, agricultural use has been widely approved and encouraged (Harrison et al., 1999).

In developing countries, governments are rarely able to deal with the significant volume of waste generated by cities. They tend to dispose of urban waste in surrounding areas outside the city centers where there are a lot of peri-urban farmlands (Hofmann, 2013). Peri-urban farmers use this urban organic waste to provide their soil and ponds with additional nutrients and organic matter (Liu et al., 2005). Reusing urban organic waste in agriculture is indeed an inexpensive and valuable input to agriculture and aquaculture, and contributes unintentionally to cities' waste management (Coffey and Coad, 2010; Hofmann, 2013). The use of urban organic waste stays close to the waste generating urban areas because it is linked to its accessibility and low price (Hofmann, 2013). In India, sewage sludge is used to irrigate vegetables, crops, fodder grass and agroforestry (Bunting et al., 2002). In China, liquid waste is also used for irrigation purposes (Liu et al., 2005). In Nigeria, garbage pick-up is so inefficient that the waste has time to start composting in the streets. This composting process accidentally gives a better amendment to poorer Nigerian farmers; the wealthier farmers prefer to buy chemical fertilizer (Hofmann, 2013).

However, due to the presence of toxic substances and metal particles, farmers using untreated wastewater to irrigate their fields expose themselves, their workers and their consumers to potential health threats that a better legislation could prevent (Hofmann, 2013; Liu et al., 2005). In India, only in some cases, the wastewater goes first through aquaculture ponds where it undergoes biological treatment (Bunting et al., 2002). When solid waste is collected, it is typically unsorted and poorly decomposed. Poorer farmers do not have the resources to sort and process it and then have little choice but to apply the waste unsorted on their fields and plots. Wealthier farmers are able to employ workers to compost the waste or to buy compost of

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[1] In this thesis, green waste will be used to refer to plant residues collected from gardening activities and maintenance of public green spaces. Plant residues are collected by individuals, private landscape companies or municipal technical services.

better quality (Hofmann, 2013).In developed countries, legislation has been better developed, but varies significantly from one continent to the other. In the US, sewage sludge is not only used for agricultural purposes, but also in residential gardens, golf courses, roadsides and parks (Harrison et al., 1999). The US standards are not as protective for human health and the environment as in European countries (EPA, 1994). But each member state of the US has the liberty to adopt stricter legislation than the federal standards (Harrison et al., 1999). In Europe, urban waste treatment and disposal are regulated by the European Union (EU) Commission. The EU encourages agricultural use of urban organic waste because other options to dispose of waste have significant economic and environmental costs (Harrison et al., 1999; Kelessidis and Stasinakis, 2012). However, aware of the possible harm to soil, vegetation, animals and humans, the European Directive 86/278/EEC (CEC, 1986) requires the member states to limit heavy metal concentrations in soil and sewage sludge, and provide regular analyses on soil and sludge samples. Individual Member States have also the option to apply stricter measures (Kelessidis and Stasinakis, 2012). The European Directive 91/271/EEC (CEC 1991) on the obligation to collect and treat wastewater led to a 50% increase in the annual production of sewage sludge in the EU-15 countries (old Members). In addition, new EU Members are still is the process of completing their obligations and this increase is expected to continue (Kelessidis and Stasinakis, 2012).

European countries differ significantly from one another in their decisions regarding sewage sludge disposal. With almost 100% of organic waste recycled, of which 97% composted, Finland is the “greener” Member state of the EU (Kelessidis and Stasinakis, 2012). In Romania only 2 out of 114 water treatment plants chose agricultural recycling in 2013, but the country expects to use 50% of its sludge production in agriculture by 2020 (Neamt and Ionel, 2013). In France, among the 1.3 million tons (in dry weight) of sewage sludge produced in 2009 (Mathery, 2012), 15% was incinerated, 25% was landfilled and 60% was recycled in agriculture (Arcimoles and Borraz, 2003). In Denmark, farmers first refused to apply sludge without a guarantee of food safety by the Danish EPA, and municipalities had to incinerate large volumes of sludge at a significant cost. After negotiations, 60% of sewage sludge was used in agriculture in 2006. The remaining 40% did not meet the country standards and were mostly incinerated (Magid et al., 2006). Poland produces the most significant volume of sewage sludge in EU-12 countries (new Members) but no specific disposal is declared for 48% of its production, which creates a situation of uncertainty regarding its actual disposal (Kelessidis and Stasinakis, 2012). Finally, following a ban introduced in 2008, Switzerland decided to incinerate all sewage sludge produced in the country (Vollmeier and Müller, 2007). Overall about half of the countries are increasing direct agricultural recycling, while the others seem to favor composting instead. These trends depend of course on local political, social and legal elements (Kelessidis and Stasinakis, 2012).

In both developing and developed countries, agricultural use of urban organic waste is regulated by legislation at the national level and at a higher level like the European Union. However, as urban organic waste management raises many questions and debates (Aznar et al., 2005), the local context of production and usage has to be taken into account. In France, organic wastes spread in agriculture are composed at 98%

of liquid and solid animal manure. Only 1 to 2% of these wastes is sewage sludge, which represents only 3% of the French total utilized agricultural area (Legroux and Truchot, 2009). However, moving urban organic waste between non-adjacent territories and independent actors has been proved difficult because of the lack of communication and agreement on the value of waste (Arcimoles and Borraz, 2003). Some argue that urban organic waste recycling can only be done at the local level, where there can be a consultation between different interests, and where actors can create a dynamic of trust and mutual relationships (Arcimoles and Borraz, 2003). It is crucial to understand the questions and debates surrounding agricultural use of urban organic waste at the local level compared to legislations at the national level. However, not so much is known on the local scale.

1.2. Objective & research questions

The objective of this study is to investigate on the recycling of urban organic waste at the local scale. Why some farmers use urban organic waste? Why some farmers strongly refuse to? Why is there a NIMBY (Not In My Back Yard) effect from their neighbors? How the recycling of urban organic waste is handled by the municipalities and elected representatives? What is the gap between national legislation and local on-field realities?

Through two case studies of urban waste recycling in peri-urban agriculture lands in Ile-de-France region, this thesis aims **to identify and understand the strengths and weaknesses of the existing networks of agricultural recycling of urban organic waste at the local scale**. Two research questions will be examined:

- How is organized the sector of recycling urban organic waste in agriculture, and what are its advantages and problems?
- What are the interests and motivations of farmers, and what factors influence their decisions?

2. Study area & methodology

2.1. Study area

Two areas in the region of Ile-de-France have been chosen as case study sites. Located around the city of Paris, the region of Ile-de-France is highly urbanized. The region is composed of an inner suburb (*la petite couronne*), and an outer suburb (la *grande couronne*) (Figure 1). While waste disposal is managed at the departmental scale in France, it is managed at the regional scale in Ile-de-France (IAU, 2015; Région Ile-de-France, 2009).

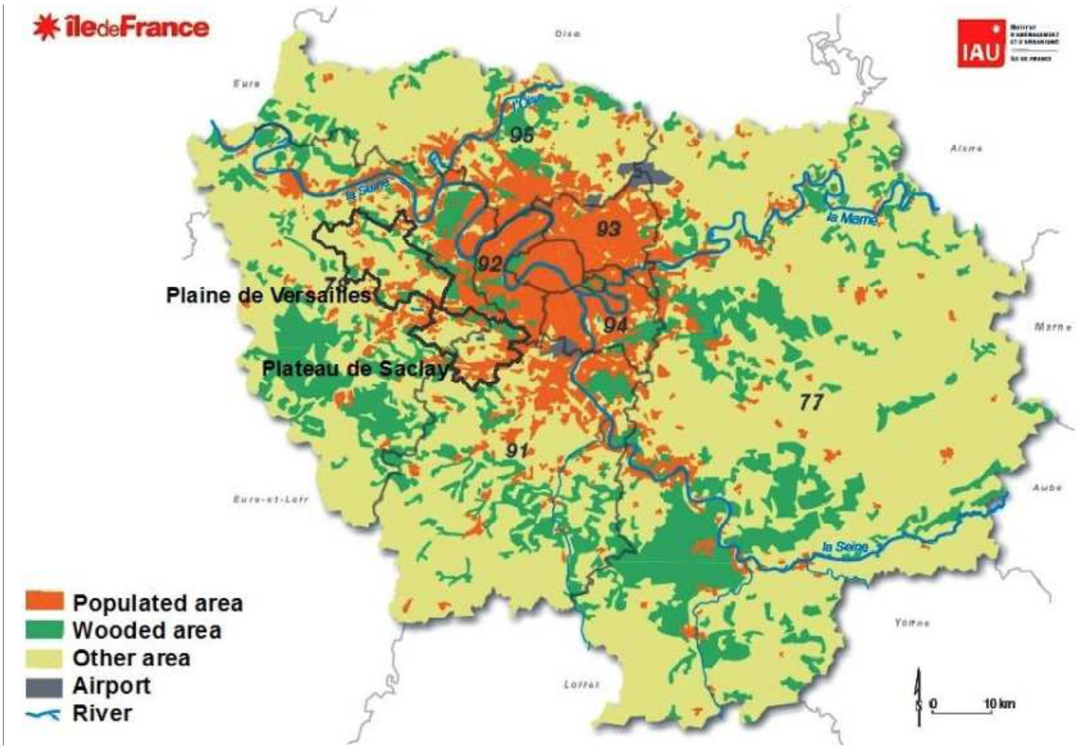

Figure 1: Land use map of the region Ile-de-France (Adapted from: IAU, 2015).

Regarding green waste compost, there were 31 composting sites in Ile-de-France in 2005, with an estimated processing capacity of 452,000 tons per year. 362,000 tons of green waste was collected in 2005, and 160,000 tons of compost was produced. The majority of compost is valorized in agriculture but other destinations include gardens and green infrastructures in the city. (Région Ile-de-France, 2009)

Regarding wastewater treatment, there are two different situations. First, the centralized system of SIAAP (Syndicat Interdépartemental pour l'Assainissement de l'Agglomération Parisienne) provides water sanitation service to Paris, the inner suburb, and 187 municipalities of the outer suburb. This concerns more than 8 million people and 75% of the total sludge produced in Ile-de-France (SIAAP, 2015). To treat the massive volume of wastewater collected, SIAAP has only six treatment plants (Figure 2). Sewage sludge is disposed of as follow: 57% for agricultural uses, 26% in incineration and 17% in landfilling (Région Ile-de-France, 2009). Being heavily urbanized, Paris and the inner suburb do not have enough land to dispose of their waste. Consequently, 20% of the sewage sludge used in agriculture is spread in the outer suburb, and 80% outside of Ile-de-France (Région Ile-de-France, 2009). The outer suburb municipalities outside of SIAAP have a significant number of wastewater treatment plants, most of which are small capacity treatment plants (Région Ile-de-France, 2009). Sewage sludge is disposed of as follow: 72% in agricultural uses, 11% incinerated, and 17% landfilled. 75 to 98% of the sewage sludge spread in agriculture is valorized locally (Région Ile-de-France, 2009).

