Soils: Under Pressure

“We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect”-Aldo Leopold

Part of the “Make Soils Healthy Again” WUR challenge

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Introduction

We are living in a rapidly changing world; it has never been this easy to go to places you have never dreamt of or to buy materials made on the other side of the world. If we want an avocado in Europe, we go to the supermarket and buy an avocado but most people buy food without knowing where it comes from, how the food is produced and how many steps it took to get from plant to plate.

The trend now is that making compost is fancy, but we don't even know the poor quality of our own compost and we're not aware that farmers are reluctant to use it. We will propose ideas to make compost more organized by measuring carefully quality compost and, this way, incorporate it in a circular economy between farmers, supermarkets and citizens. We think sharing compost will also increase awareness of soil quality to a wider public because people will be able to touch and see it.

In this paper we try to explain how we got here, assess the links between society and soil, the importance in preserving good soil quality and we propose a new concept of how the society of tomorrow could participate in making soils healthy again through the circular economy of compost. Bringing soil closer to the people, and shortening the food supply chains.

Bridge

Industrial agricultural practices in developed regions have repeatedly shown that it is ineffective at sustaining soil productivity, especially in the context of smallholder family agriculture (Titonell and Giller, 2013). New ways of managing soil fertility are needed in order to restore soil productivity and increase ecosystem services. These include:

- Innovative precision agriculture; targeting resources in space and time to increase efficiency, build resilience and reduce negative impacts. Local knowledge can be the basis for precision agriculture in developing countries.
- Systems approach to nutrient acquisition and management; nutrient management cannot be seen separate from management of other farm resources and processes such as recycling of organic matter.
- Agro-ecological strategies; rural population growth in developing countries, mainly in the tropics, lead to accelerated soil degradation. Land previously under forest and grazing is now used as annual cultivation leading to increased ploughing and less organic matter inputs.

How did we get to where we are today? Why do we need to change the way we think about the soil? What can be done about the changes we are going through and how can we stop this unsustainable land-use management.

I. How did we get to where we are today and why is it important?

Water pollution, climate change, biodiversity loss and our food supply are largely impacted by processes carried out by the soil (Weil and Brady, 2017). The rise of mankind has led to changes in how soil has functioned and benefited many species over the past 4.5 billion years. Humans have switched from nature as a preferred habitat to cities as their preferred habitat. As a result, we have lost the intimate contact with the soils that sustain us.

Soil allows us to breathe, build and eat; we largely depend upon soil for our survival. It is formed by different processes: physical, chemical and biological weathering of the deposit at the earth's surface, the parent material (Puig de la Bellacasa 2015; Weil and Brady, 2017). Physical weathering is the breakdown of rocks in the form mechanical action (i.e. temperature change, abrasion or frost), chemical weathering is the breakdown of rocks through the change in chemical make up (e.g. minerals reacting with water, air or other chemicals) and biological weathering is the breakdown of rocks by living organisms (e.g. microbes or burrowing animals). Overall, there are 5 main factors which affect soil formation: type of parent material, living organisms present, climate, topography and time (Ashman and Puri, 2002).

The earliest recorded agricultural practice occurred around 11,000 BC in Jarmo, Iraq. There is evidence that irrigation was used for agriculture in southern Iraq as early as 7,500 BC. Throughout history, settlements were made in areas where soil was most fertile. From 3,300 BC Egyptians started to move towards the Nile and make their settlements there (Brevik and Hartemink, 2015). One of the main reasons was that soil was much more fertile near the river and it also provided people with food, water and easy ways of transport (Troeh et al., 2004). Rainfall was scarce in Egypt and people dependent on the floods of the Nile to sustain their crops from adequate moisture and nutrients. Between 6,000 and 500 BC, soil management techniques were developed in various parts of Europe making management practices more and more complex by the use of plows, implementing tillage, terracing and irrigation in agricultural systems (Brevik et al., 2017). Soil erosion was a serious problem in ancient Greece due to the way soil was managed, and lack of understanding of how the soil functions. Hence, from 2,000 BC Greeks started to accumulate more knowledge about different soil properties and soils were thoroughly studied. After the Greeks, the Romans continued the Greek's studies and considered soil as one of the most important components.