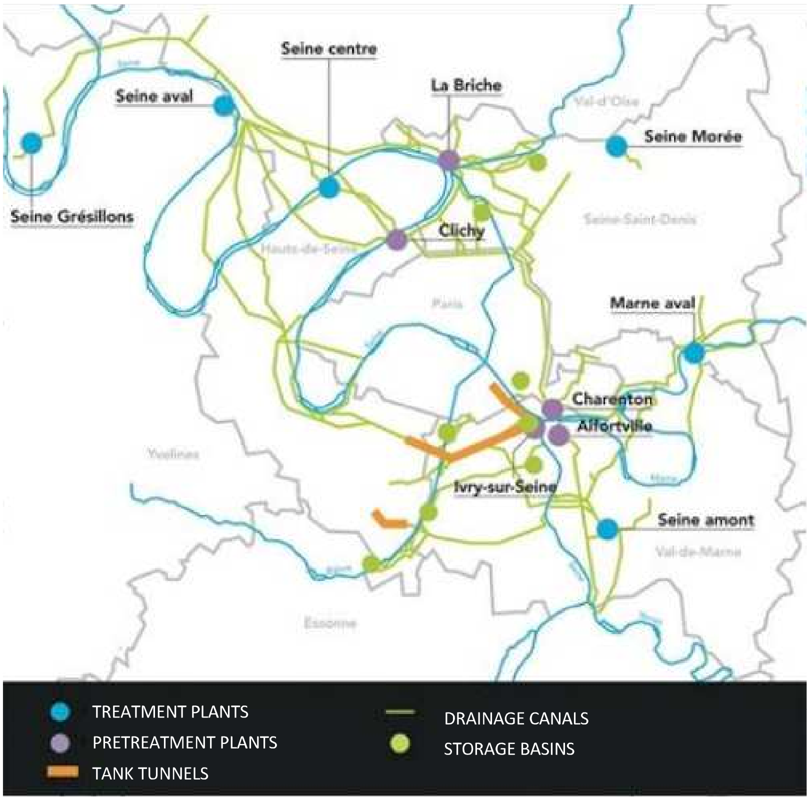

Figure 2: Map of SIAAP network (Adapted from: SIAAP, 2015).

The two study areas, namely Plaine de Versailles and Plateau de Saclay, are located to the West of Paris: (Figure 1). They have both coherent geographical features but concern different administrative units, which results in certain obstacles in management (Table 1). The limits adopted in this work are that respectively those of APPVPA (Association Patrimoniale de la Plaine de Versailles et du Plateau des Alluets) (2014) and Terre & Cité (2014), two associations dedicated to help communication and interaction between the different actors of the area.

Plateau de Saclay and Plaine de Versailles, located both in the peri-urban areas of Paris, present specific characteristics: having a high population density, suffering significant urban pressure, having grain as the main agricultural production and very little animal production. However, they have significant differences behind these similarities. Plateau de Saclay is smaller than Plaine de Versailles and its population density is much greater. In Plateau de Saclay, farmlands represent only 17% of the territory while in Plaine de Versailles farmland surface takes up 45%, similar to the country's average (APPVPA, 2014; Terre & Cité, 2014). In addition, 2,300 ha of Plateau de Saclay have been classified as protected area in 2013 to preserve farmland and food production (Terre & Cité, 2014). Plaine de Versailles has 8 wastewater treatment plants and 2 composting stations. Plateau de Saclay has one composting site, but has no wastewater treatment plant because the territory is in the limit of SIAAP.

Table 1: Quantitative information on Plaine de Versailles and Plateau de Saclay.
(Adapted from APPVPA, 2014; Insee, 2015; Terre & Cité, 2014)

	Plaine de Versailles	**Plateau de Saclay**
Location	20 km west to Paris, all in Yvelines department.	20 km south-west to Paris, one part in Yvelines department and one part in Essonne department.
Population (density in France in 2014: 117 people per km²)	140,000 inhabitants in 24 municipalities, with a density of 700 people per km²	200,000 inhabitants in 20 municipalities, with a density of 1 265 people per km²
Farms and farmlands (farmlands account for 48.9% of France land surface in 2013)	82 farms and 9500 ha of farmlands in 2010, standing for 45% of the area's surface.	10 farms and 2,640 ha of farmlands in 2014, standing for 17% of the area's surface.
Food production (cereal production represents 95% of the agricultural production in Ile-de-France in 2014)	2/3 of farms (90% of utilized agricultural area) produce cereals (wheat, barley, corn, rapeseed), 1/3 of farms produce fruits, vegetables and decorative plant nurseries. There is very little animal production: one chicken farm and one experimental farm with cattle, sheep and goats, and 23 equestrian centers.	Cereals represent 87% of agricultural production. Other products are vegetables, fruits, milk products, bread, chicken, eggs, honey and decorative flowers. There is very little animal production: one chicken farm, one milking cow farm, and 2 equestrian centers.
Urban waste management	8 wastewater treatment plants and 2 composting sites	No wastewater treatment plant and 1 composting site.

2.2. Research methodology

The theoretical framework and methods supporting this study are case study research and theory building from case study research (Appendix A). The work focused on two types of urban organic waste: green waste compost and sewage sludge from wastewater treatment plants. Other types of urban organic waste (organic waste from households, restaurants, canteens and food supermarkets) are not widely recycled yet and hard to track.

For this study, a literature review was conducted at the European, national and regional scale with the aim to understand the network between different actors in this sector, and identify the key issues, including legislation and tensions. The documents used included scientific papers, previous interviews with agricultural chamber and public authorities, and reports of different associations and agencies, such as ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie), Ile-de-France region, CEC (Council of European Communities), Terre & Cité, etc.

In order to understand the sector of urban waste recycling at the local scale, 16 interviews (King-Eveilaard et al., 2012; Kvale and Brinkmann, 2009) have been conducted between February and June of 2014 with different actors (Appendix B):

- **5 waste producers**: a water syndicate[2], a water treatment company, a sludge processing company and three green waste composting sites;
- **8 farmers**: 1 farmer used no urban organic waste, 2 farmers used only green waste compost, 1 farmer used green waste compost and sewage sludge, 3 farmers used green waste compost and stopped sewage sludge use, and 1 farmer used green waste compost and dried organic waste from a local canteen;
- **1 ex-elected representative**;
- **1 canteen manager**.

Background information on interviewed farmers includes:

- **Localization:** 5 farmers in Plaine de Versailles, and 3 in Plateau de Saclay.
- **Activity:** all cultivating cereals. In addition, 1 farmer partially certified organic agriculture and 1 was cultivating fruits and vegetables.
- **Farm size:** all farms have a size between 200 and 300 ha, except for one having 82 ha. For comparison, the medium size of Ile-de-France is 130 ha (Joncoux, 2013).
- **Crops:** cereals cultivated are wheat, rapeseed, corn, barley and fava beans.

For each interview, a full file was compiled, including the background information, an audio recording, the written transcription, and field notes. Each interview lasted from 30 minutes to 2 hours long. Profound interviews with particular cases, such as the example of Plaisir.

Regarding data analyses, two methods were used for this thesis: within-case analysis and cross-case synthesis (Eisenhardt and Graebner, 2007; Eisenhardt, 1989; Lynham, 2002; Yin, 2009). The information was arranged into tables including descriptive information, fertilization methods, waste management, material elements, perspectives on various subjects (sewage sludge, compost, land application, methanization, remuneration, etc.). Diagram, maps and tables were made by comparing the different cases (i.e. different actors in the two study areas).

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[2] In France, a water syndicate is a municipal or inter-municipal association in charge of maintaining and exploiting facilities necessary to wastewater decontamination, such as collection pipes and treatment plants. It is managed by a board of elected representatives.

3. Instability and tensions in urban organic waste recycling

In France, urban organic waste may have a status of waste that need disposal, but can also get a status of product that can be commercialized in the markets as an organic fertilizer or amendment. The legislation has greatly influenced the status of different organic waste and resulted in different opportunities and problems in their disposal. Green waste compost has always kept a status of product, but the status of sewage sludge has changed over the years. First considered as both a waste and a fertilizer used spontaneously by farmers, sewage sludge has now the status of a waste heavily regulated by national and European legislations, but new technologies such as co-composting with green waste provide possibilities for sewage sludge to get a status of products, which may facilitate its disposal. This evolution of status has aggravated instabilities and tensions in urban organic waste recycling, more importantly in the disposal of sewage sludge than that of urban green waste. In this section, a review on the influence of legislation on the status of urban waste in France is presented. Then considering that it is more complicated in the recycling of sewage sludge, a framework is drawn to show the relations between different actors influenced by the change of status.

3.1. Waste or product: influence of legislation

3.1.1. The evolution of legislation changed sludge status

In France, sewage sludge was first used as an organic agricultural amendment in the 1960s, and then as a fertilizer or substrate in the 1970s. The benefits and costs of sewage sludge used as an agricultural input were debated through the 1980s. It acquired the image of a risk in the 1990s. (Nicourt and Girault, 2002)

From the 1990s, ecological concerns began making their way into agriculture. In 1992, following the regulation of European Directive 91/271/EEC (CEC 1991) that all agglomerations of more than 2 000 inhabitants must collect and treat their wastewater, two new laws on water protection and waste management were implemented: (a) agricultural use of sewage sludge had to be supervised in the same way as other organic fertilizers, and (b) industries had to recycle their waste (Joncoux, 2013; Nicourt and Girault, 2002). Local authorities then were forced to organize sludge disposal (Nicourt and Girault, 2002). At that time, agriculture was the main recipient to dispose of organic waste (Nicourt and Girault, 2002). From 1993, it was required to conduct a public enquiry and go through the procedures of building a land application plan for the spreading of sewage sludge. This protocol was very similar to that of liquid and solid animal manure (Nicourt and Girault, 2002).

Then, the Directive 86/278/EEC (CEC 1986) of EU was amended to limit heavy metal concentrations in soil and sludge. In France, a new article of the Environmental Code was created in December 1997 and January 1998, seeking to set up a national standard and to strictly monitor usage of sewage sludge. Pollution was more severely restricted. More importantly, sewage sludge acquired the official status of waste

(Joncoux, 2013). This created a break in the history of sludge disposal by introducing a waste into the food production chain. Using sewage sludge became a source of risk regarding soil pollution and health hazards. Requirements on sludge traceability and soil protection appeared for the first time in this article as well (Nicourt and Girault, 2002). Sludge producers were required to eliminate their waste with minimum harmful effects. Agricultural use of sewage sludge implements the principal of "*zero euro rendu racine*", which means that the waste is brought to the field at no cost for the farmer. It also relieves farmers from any responsibility in case sewage sludge use causes a severe harm (Legroux and Truchot, 2009).