Not only did the ancient Greeks encounter problems with eroding soils, throughout history of agriculture, land intensification through land management practices gave way to various forms of land degradation (e.g. soil erosion, salinization) (Troeh et al., 2004; Brevik et al., 2017). Skipping ahead to more recent events regarding how humans have affected soil health is the disrespect towards the soil and the unsustainable management practices of the land. In the mid 1930's land was bare in the north american high plains allowing powerful storms to carry the topsoil away from intensively farmed land. The loss of the top soil resulted in devastating livelihoods and led to displacement of hundreds of thousands of people (i.e. the dust bowl; Puig de la Bellacasa, 2015). Also, in the early 1950s there was famine in large parts of Asia and Africa, which caused an agricultural movement called the Green Revolution. During the Green Revolution an increase in artificial fertilizer production and application was observed, higher

yielding crop varieties were developed resulting in more intense cultivation and high yields (Tilman, 1998).

The Green Revolution was mainly a success largely due to the increase in genetically improved varieties and therefore a higher understanding occurred of the genetic potential of crops (Khush, 2001). Famine was averted in the late 1960s because of the improved high yielding varieties and intensification of farm management systems (e.g. more agrochemicals, more large scale monocultures and an increased soil management). The Green Revolution was a success as food production soared. However, the high yielding varieties were very responsive and dependent on external inputs and in the mid 1980s degradation and loss of soil was observed and some people recognized this is a threat to long-term sustainability and food production (Puig de la Bellacasa, 2015).

Continued intensification of farming practices resulted in a loss of soil health and ultimately a decrease in production. Hence, forests and natural landscapes were eradicated to increase crop yields again, depleting the soil further. In 2015, the FAO called out the year of the soil, labeling it as a “finite non-renewable resource on a human timescale under pressure of processes such as degradation, poor management and loss to urbanization”. Not only is soil important as a medium for growth, it also purifies water, it can be used as an engineering medium, it recycles nutrients and organic waste and it is a habitat for soil organisms (Weil and Brady, 2017).

Right now, in the case of soils, economic moves can be seen in the rush to grab fertile land (Borras et al., 2011); the less there is, the more valuable an investment becomes and therefore exploitation is further accelerated. An increasing need for an interdisciplinary approach is needed to manage the soil. Different stakeholders perceive soil health in different ways. A conventional farmer focuses on how he can optimize his management practices to get the highest yields, an environmentalist focuses on the biodiversity living in and around the soil while an engineer might consider soil health as the ability of the soil to function as a building medium. As the soil has different functions and different stakeholders have different ideas what to do with the soil, the definition of soil health is therefore vague. An increasing need for an interdisciplinary approach is apparent.

II. A new perspective on soil health

One of the main challenges soil science has faced in the past decades is in finding an indicator for what a “good” soil is. Concepts such as soil quality and soil health have been developed, but frustratingly little progress was booked towards a universal indicator. Soil health, the most recent of the two concepts, is currently defined as the capacity of a soil to contribute to the achievement of the Sustainable Development Goals (Keestra et al., 2016). Soil health defined as such is not an intrinsic property of soil, but rather an extrinsic property that depends on a soils’ relationship with humans. Our relationship with the soil through the plants we eat, the structures we build on it and the other services it offers us is therefore essential in our understanding of healthy soil. Here we also find one of the fundamental difficulties in quantitative or even qualitative understanding of soil health. As soil health is a relative concept, it is specific to a certain spatio-temporal context and the needs of the soil stakeholders within that context.

One of the barriers to a multidisciplinary understanding of soil health may be the “information silos” that exist within science today. Without a common framework to organize findings, isolated knowledge does not cumulate (Ostrom 2009). There is a need for a holistic framework that is useful for scientists, policy makers and “soil stakeholders” alike.

In this section we propose a modified version of the social ecological systems (SES) framework originally developed by Elinor Ostrom (2009) that aims to facilitate this trans-disciplinary conversation. The SES framework was initially contrived as a way to assess the sustainability of resource systems, but was later adapted to be applicable for environmental management at large by Virapongse et al. (2016) (Fig. 1).

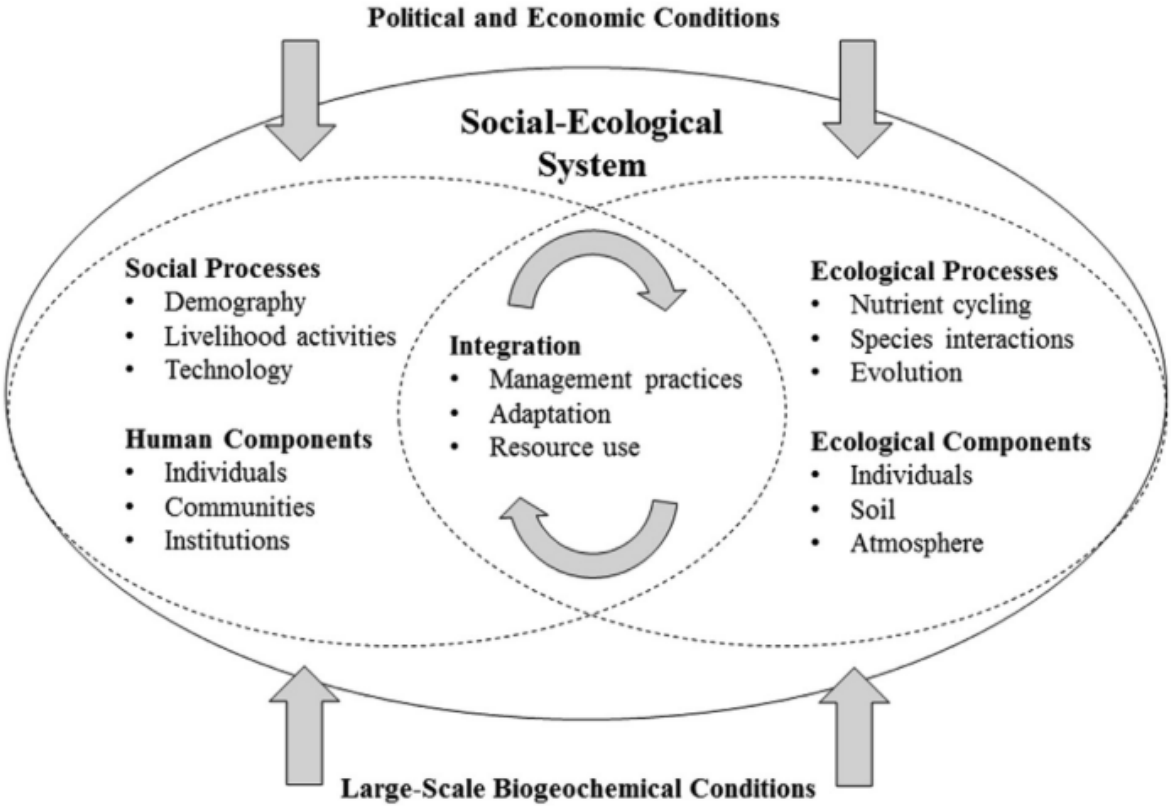

Figure 1 Social-Ecological System Framework

Studying the relationships between components of a system may be more productive than studying the components themselves. Soil scientists should look for ways to match the soil's products, e.g. food or carbon sequestration, with soil stakeholders' needs. Furthermore, the relationship between the soil and the general public should become much more salient in society.

Most of the world's population lives in cities and with the rise of urban agriculture and local food production, cities may be a good unit to study as a system. Furthermore, people identify themselves as inhabitants of a city. The general public's understanding of the connections between soil, their food and themselves may be improved when explained from a city perspective. One of the opportunities for emphasizing the connection between soil and people in an urban context is composting of food waste. In the following sections, we will explore composting as an opportunity for bringing people closer to the soil that sustains them.

III. Dealing with biowaste and food legislation nowadays

"*Municipal waste is defined as waste from households and waste from other sources, such as retail, administration, education, health services, accommodation and food services, and other services and activities, which is similar in nature and composition to waste from households*." (European Commission 2018)

In 2012, Europe produced 1.5 to 2.5 kg of municipal solid waste (MSW) per person per country per day (Figure 2; Orteng-Abadio et al., 2018). But what happens to this enormous amount of food once we throw it away? The answer is that food waste in the garbage, mixed with a lot of different waste, is picked by a truck and then either transported to landfills or will be incinerated (Figure 3). Nowadays it is also used for biofuels. Hence, improving soils through bio waste is not primordial but also the transport of this material emits huge amounts of CO_2 into the atmosphere. Furthermore, in the landfills, it generates methane emission. Not only does this contribute to global warming but it is also irreversibly lost. On the other hand, Germany is very good in separating their waste, number 1 in recycling of waste and composting (eea.europa, 2019) in Europe, they use a lot of organic waste for biofuels but isn't now primordial we use this organic matter for improving our soils?