Besides being spread directly in agriculture as a waste, there's also an opportunity for sewage sludge to change its status and become a product. Since 2004, when sewage sludge is mixed with green wastes or other organic wastes and thus transformed into a fertilizing matter or substrate, it can be commercialized as a sludge based product if it is licensed and conform to the standard called NFU 44-095 (Région Ile-de-France, 2009). The waste processing companies only need to mark the composition and usage instructions of the products, as they would do for any organic fertilizer (Agence de l'eau, 2011). Sewage sludge as a standardized and commercialized product, is interesting for all sectors: government and local authorities find a good way for waste recycling; waste processing companies meet the financial interests by selling the products; and farmers have safe, effective and reliable organic fertilizers or amendments (Région Ile-de-France, 2009). However, the new status implies a much more complicated relation regarding responsibility over the use of unqualified sludge based products: farmers can complain against the waste processing company, while food consumers can also complain against the farmer. None of the actors can switch off from the chain of responsibilities (Legroux and Truchot, 2009). Sludge products are subject to markets in which actors seek to maximize profits. This has also evoked worries fir some actors (Arcimoles and Borraz, 2003).

3.1.2. Green waste compost and other products

In less than 30 years, compost of organic waste has increased significantly in France. Composting technology was first used for organic soil-enricher products. In the 1970s, it was extended to kitchen organic waste, and in the 1990s to green waste collected from municipal services, landscape companies and households (Plumail and Leclerc, 2008). In 2002, French law authorized on-farm composting of green waste from outside the farm and simplified the administrative procedures for composting plants that produce less than ten tons of compost per day. This led to a significant increase in the number of composting facilities (Plumail and Leclerc, 2008). Composting of sewage sludge, organic waste from industries and animal manure did not appear until the late 1990s. Regarding legislation, green waste composts must be conform to the standard NFU 44-051, while co-compost mixing green waste and sewage sludge must meet the standard NFU 44-095.

Today, the main composts used in agriculture in France are green waste compost and co-compost mixing green waste and sewage sludge. One million tons of green waste from municipalities was collected for composting in 2009, not counting those from households (Mathery, 2012). Co-compost is increasing rapidly: in 2000 only 3% of sewage sludge was co-composted, while in 2008 this number swelled to 28% (Legroux and Truchot, 2009). In 2008, 1.87 million tons of compost was produced from 5.5 million tons of organic waste, which included green waste, sewage sludge and organic matter of household waste (Mathery, 2012).

The agronomic effectiveness of compost is essentially determined by two criteria: fertilizer value and soil-enrichment value. Studies have proven that repeated supply of compost improves the stability of soil structure, stimulates biological activity and gives yields equivalent to those obtained with mineral fertilizers (Houot et al., 2009). Regarding environmental and sanitary risks, studies showed no degradation of grain quality after 10 years of compost use in the fields when respecting the standards (Houot et al., 2009). No accumulation of trace organic compounds or soil degradation has been observed. However, seasonal variations of raw materials have a significant effect on green waste management and compost quality, which is not always under control. In 2008, one out of eight green waste composting plants and one out of two co-composting plants were not conforming to standards (Plumail and Leclerc, 2008). Therefore, legislation for products made from organic wastes needs to be complemented.

Methanization also develops progressively, encouraged by the legislation. Similar to composting, methanization also needs large volumes of green waste, which may lead to competition between producers for green waste (Legroux and Truchot, 2009). This also calls for improvement of the related legislation.

3.2. Relations between different actors in recycling of sewage sludge

Different actors have different positions in the sector. There distinguished 4 categories of actors: food industries, farmers, water treatment companies, local municipalities, and the government and environmental associations. Figure 3 shows the relations between these actors.

In France, water treatment and sludge management are handled by local authorities and municipalities, either in their own water treatment stations or delegated to specialized water treatment companies (Déprés et al., 2008). Then, sewage sludge is spread in agricultural lands with the permission of farmers or agricultural corporations. But the actors in food industries can influence farmers' willingness for the use of sewage sludge, by building agreements with farmers on farming practices (Joncoux, 2013). The government and environmental associations can make or influence the legislation to limit or encourage sewage sludge use, on behalf of local residents or common interests at a higher level for environment protection and human health (Kelessidis and Stasinakis, 2012). Three key tensions between actors are identified and discussed below.

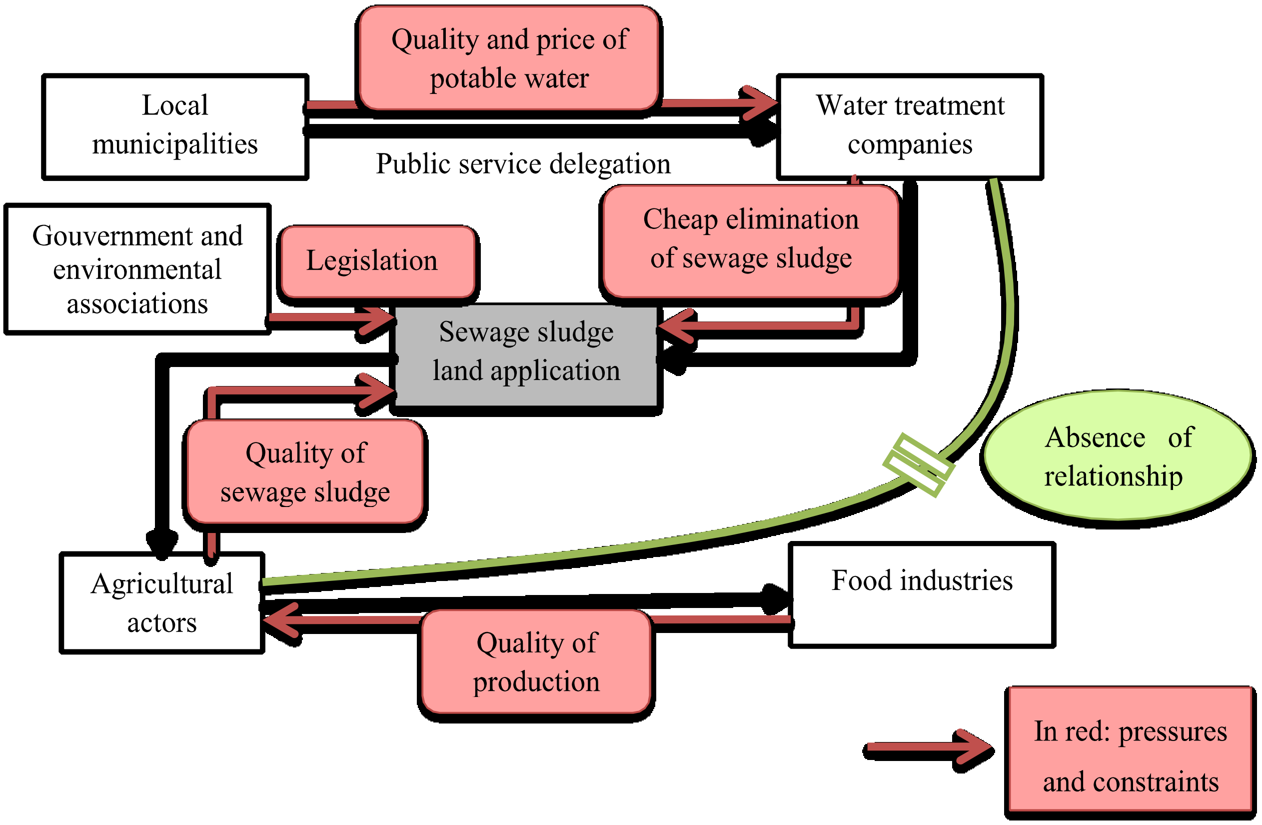

Figure 3: Pressure between actors in sewage sludge recycling.

(1) A service from farmers to the city?

When sewage sludge has the status of waste, its agricultural use may be seen as a service provided by farmers to the city, but there are a lot of debates around it. The vast majority of farmers and agricultural representatives are in favor of defining sewage sludge as a waste for several reasons (Arcimoles and Borraz, 2003; Joncoux, 2013; Nicourt and Girault, 2002): in case of environmental or public harm, the responsibility falls upon waste producers; in addition, sewage sludge is free of charge for farmers. Eager to get a more positive image, the agricultural sector emphasizes on the service provided to the city and argues that the agronomic value of sewage sludge is not vital to farmers.

As for municipalities and water treatment companies, they need to eliminate large volumes of sewage sludge and therefore largely rely on agricultural outlets. They emphasize on the agronomic positive effects of sewage sludge since the view of a service from farmers to the city would lead to the questions of remunerations to farmers. ADEME, the French environment and energy control agency, insisted that farmers should not use sludge to provide a service to urban areas, but rather use it for agronomic and economic interests. ADEME also claimed that sludge producers should not take agricultural use of sludge as a cheap and convenient way to get rid of it but rather work on it as a process of waste recycling (Arcimoles and Borraz, 2003).

(2) Sanitary risks in the food

This tension concerns primarily farmers and food industries, and in turn influences on the relation between farmers and waste water treatment plants. In the 1990s, there were significant sanitary crises in France, such as the mad cow disease crisis, the first debates regarding GMOs (Genetically Modified Organisms) and the tainted blood scandal. To prevent such crises from happening again, food industries imposed in their contract with farmers some strict rules over or even prohibition of sludge spreading. This reaction interfered with the ongoing national standardization process and multiplied private standards. At that time, sewage sludge was exclusively considered as waste and became an environmental, sanitary, political, economic and social risk. Precautionary principle became the main motto and farmers started refusing to spread sludge (Joncoux, 2013). Some food processing industries and agricultural cooperatives chose to banish sewage sludge application on any lands growing the products they will buy. Wether confidential or public, in oral or written specifications, these demands take the form of quality labels, certifications or contracts with farmers (Legroux and Truchot, 2009; Nicourt and Girault, 2002). These practices exist in almost all departments of France and are considered to be an essential factor in a farmer's decision of spreading sludge or not (Legroux and Truchot, 2009).

A significant example for this issue is Achères in Ile-de-France region. Treating 55% of SIAPP's wastewater, it is the largest treatment plant in Europe. In the late 1990s, Achères made the headlines after the discovery of high pollution levels in the nearby Plaine de Herblay-Pierrelaye-Bessancourt where the fields were used to spread sewage sludge. As a consequence, production and marketing of vegetable crops was banned in this area in 2000 (Joncoux, 2013). The whole territory was blamed and questioned. This event was a major traumatism for all farmers located in surrounding departments. Today, the over-dosage of pollutant elements observed in the sewage sludge in 1997 (from 10% to 100% over the allowed dose) decreased significantly and most farmers recognize a real improvement in sludge treatment practices. However, the history of Achères is still in their memories and farmers distinctively mistrust oversized wastewater treatments plants (Joncoux, 2013; Nicourt and Girault, 2002).