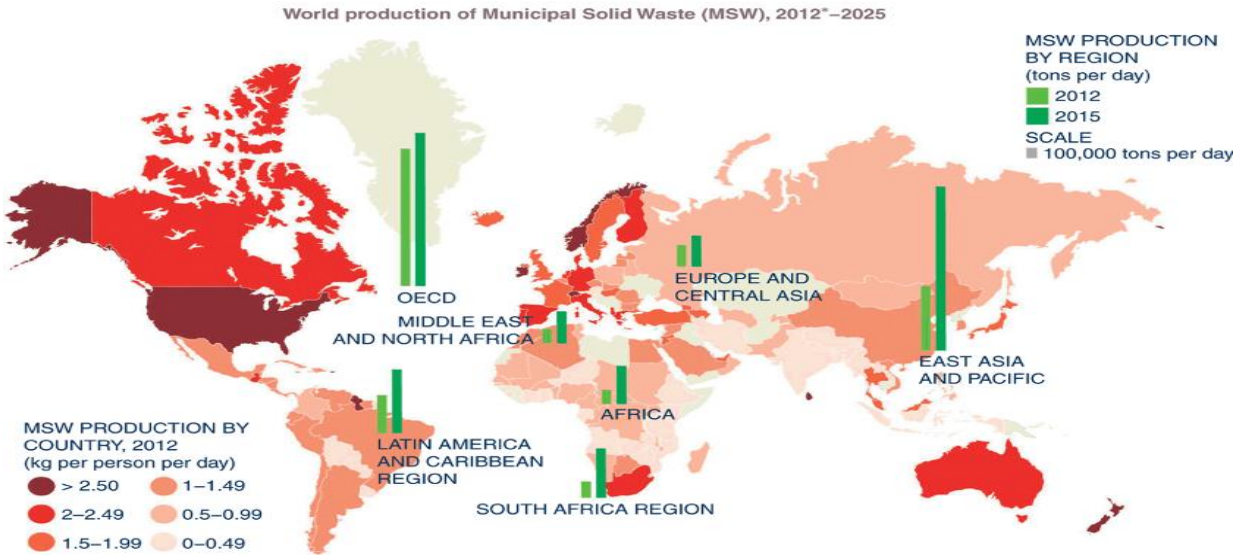

Figure 2 Municipal waste production by country(Cambridge, 2018)

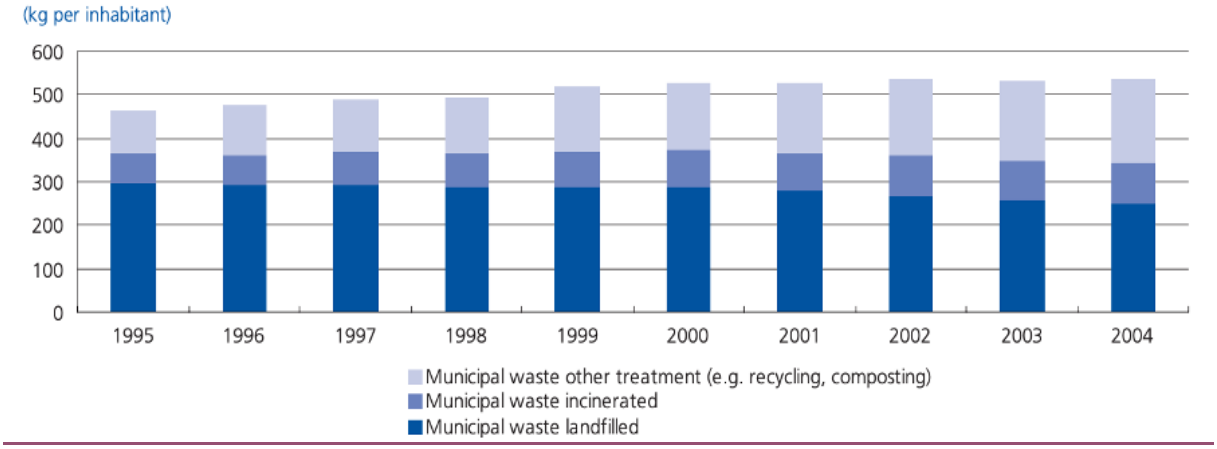

Figure 3 Distribution of municipal waste

In 2017, European countries about 46.4 % of waste is recycled meaning that still more than 50% is lost. By 2050, European countries are now required to recycle 55% of their municipal waste (ec.europe.eu, 2020). But in order to attain this number, we need to boost people's initiative to actively participate in recycling their biowaste.

In 2018, the Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste pushed again towards reducing the food waste, by aiming at creating a stable set of regulations for the whole EU members. In this directive, as well as in other laws on food waste, there was stated that each EU country has to deal with the waste in a sustainable way, however we were wondering if this new directive puts enough pressure in order to achieve a substantial change in how food waste is dealt with. Moreover, the municipal waste is, as presented below, coming from retail as well. Therefore, we chose to also focus on how supermarkets deal with their waste. When it comes to the supermarkets, it appears that there is no specific framework. For example, France took initiative on the matter by banning supermarkets from throwing away food waste, thus obliging them to give it to charities or food banks (Chrisafis, 2016). Italy followed the same route, even if not so strict, thus creating more space for companies to donate their waste (Kirchgaessner, 2016). Considering this, we decided to investigate this issue of what appears to be fragmentation, by interviewing different people working in the retail industry.

In our interview with Mrs Jane Gilbert, Vice-President of the International Solid Waste Association (ISWA), these unclarities regarding a specific framework for the EU countries were raised. The 2018 EU directive on Food Waste was mentioned and in the light of this, the main outcome of the discussion was that the directive will put enough pressure on the EU countries to deal with food waste, as there is a clear requirement for collection. However, the way each country, each municipality interprets and comes up with solutions is not defined, thus leaving freedom for different ways of dealing with food waste.

In the light of point 32, *"In order to prevent food waste, Member States should provide incentives for the collection of unsold food products at all stages of the food supply chain and for their safe redistribution, including to charitable organizations. Consumer awareness of the meaning of 'use-by' and 'best-before' dates should also be improved in order to reduce food waste."* and the Waste Hierarchy attached below, the first measure taken in order to reduce food waste is prevention, the reusing/recycling by giving it to NGOs or other organizations that can redistribute the waste. However, redistribution of food waste to the people is in a way restricted, in terms of safety as the directive mentions as well. If we take a closer look at the next step of the hierarchy, namely other recovery, this is where composting could come in.

Figure 4 European Union Waste Hierarchy (ec.europa.eu, unknown)

Thus, we believe that composting is a good approach, and we will explain the benefits of compost and then introduce our concept in the sections below.

IV. A new way of composting

Massive food production has a big impact on our soils. Most people don't understand the importance of preserving the quality of the soil. But what if we could change this? Is there an effective way to change our behavior, to communicate soil science to the public and to communicate better with the producers and those that implement the laws?

Compost has been used all over the world for many years in the stabilization of organic residues. It is a mixture consisting of decayed organic matter (e.g. plant material or animal faeces) and when this compost is mature enough, it can be used as nutrition for plants but also build up the soil organic matter and improve soil structure (Haug, 2018).

Intensified agriculture risks irreversible soil organic matter (SOM) losses which may lead to depletion of essential plant nutrients to ground and surface water, increased risk of soil erosion, loss of above and belowground biodiversity and increased compression of the soil (Celik et al., 2010; Tsiafouli et al., 2015). Hence organic matter is needed to preserve soil health and aim for more long term, resilient, agricultural practices. The European Union in the Thematic Strategy for Soil Protection listed loss of organic matter as one of the main threats today affecting soil quality (European Commission, 2012).

Therefore, we thought of compost addition to soils as being a solution to improve soil health and a way for people to get involved and better understand soils. In addition to this, citizen's pressure will maybe change the way we think about intensive practices over time. In this section, we will handle current practices, why compost could potentially replace fertilizers and our concept of compost along with interviews.

Figure 5 Compost's circular economy (Flannerys, 2019)

1) Compost: a solution for replacing chemical fertilizers:

We apply fertilizers because we want to optimize plant productivity. Applying chemical fertilizers decreases soil life, changes the soil physical properties and therefore reduces the organic matter content in the soil. A reduction in organic matter reduces plant nutrient uptake, therefore more chemical fertilizers are applied to counterbalance the lack of nutrient uptake. But what if compost could replace fertilizers? How much should be applied in order to maintain the same yield?
Table 1 (Diaz et al., 2018) shows the different emissions related to fertilizer use (ammonium nitrate and triple super phosphate). This table comes from a scientific research paper, dating back to 2018, shows the life cycle of compost and assesses its environmental impact. From the table, the application rate of 0.088kg/m^2/year for ammonium nitrate and 0.038 kg/m^2/year for triple super phosphate correspond to the same amount of N and P content as in 3 kg/m^2/year. Hence compost could replace fertilizers like triple phosphate and ammonium.