The definition of sewage sludge as waste has created confusion on the question of sanitary and environmental risks and precautionary sanitary measures only contribute to suspicion (Arcimoles et al., 2001). Studies have however proven that mineral fertilizers bring more heavy metals to soil than sewage sludge, and that animal liquid and solid manure contain significant traces of antibiotics (Legroux and Truchot, 2009; Nicourt and Girault, 2002). Agricultural use of sewage sludge has still many uncertainties to address, as the scientific knowledge is incomplete about its sanitary and environment risks.

(3) Complaining against farmers from neighborhood or environmental associations

There are also many tensions between farmers and residents represented by environmental associations and public authorities, and between farmers and institutions on behalf of common interests at a higher level, such as agricultural chambers or public authorities. This is especially true in peri-urban areas, where urban and rural area have to coexist (Nicourt and Girault, 2002). In some cases, local authorities banned agricultural use of sewage sludge after complaints from local residents., but these orders are in fact illegal in France (Legroux and Truchot, 2009). Compromises are thus difficult between public authorities and actors in sewage sludge recycling.

In addition, sewage sludge recycling is impaired by the intervention of local residents who question farmers' methods, and quickly put forward precautionary actions and complaints on the nuisance (Legroux and Truchot, 2009; Nicourt and Girault, 2002). The three main issues for local residents are the strong odor, sanitary and environmental risks, and lack of transparency on decision making, and control or monitoring measures (Nicourt and Girault, 2002). In some cases, people moved to rural area with an assumed picturesque image in mind and sewage sludge does not have its place. According to a study by Nicourt & Girault (2002), 51% of the rural population think that rural area is firstly associated with a high quality of life; only 30% mention farming at the first place (Nicourt and Girault, 2002). Communication is thus difficult between farmers and resident.

4. Results

This section is the result of the analysis of the information collected in the two case study areas. The first part aims to understand the existing network between different actors of urban organic waste recycling in the case study sites. The second part aims to identify the factors influencing farmers of the case study sites in their decisions regarding urban organic waste use.

4.1. The network of urban organic waste recycling

4.1.1. Relationships and links between actors

Figure 4 presents the relationships and links between the actors of urban organic waste recycling in Plaine de Versailles and Plateau de Saclay.

Regarding the compost sector, green waste comes mostly from landscaping companies and municipalities' gardening services, in a collection perimeter of 10 to 20 km. Main customers of composting sites' are farmers, with landscaping companies taking up a few percentages as well (Appendix D). The main source of income for composting sites is the entry taxes paid by green waste producers for its disposal. Farmers buy compost at 1 to 3€ per ton only, and pay 10 to 15€ per ton for transportation costs.

Wastewater management is more complex. Wastewater must first be decontaminated in a treatment plant through different technical stages (Appendix D). Sewage sludge resulting from this decontamination then undergoes a variety of transformation processing, the choice of which differs according to its future use. For example, sewage sludge directed to co-compost will be partially dried to reduce its volume and thus the transportation costs. The choice of the transformation processing and future use of sewage sludge depends on the municipality's politics and economic situation.

In France, municipalities are responsible for managing the wastewater treatment and the sewage sludge disposal. Very few municipalities choose to manage all stages of this process themselves and most of them choose to delegate one, several, or all stages. The first and most important stage is *decision making.* Some municipalities delegate this stage and all following stages to private companies (indirect management), others choose to stay in control and make the decisions themselves through their water syndicate (direct management). The second stage is *water decontamination.* Again, some municipalities choose to delegate the technical stages to private companies while a few choose to hire people and manage this stage internally. Note that private companies can also delegate some stages to other private companies.

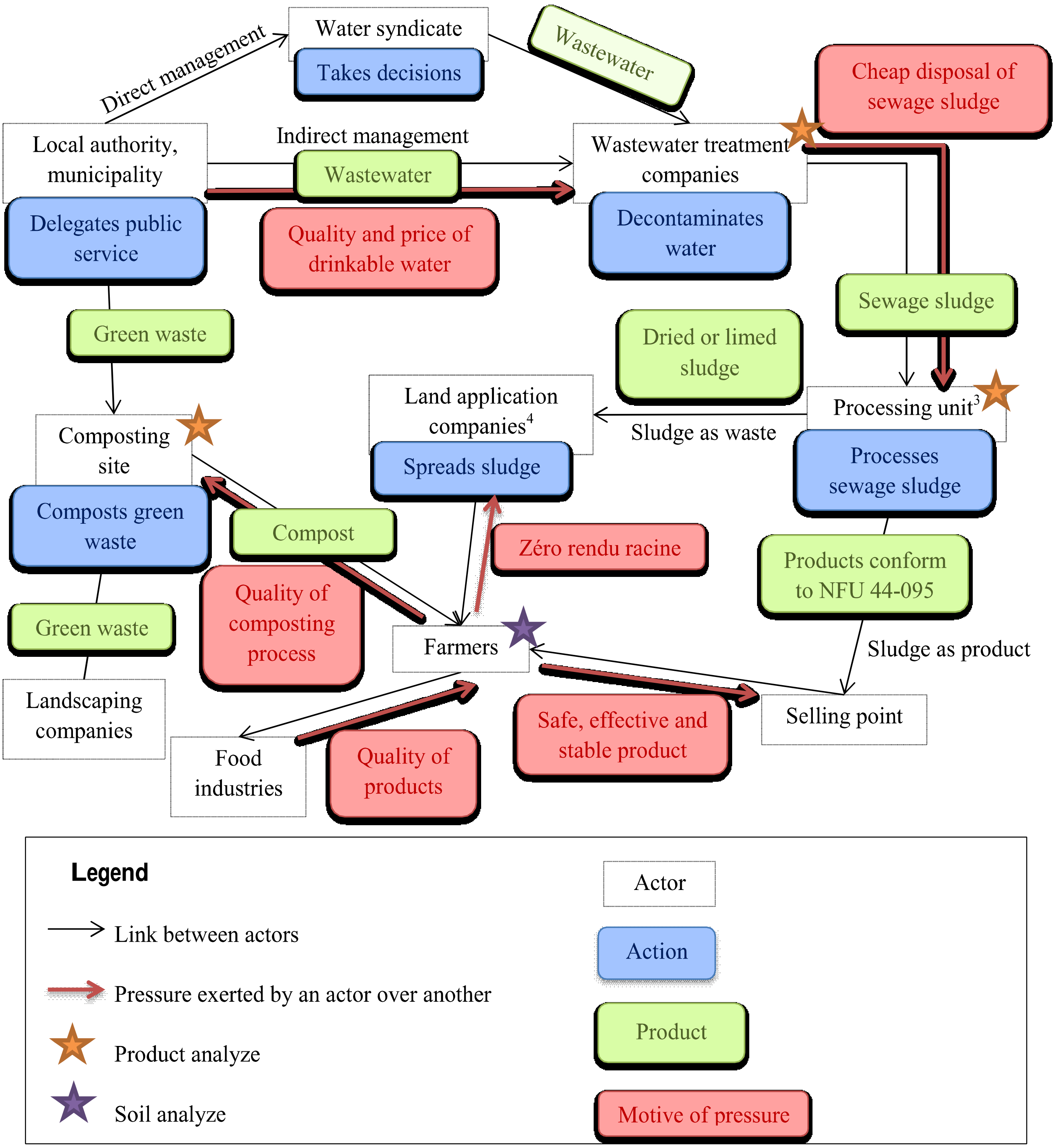

Figure 4: Current situation of the urban organic waste sector.

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[3] Processing units can be part of the water treatment company or be independent. Main processes are drying and liming when sludge keeps waste status, and co-composting with green waste and mixing with other products such as animal flour to transform sludge into a product.

[4] Land application companies can also be part of the processing unit or be independent.

The third stage is sewage sludge *processing*. As mentioned earlier, the choice of the process depends on the future use of sewage sludge, and is decided during the first stage. This decision then determines the future status of sewage sludge as a waste or a product. Sludge based products are commercialized through selling points such as farmers' cooperatives, while sludge with the status of waste is spread in agriculture. Spreading in agriculture is either handled directly by the same actor of the processing stage, or delegated to specialized companies. In any case, farmers do not pay anything for land application on their field when sludge has a status of waste (*zero rendu racine*). To guarantee sludge and compost quality, during this procedure, product analyses are required at several stages: on compost produced, in and out of wastewater treatment units, and after sludge processing. *Zero rendu racine* includes also soil analyses of the fields used for land application.

4.1.2. Influence of geographical proximity

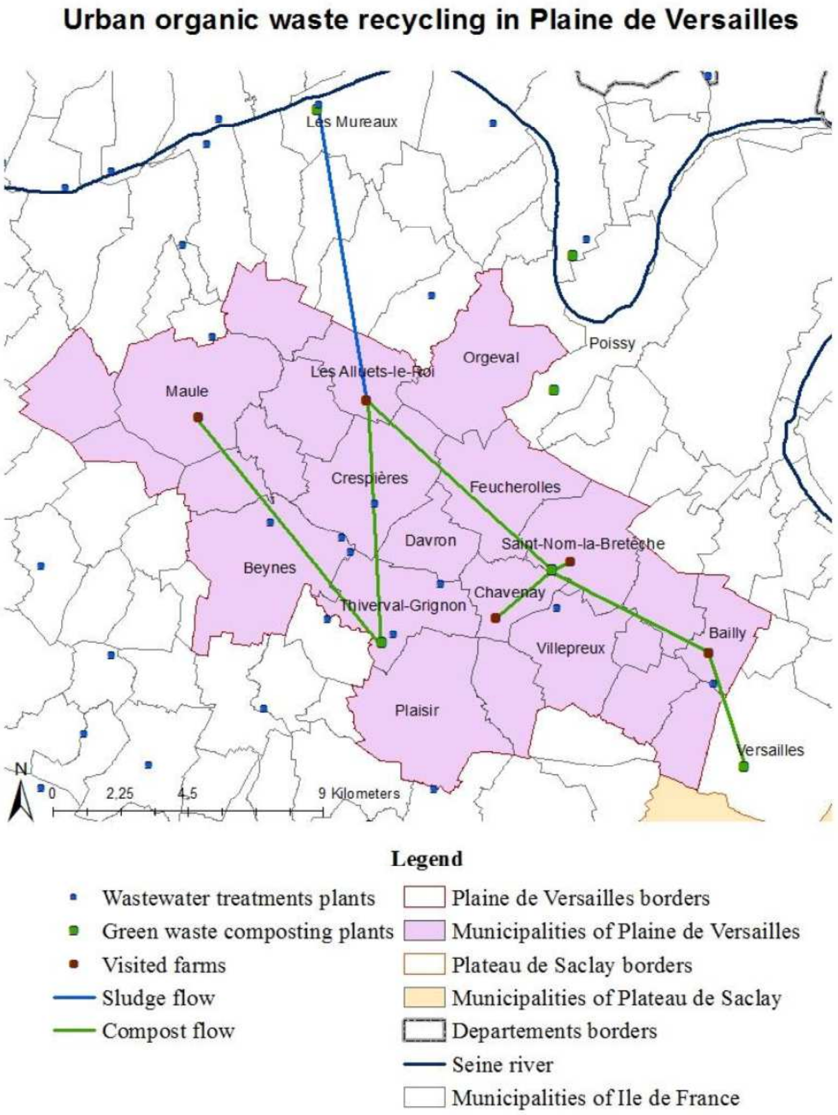

Figure 5: Geographical locations of waste processing actors in Plaine de Versailles.

Data gathered during case studies show that distance between farms and urban organic waste processing units (composting site and water treatment plant) could have an impact on farmers' decision in using or not urban organic waste. Figure 5 and Figure 6 show the location of the different actors, and the flows of compost and sewage sludge existing between them in Plaine de Versailles and Plateau de Saclay, respectively. In both figures, farmers get supplies from the closest urban organic waste facility and the distance between each farm and its providing urban organic waste facility never exceeded 10 km[5].

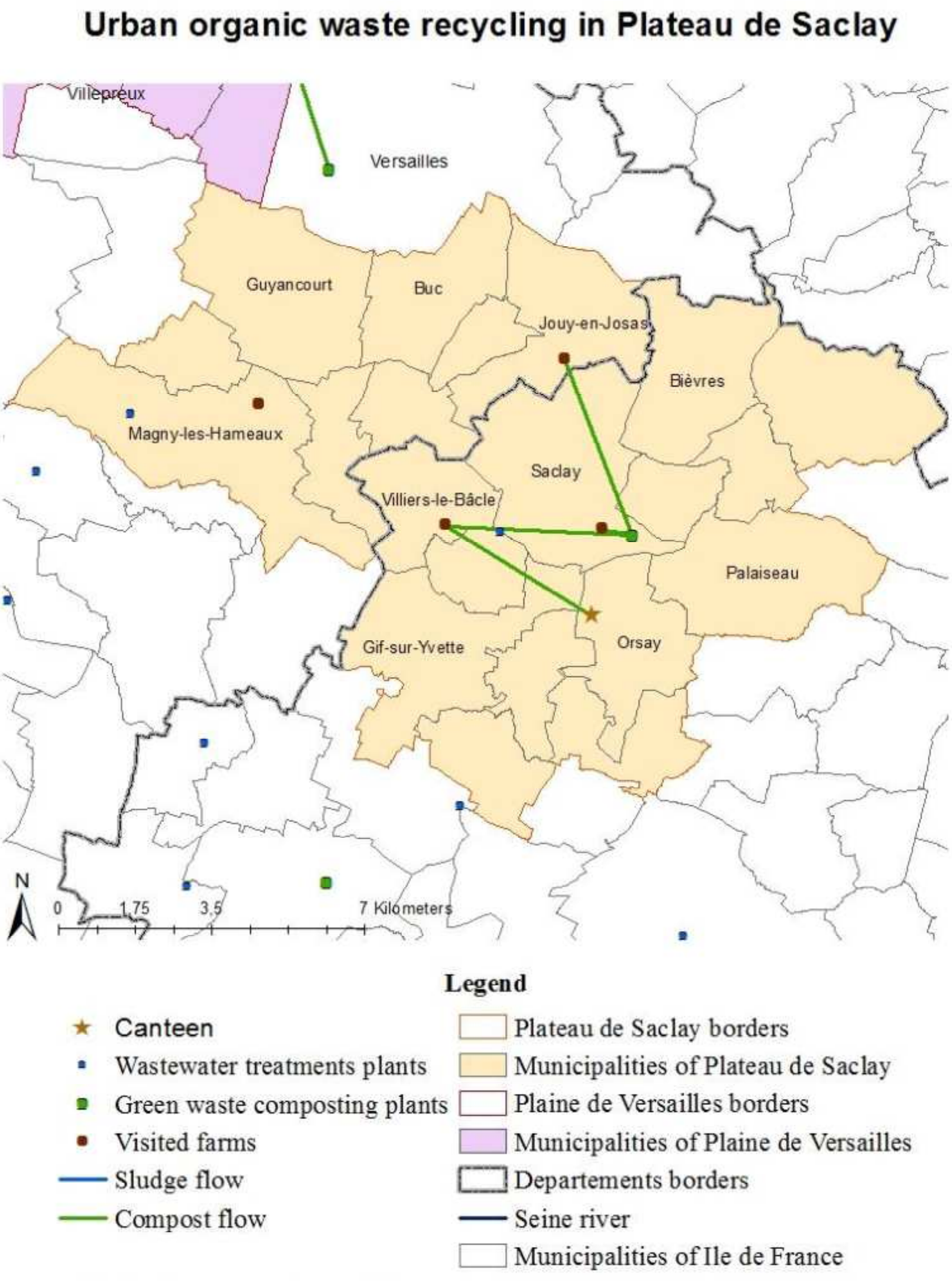

Figure 6: Geographical locations of waste processing actors in Plateau de Saclay.

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[5] Road networks are relatively dense in Ile-de-France, and straight line distances are fairly representative of road distances.

In addition to urban organic waste, the majority of interviewed farmers buy organic waste from agriculture (mostly dried animal manure) from up to 500 km away. As there are very few animal farms in the region of Ile-de-France, it is difficult for grain farmers to get local organic waste from the agriculture sector. These agriculture-originated organic wastes mainly come from the region Bretagne in western France, followed by other areas, such as Belgium and the Netherlands. There are worries of the products' quality and eventual accidents of contamination because European standards are less strict than French standards. However, some farmers prefer to buy agriculture-originated organic waste products coming from a long distance, rather than free local urban organic waste. There are significant trust differences regarding the origin of wastes; farmers will more readily trust farm products than urban products.

4.2. Factors influencing farmers' perceptions in using urban organic waste

4.2.1. Constraints and strengths of urban organic waste use

Opinions of the farmers interviewed have been arranged according to different categories (Appendix C). The following tables represent a synthesis of the constraints (Table 2) and strengths (Table 3) in the use of sewage sludge and green waste compost, as felt by the farmers.

(1) Constraints

Table 2: Constraints caused by urban organic waste use.

<table>
<tr><th>Constraints</th><th>Sewage sludge</th><th>Green waste compost</th></tr>
<tr><td>Personal</td><td>Trusting issues over pollution and regulations.</td><td>No significant personal constraint.</td></tr>
<tr><td rowspan="2">Technical</td><td colspan="2">Material, logistical and meteorological constraints.</td></tr>
<tr><td>No significant technical constraint.</td><td>Problem of dumping and thievery.</td></tr>
<tr><td rowspan="2">Agronomical</td><td colspan="2">Difficulties with long term planning, quantifying, and problem of soil compaction.</td></tr>
<tr><td>Pollution by heavy metals and antibiotics.</td><td>Weeds and unwanted items, such as plastics and wood pieces.</td></tr>
<tr><td>Neighborhood</td><td colspan="2">Conflicts due to NIMBY effects.</td></tr>
<tr><td>Political and administrative</td><td colspan="2">Misunderstanding between political and territorial institutions on one side, and farmers on the other side.</td></tr>
</table>

Constraints from personal representation

Regarding sewage sludge, there are severe trust issues over pollution and regulations. Farmers feel they cannot trust people in charge of urban organic waste, because they feel these people only want to get rid of it:

> *"It works with standards in France, so as long as you are within the standards you are good. If for example there is a sludge that is outside the standards, they will mix it with compost and still sell it."* (E., interview, 14 April 2014)

Farmers feel they cannot trust regulation either, because it evolves over the years:

> *"We see very well what happened in the plain of Achères. They spread in respect of the standards, but in time standards were changed. [They spread] until the land was left unable to produce food. So for me, [using] sewage sludge is a risk for the future, even if it is under control and analyzed."* (C., interview, 16 April 2014)

Only the farmers using sewage sludge trusted its monitoring and controls, and the people in charge of it.

Technical constraints

For the same fertilization effects, the volume of the organic material needed can go up to ten times the volume of mineral fertilizers. Such a volume causes storage difficulties and increases financial and environmental transportation costs, as well as time needed for spreading. Spreading time is also difficult to plan because it is highly weather dependent. In addition, the ideal spreading period is very short, and in most cases the necessary equipment are shared between several farmers.

Thanks to principal of *zéro rendu racine*, sewage sludge use encounters no other technical constraint. For compost however, there are some cases of dumping and thievery, specifically in urban and peri-urban areas. Because of the lack of storage facilities, compost is very often stored on field edges between its receipt and use, which leave open the possibility of uncivilized comportments:

> *"You put a pile of compost on the edge of the road, you can be sure that 10 trucks of rubble will be dumped within 3 days. It's staggering, but we are in Paris' suburbs here, anything is possible. [...] There are people who stop and who take manure, they fil up entire bags."* (E., interview, 14 April 2014)

Agronomical constraints

Unlike mineral fertilization, organic fertilization requires long term planning and it is difficult to quantify long term effects. The substantial volume needed requires numerous tractor passes, which in turn cause soil compaction.

As discussed in section 3.2, sewage sludge have been subject to significant pollution scandals and acquired a bad reputation, especially among farmers who are on the front line of the conflict. As a consequence, many farmers are suspicious of heavy metals, antibiotics and estrogens with sewage sludge. Compost also has some problems, sometimes containing weeds and unwanted items such as plastics and wood pieces.

Constraints from neighborhood

As briefly mentioned in section 3.2, some neo-rural residents have an assumed picturesque image of rural areas. They are often ignorant of agricultural issues, and their ideas of farming are not consistent with reality. They want organic food and sustainable energy without any drawbacks, such as smell, dust, noise, etc. This position is called Not In My Back Yard (NIMBY), which refers to a situation when a person supports project as long as it has no direct negative impact on his/her life. NIMBY is commonly encountered in peri-urban areas and leads to strained relationships between farmers and local residents. Regarding the use of urban organic waste in agriculture, conflicts observed include foul smells, dust, trucks, and dirty roads.

Political and administrative constraints

Similarly, politics are often ignorant of farmers' realities and want the best for environment without the problems. Along with public institutions, they promote local organic food and local waste recycling, but limit action by prioritizing zero risk bias. At the end of the decision chain, farmers have to face restrictive and inconsistent regulation and cumbersome administration. These deep misunderstandings have created significant frustration for farmers and do not favor the recycling of urban organic waste in agriculture. On a more local scale, very few municipalities are in direct contact with local farmers:

> *"Overall, municipalities don't think about closing the loop. They manage waste collection, and goodbye. No municipality, even this one, thought about bringing farmers together to tell them "well, what could you do for us, do this, do that". [Communication] doesn't exist: I don't know any [of this kind]. It might exist occasionally, I don't know, I don't know any such project. Never heard of it."* (J., interview, 12 March 2014)

(2) Strengths

Table 3: Services brought by urban organic waste.

Strengths	Sewage sludge	Green waste compost
Agronomical	Soil fertilization.	Long term soil health improvement.
Economical	Reduced mineral fertilizer uses and significant financial savings.	No financial savings.
Ethical	Mutual service between cities and farmers, transport reduction, waste recycling.	

Agronomical strengths

What everyone agrees about sewage sludge is that it brings many fertilizing elements. The most significant ones are phosphorus and nitrogen. Fields spread with sewage sludge do not need additional mineral fertilizers, except for a small quantity of nitrogen. In addition, when sewage sludge is co-composted with green waste, it has a neutral pH.

The fertilizing value of compost is more debated. Only one of the farmers interviewed thought that the compost used brought mineral elements:

> *"[Compost] brings nitrogen, organic matter and potassium. As I'm exporting the straws, I assume that all potassium is exported with the straws, I bring it back with green waste compost. [...] I use zero [mineral] phosphorus and potassium but I keep using [mineral] nitrogen because [compost] cannot complete all. But I have good results in total decreasing of nitrogen dose."* (C., interview, 16 April 2014)

However, all farmers agreed on the fact that compost brings organic matter and improves long term soil structure.

Economical strengths

As mentioned just earlier, sewage sludge dramatically reduces the need for chemical fertilizers. Fertilizers being a significant part of farms' expenses, sewage sludge brings substantial financial saving for farmers. In addition, sewage sludge is spread on the field at no cost for the farmers. Finally, every field spread with sewage sludge receives a free soil analysis conducted and paid by wastewater treatment plants.

Unlike sewage sludge, compost does not reduce the need for mineral fertilizers. In addition, compost has a status of product, which means that farmers have to buy it and pay for all expenses linked to its use (transport and land application). As a consequence, many farmers do not use compost on a regular basis. Occasionally though, when finances allow an extra expense, these farmers will consider long term issues and spread compost to improve their soil structure.

Ethical strengths

Recycling urban organic waste in local agriculture offers ethical strengths on various points and makes financial and environmental sense:

- Recycling urban organic waste in agriculture offers an alternative to incineration and landfilling, which are expensive techniques, financially as well as environmentally.
- Recycling organic waste in agriculture offers a way to close the nutrients' loop. It prevents precious resources (nitrogen, phosphorus, etc.) to be lost or wasted. Nutrients recycled in local facilities can be reused in the same soil they originate from.
- Recycling urban organic waste in local agriculture considerably decreases long distance transportation, which in turn decreases environmental and financial costs.

Recycling urban organic waste in agriculture is considered by different actors as either a service provided by the farmers to the city, or a service provided by the city to the farmers, or a mutual service between cities and farmers. In spite of the different opinions, it creates an undeniable opportunity to build a relationship between cities and farmers.

4.3. An example of the evolution of sewage sludge disposal: the case of Plaisir

The water treatment plant of Plaisir is a representative example of ongoing tendencies in the disposal of sewage sludge from direct spreading to co-composting.

Plaisir is the ninth municipality of the department Yvelines, with 31,000 inhabitants (Ville de Plaisir, 2015). For comparison, the average population size of a municipality in Ile-de-France was 9,000 inhabitants in 2008 (Insee, 2015). Plaisir's land area is of 1,800 ha divided as follow: 50% of urban area, 25% of forest and 25% of farmland (Ville de Plaisir, 2015). Plaisir's wastewater, along with 1/3 of the neighbor municipality Les-Clayes-sous-Bois, is decontaminated in the treatment plant Val-des-Eglantiers. The water syndicate and its management board of elected representatives make decisions over and assume responsibility of wastewater treatment and sludge disposal.

Before 2002, sludge was limed and spread on non-local fields. In 2002, the technical management of the facility was delegated to a new company, Valterra. A new way of sludge disposal was put into place, under the impulsion of J., farmer and mayor of Plaisir at that time. Sludge was dried through a gas dryer and put into the form of pellets at a dryness rate of 90%. 700 tons of pellets were produced each year and stored year-round on site. Local farmers (within the distance of 5 km) were contacted by J. and a land application plan was put into place (Figure 7). This land application plan included about 10 farmers and 3,000 ha. Pellets were spread between August and October with a 5 year rotation. Valterra managed transportation, spreading and analyses of the pellets. It was a very innovative approach, and Val-des-Eglantiers was one of the first treatment plants to use a gas dryer. The pellets looked attractive, smelled faintly and were well accepted by farmers. In 2012, the project was stopped because of technical and financial issues. The method was a prototype: the abrasive pellets damaged the machine, which had to be regularly stopped for 3 weeks. Regardless of its numerous advantages, drying was too expensive.

In 2012, the water syndicate called a public tender for the management of the treatment plant and received different propositions and prices. Today, the technical management of the treatment plant is delegated to Lyonnaise des Eaux, which in turn delegates sludge disposal to Valterra. The liquid sludge produced is partially dried to obtain a thickened form with dryness rate of 20%. This process reduces its volume and thus its transportation costs. The sludge is moved into two containers and picked up by truck every day. It is then sent to facilities outside Ile-de-France (up to 150km) to be co-composted. The compost obtained is a product conforming to NFU 44-095 standards, so the water syndicate's responsibility over the sludge ends after its transformation into compost. This option was chosen for several reasons. First, local farmers did not want to spread thickened sludge because it smells significantly stronger and is visually less attractive than pellets. Secondly, thickened sludge caused storage difficulties because it is not a stabilized product. Finally, the increasing demand for composted products makes it financially interesting for the water syndicate.

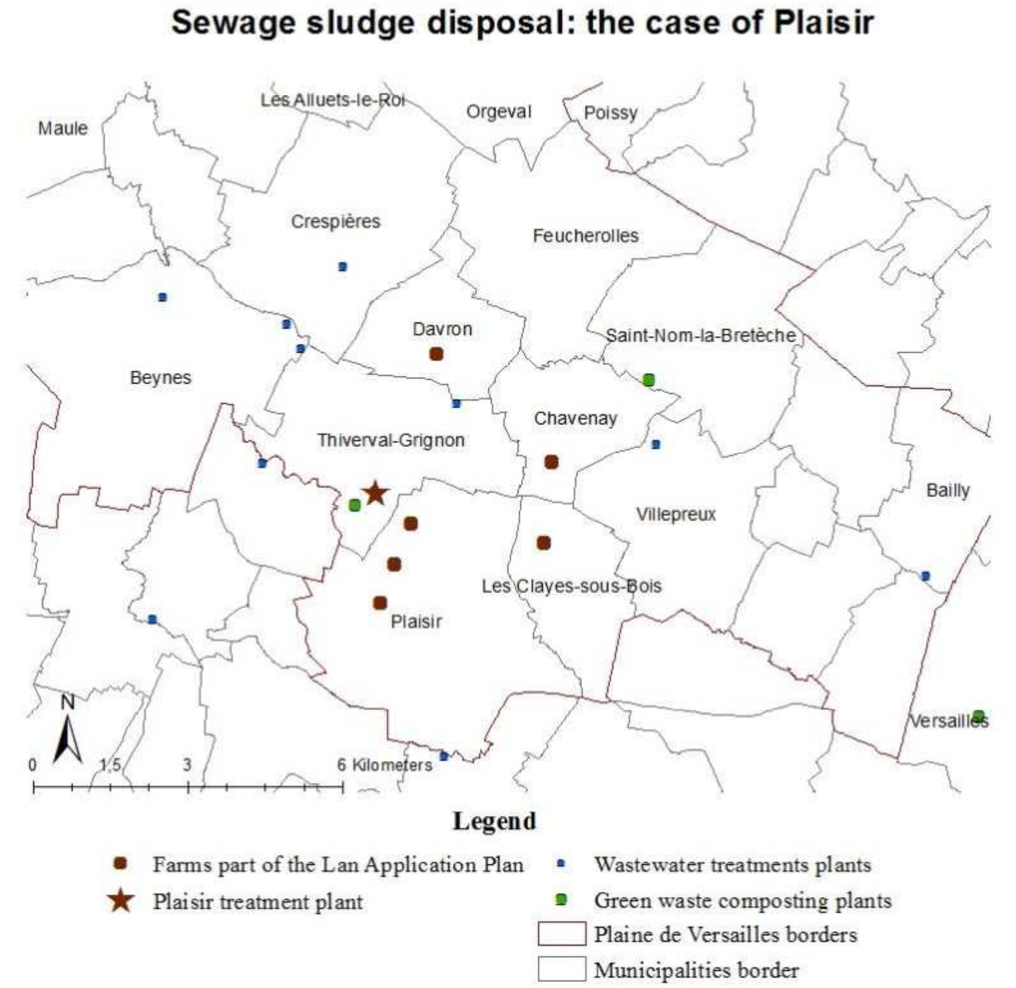

Figure 7: Location of sewage sludge disposal in Plaisir

5. Discussion

5.1. Should farmers be paid?

The results above have already shown a difference between sewage sludge as a waste and sewage sludge as a product. Sewage sludge spreading is free of charge for farmers, while co-compost of sewage sludge with green waste is paid by farmers, though to a low price. The case of Plaisir described in section 4.3 was unique because all farmers involved in this land application plan were paid. This leads to a third strategy in organizing the issue of recycling sewage sludge in agriculture. In this case, farmers are considered as providing a service to the city.

In Plaisir, farmers were paid as compensation for soil packing and other physical soil problems due to sludge spreading. It was Mr. J., the initiator of the project, who insisted and made no compromise on this point:

> *"We compensate companies collecting the waste, we pay incineration plants. Why the farmers, who are in the circuit, would not be compensated?"* (J., interview, 12 March 2014)

Mr. J. was a member of the farmers' group, mayor of Plaisir, and elected representative of the water syndicate's management board. According to him, the main source of pollution comes from urban people, who should thus pay for water decontamination. Farmers are the only ones who agree to take sludge. They do it not for fertilizing purposes but as a service provided to the city (J., interview, 12 March 2014). To the contrary, the company in charge, Valterra, did not want the compensation to become a common principal and tried to bargain against the idea of Mr. J. The manager of Valterra thought the idea of compensation was ridiculous because sludge was of excellent quality. In the end, it was agreed that farmers will be compensated (B., interview, 14 March 2014).

However, Mr. O., a farmer interviewed who spread sludge from another treatment plant, did not have the same opinion:

> *"At one point they wanted to pay us, but I said no because if they give you money to spread [sludge] in your soil, it's even worse. You become owner of this sludge and responsible for it. They must not pay me because it becomes a legal issue, it involves insurances."* (O., interview, 8 April 2014)

The core among the three strategies is the transfer of responsibility that everyone is not ready to accept. Along with other interviews, the case of Plaisir illustrates the paradoxical position of farmers and the fragile balance of the actual situation. Farmers do not want to be responsible of sewage sludge in case of harm, so they prefer that the sludge keeps a status of waste. They want to be recognized as part of the wastewater treatment system and be paid as such. But at the same time, most of them do not want their fields to be considered as trash and receive trash. The question of paying farmers or not for using urban organic waste does not have a straight answer. Payments to farmers do not necessarily promote the use of urban waste by farmers.

5.2. Influence of individuals

The example of Plaisir illustrates as well the influence of individuals. Being the central person of the project, Mr. J. had a significant influence on farmers during the negotiations for the land application plan. As he offered his own farmlands to be part of the plan, it might have been a guarantee to other farmers: *"what was good for [him] should be good for them"* (J., interview, 12 March 2014). Farmers' decision to be part of the plan had probably other motivations: (a) the compensation would bring cash income, (b) they would have financial savings on nitrogen amendments, (c) the nitrogen supply from sewage sludge spread before winter was interesting for rapeseeds fields and (d) unlike sludge, pellets are odorless and very easy to handle (P., interview, 24 April 2014). But after the waste treatment plant of Plaisir stopped its activity of sewage sludge spreading several years ago, the farmers stopped using sewage sludge, though the authorized land application plan of Plaisir is still active. No farmer tried to spread sludge from another treatment plant neither[6]. This situation raises questions about the initial motives of farmers to spread sludge. Farmers were probably encouraged by Mr. J.'s recommendations. The unique agreement on compensation to for farmers also came from Mr. J.'s idea.

Mr. J.'s influence had a significant role in this project. As Bagdonis et al. (2009) explained, individuals can have a significant impact and one person's networks, resources and one personality can shape an entire project. The land application plan implemented in Plaisir between 2002 and 2012 with the help of Mr. J. had many benefits. It generated a form of waste attractive to farmers, enabled the city's waste to be recycled locally (no further than 5 km) and dramatically reduced transportation impacts, which brought financial and environmental benefits. If one of those farmers wants to spread sludge today, he/she will have to go through the administrative process of cancelling the old land application plan, then canvass neighboring treatment plants to find a suitable one, and then go through the administrative process of building a new land application plan. Even if this farmer would be willing to go through this complicated process, he/she would still have to handle local residents' complaints about foul smell or trucks' passages. Indeed, the sludge to be spread would most certainly be thickened sludge because of a lack of dryer equipment. Furthermore, the farmers would possible have no financial compensation in the new agreement.

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[6] To guarantee the best possible traceability, sludge from different treatment plants cannot be mixed (Direction Générale de la Prévention des Risques, 2012). To spread sludge from another treatment plant, a farmer should first ask to be taken out of the land application plan.

5.3. Gap between scales: from national and European legislation to local reality

From 2008, the European Environment Council gave priority to waste reduction at source and development of waste recycling (Mathery, 2012). In theory, recycling sewage sludge in agriculture remains the best economic, environmental and ethical option but on-fields realities are often significantly different. This gap between legislation and reality is hindering the recycling of urban organic waste.

Firstly, the legislation is usually unstable and complicated regarding urban organic waste recycling. Significant food scares or sanitary crises lead to the creation of new laws, in order to prevent any accident. For acting against harmful practices these laws are of course valuable. But when promoting the principle of “zero risk”, new laws act against formerly legal practices by changing the existing standards and pollution thresholds. Legal practices thus become illegal, which confuses local actors, who cannot trust anymore the ever-changing legislation. In addition to this instability, administrative processes are cumbersome, long and complicated. For example, it takes up to five years of administrative procedure to open a co-composting station.

Secondly, there is a gap between agricultural and non-agricultural actors. In France, organic farming and local food consumption have developed and significantly increased. Pressed by public opinion on food quality, health and sanitary risks, French legislation is evolving toward these trends. Many municipalities and local residents have asked the farmers located nearby to adjust or modify their practices to fit with an assumed picturesque image of farming, which does not match the reality. For example, one of farmers interviewed was asked by its local municipality to grow organic food, but received complaints when his trucks had to cross the village to deliver organic fertilizers, i.e. animal manure and green waste compost. These issues come from the fact that non-agricultural actors are often ignorant of the on-field realities. This ignorance is often coupled with a negative image of agriculture. Farmers are often considered as partly responsible for environmental issues and human health risks regarding food. Such a negative image is felt strongly by farmers, which causes difficulties for both communication and urban organic waste recycling.

To improve relationships between actors in agricultural and non-agricultural sectors and build a positive image of agriculture, there is a need for education and compromises. Land application of organic waste has a very specific nature. It is part of a global system of interdependent sectors but the local context of production and usage has to be taken into account. Regarding urban organic waste, small scale facilities and local relationships should be promoted. They facilitate communication and trust between actors and contribute to common agreements based on win-win relationships.

6. Conclusion

Urban organic waste recycling in agriculture has long been developed in France, as in many other countries in Europe and around the world, and takes various forms. The recycling of sewage sludge is more complicated than that of green waste composting, because pollution risks and past mistakes in using sewage sludge are still present in memories. Major advantages of the existing organization of the sector are geographical proximity, financial economies and transport reductions. Problems hindering agricultural use of urban organic waste include the complex and unstable legislation, the gap between legislation and on-field reality, the tensions around sanitary risks between different actors, such as farmers, local residents, public institutions and authorities.

Farmers are interested to spread urban organic waste for agronomical, economical and ethical reasons: improvement of soil fertilization and soil structure, financial savings on fertilizers and transport, and recycling of waste and nutrients. In addition, for sewage sludge recycling, numerous analyses provide security guarantees for its use and the principal of *zero euro rendu racine* free of charge for farmers relieve them from any responsibility in case of sludge-caused harm. Long-term results like soil structure improvement are considered as a bonus. The majority of farmers who do not use urban organic waste are grain farmers. They are not used to handling organic matter and use mineral fertilizers primarily. Some other farmers strongly refuse to spread sewage sludge because of personal reasons, not trusting sewage sludge regarding pollution problems for example.

To further develop agricultural use of urban organic waste, several important issues have to be addressed. Firstly, the legislation and status of sludge have to be simplified and stabilized, which will help to define farmers' position as either providing a service to cities by recycling their waste or being integrated into the chain of actors recycling urban waste. In addition, a significant work is needed to improve education in understanding the role of farmers and improving the image of agriculture. Finally, urban organic wastes need to be more attractive in terms of their physical characteristics (especially for thickened sewage sludge) and on an agronomical values. Taking co-composting of sewage sludge and green waste as an example, mixing several materials seems to be an interesting option, but more research is needed.

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Table of appendices

Appendix A: Steps of the theoretical framework

This section presents the different steps of this study, based on the following theoretical framework and methods: case study research and theory building from case study research (Eisenhardt, 1989; Yin, 2009).

It is relevant to use such methods when there is a lack of knowledge or when new perspectives are needed on an ongoing phenomenon. It is especially well-suited when the investigator asks “how” and “why” questions. Including elements of context also provides the investigator with a deep understanding of real-life event. (Eisenhardt, 1989; Yin, 2009)

Step	**Activity**
Getting started	• Formulate a research focus • Decide what kind of data needs to be gathered and what kind of institutions/person needs to be questioned
Designing	• Target a population and define the limits of the study • Select the cases to be studied
Preparing tools	• Select multiple methods • Prepare qualitative interview guides (King-Eveilaard et al., 2012; Kvale and Brinkmann, 2009)
Collecting data	• Be adaptive and flexible • Have a good understanding of the issues examined • Avoid bias
Analyzing data	• Process the data in as many different and structured ways as possible • Within-case analysis: write a report for each case and familiarize with each individual case, which facilitates generation of insights, emergence of patterns, and cross-case comparisons • Cross-case synthesis: create tables compiling the data from individual cases into a common framework and analyze them from different angles (horizontally or vertically)
Discussing findings	• Compare the emergent ideas with evidence from each case • Assess how well or poorly it fits with case data

Appendix B: list of interviews

1. Farmers

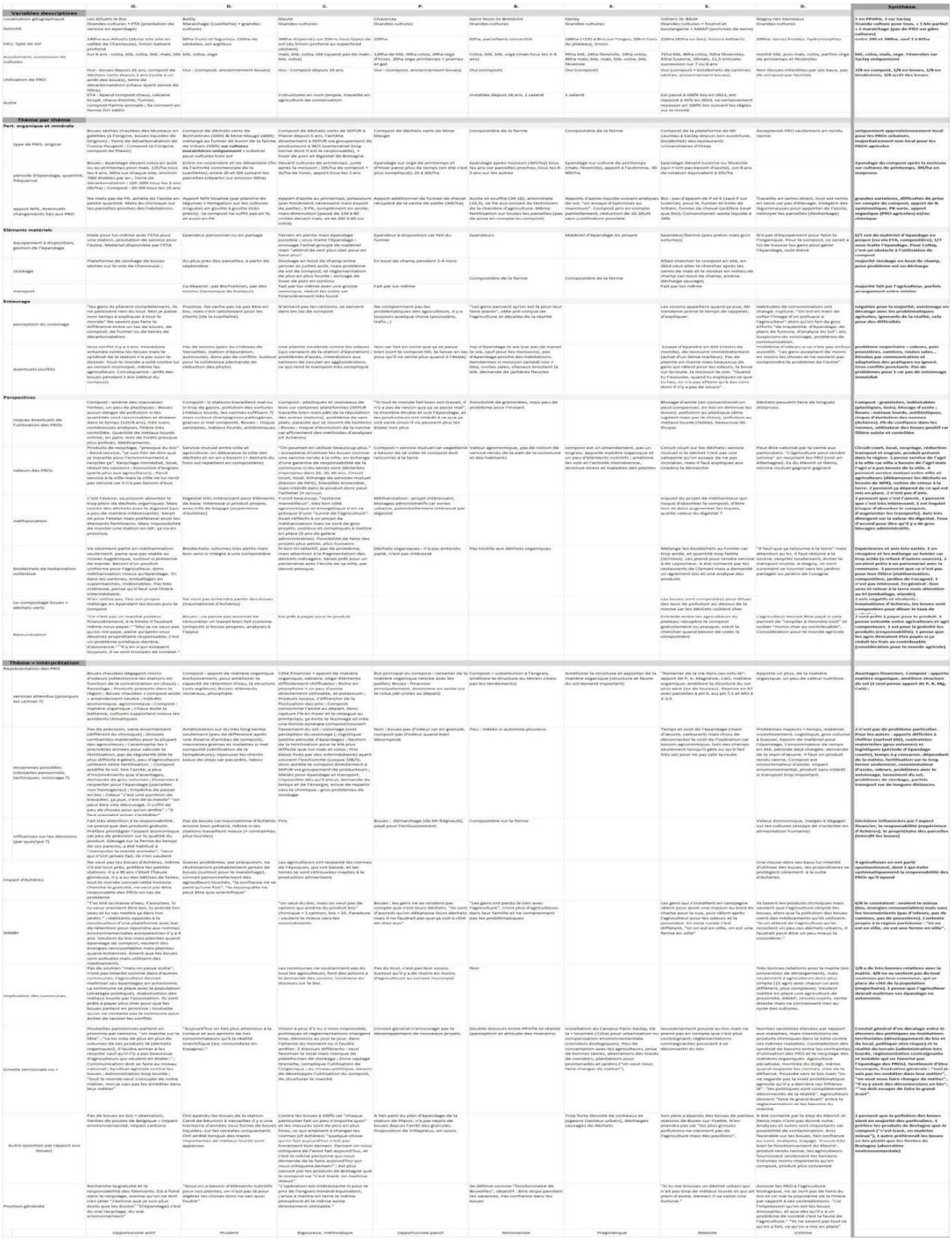
Initial	Location	Date
D.	Bailly	12 March 2014
D.	Magny-les-Hameaux	3 June 2014
O.	Les-Alluets-le-Roi	8 April 2014
C.	Maule	16 April 2014
E.	Saclay	25 March 2014
B.	St-Nom-la-Bretèche	11 March 2014
P.	Chavenay	24 April 2014
E.	Villiers-le-Bâcle	14 April 2014

2. Key stakeholders

Name	Organization	Location	Date
D. Guille	SIEARPC (water syndicate of the wastewater treatment plant 'Val des Eglantiers')	Plaisir	28 February 2014
E. Laureau	Composting station	Saclay	11 March 2014
E. Lepêcheur	CESFO (university restaurants)	Orsay	6 March 2014
B. Mauge	Composting station	St Nom la B.	11 March 2014
L. Prunier	Composting station 'BioYvelinesServices'	Versailles	21 February 2014
J. Régnault	Councilman, former mayor and former farmer	Plaisir	12 March 2014
B. Richard	Valterra (treatment and recycling of organic matters)	Montrouge	14 March 2014
M. Trahard	Lyonnaise des Eaux (manager of the water treatment plant 'Val des Eglantiers')	Plaisir	6 May 2014

Appendix C: Searching for cross-case patterns

The size of the tables does not allow a full display in this thesis. The excel document can be retrieved from the author of this thesis upon request.



Appendix D: Urban organic waste processes

1. Wastewater treatment process

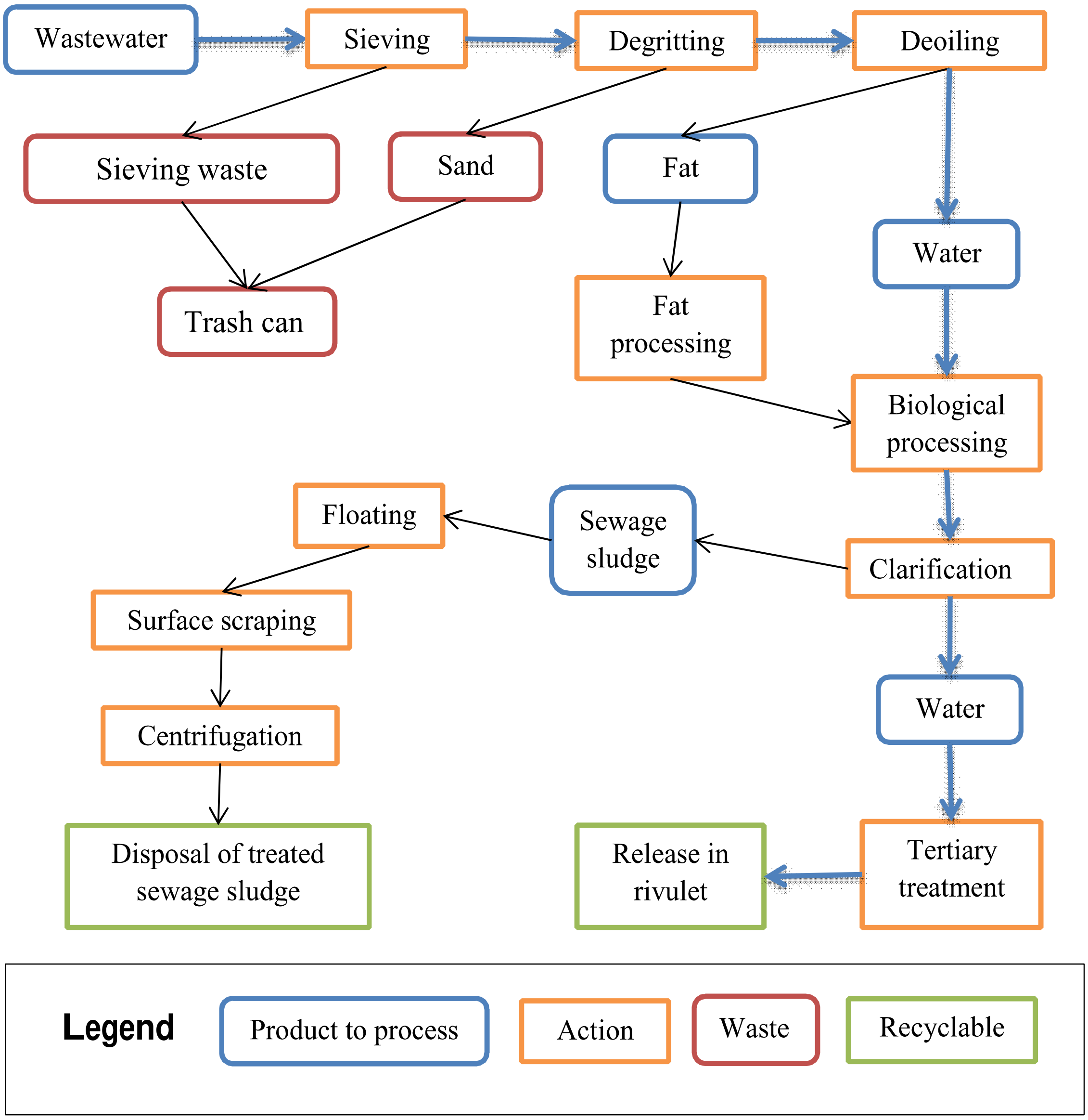
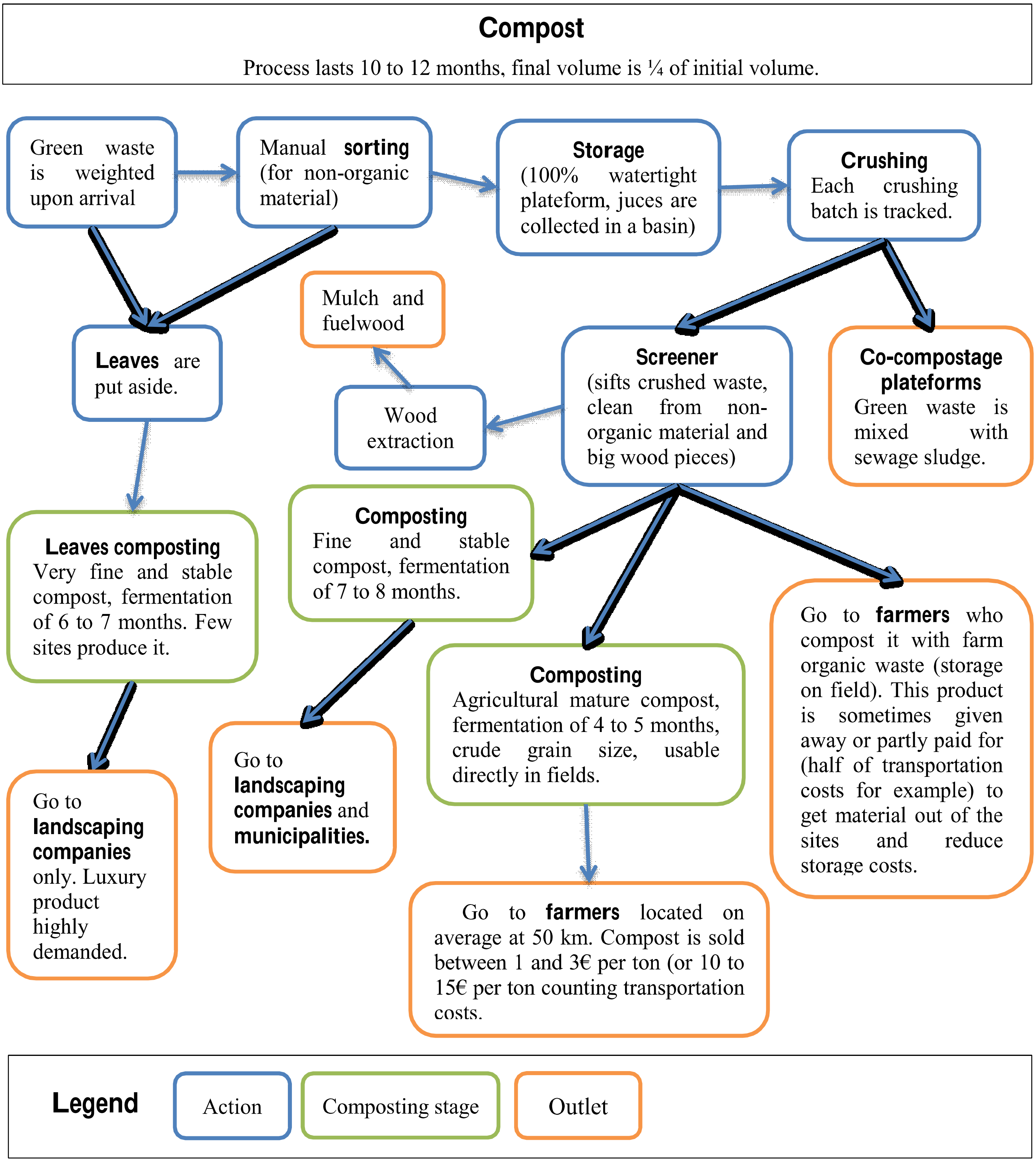


Diagram 1: Wastewater treatment process.

2. Composting process



Compost

Process lasts 10 to 12 months, final volume is ¼ of initial volume.

Green waste is weighted upon arrival

Manual **sorting** (for non-organic material)

Storage (100% watertight plateform, juces are collected in a basin)

Crushing Each crushing batch is tracked.

Leaves are put aside.

Mulch and fuelwood

Wood extraction

Screener (sifts crushed waste, clean from non-organic material and big wood pieces)

Co-compostage plateforms Green waste is mixed with sewage sludge.

Leaves composting Very fine and stable compost, fermentation of 6 to 7 months. Few sites produce it.

Composting Fine and stable compost, fermentation of 7 to 8 months.

Composting Agricultural mature compost, fermentation of 4 to 5 months, crude grain size, usable directly in fields.

Go to **farmers** who compost it with farm organic waste (storage on field). This product is sometimes given away or partly paid for (half of transportation costs for example) to get material out of the sites and reduce storage costs.

Go to **landscaping companies** only. Luxury product highly demanded.

Go to **landscaping companies** and **municipalities.**

Go to **farmers** located on average at 50 km. Compost is sold between 1 and 3€ per ton (or 10 to 15€ per ton counting transportation costs.

Legend

Diagram 2: Composting process.

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