Table 1: Energy consumption, global warming potential, eutrophication potential, acidification potential and abiotic resource use due to mineral fertilizer production and emissions related to their use.

	Ammonium nitrate	Triple super phosphate
Emissions related to fertilizers production/kg fertilizer		
Energy consumption (MJ)	40	30
GWP (kg CO_2 eq.)	6.2	1.7
EP (g PO_4^{3-} eq.)	0.5	0.7
AP (g SO_2 eq.)	4.7	8.1
Abiotic resource use (g Sb eq.)	23	15
Air emissions related to fertilizers use g/kg fertilizer		
NH_3	20	-
N_2O	17	-
NO_x	3.5	-
Groundwater emissions related to fertilizers use g/kg fertilizer		
NO_3^-	347	-
PO_4^{3-}	-	1.3
Soil emissions related to fertilizers use mg/kg fertilizer		
Pb	1.6	20
Cd	0.08	95
Ni	0.05	10
Cr	0.54	927
Zn	2.8	1,794
Cu	1.0	158
Hg	0.02	1.55

This paper concludes that replacing fertilizers by compost is beneficial in terms of decreasing the global warming potential and ecotoxicity potential. However, the metal content is higher in compost than in fertilizer but still 5 times lower than the upper limit NF-4405 fixed by the French norms, in this case.
Hence, application of compost could thus be used to replace fertilizers and recycle bio waste but has to be measured and monitored carefully. If it's quality-controlled farmers would be more open to use it.

2) What if we sorted our composts?

A study on agricultural use of compost (Houot et al., 2005) analyzed the quality of 4 different composts: sewage sludge compost (GWS), municipal solid waste compost (MSW), biowaste compost (Bio) and farmyard manure (FYM).
This study showed that application of GWS and BIO composts showed the largest increase of the soil organic carbon, followed by the FYM and only then MSW.
The main problem found is that in MSW there is too much Cr and Pb, however MSW and the other types of composts still fit below the standards of organic pollutants (PAHs and PCBs).
Furthermore, N bioavailability is an essential nutrient for crops growth. This study finds that MSW has the highest bioavailable N, then GWS, then FYM and then BIO compost. However, after a 3rd application for GWS and BIO, N concentration also increases quickly.
Moreover, structure stability is also important because it prevents soil degradation. For example, in loamy soils, OM has a big influence on structure. This study shows that after 4 years, the soil structure increases (more aggregates).
Finally, trace elements analysis in crops has also been studied, in this case for maize and no fortunately no trend has been observed.

This study shows that different composts have different properties. It also concludes that MSW increases the crop yield and has the largest N availability and that BIO composts can increase efficiently the soil organic carbon in the soil. Additionally, the 4 different composts stimulate the microbial activity in soils which in turn improves the soil structure stability. Hence, it would be interesting to encourage citizens to sort their composts. One compost collector only for biowaste (leaves, grass), another one for kitchen waste and one for wood and cardboard (improves structure soil by creating pores filled with air). Hence the different composts will have different properties and can be used depending on the soil's need.

3) *Concept:*

Our concept basically consists in changing current practices of nowadays bio waste recycling and compost. On a household level, composting exists, but it's not well monitored, citizens do not know for example that the presence of pesticides is dangerous or that rain can rot the compost. To increase awareness, improve soil quality and to boost people to be more active, we thought of implementing a compost cycle, in order to achieve the circular economy goals (figure 6). Meaning, people handing in their compost to local farmers around cities and in exchange getting some food or lower prices on local food from those farmers. This is meant to break the barrier of unconsciousness of where our food is coming from. But in order to achieve this, the compost should be quality controlled so that farmers will not be reluctant to use it. This circular economy should be accompanied by workshops, distribution of fliers, organized by the city's municipalities. This will also increase the awareness about the importance of soils in our changing climate and how everybody can contribute even though it's only a drop in the bucket. This could also stimulate the social link between citizens and neighbors of the same quarter. Citizens will be in direct contact with farmers and even help if needed during harvest season.

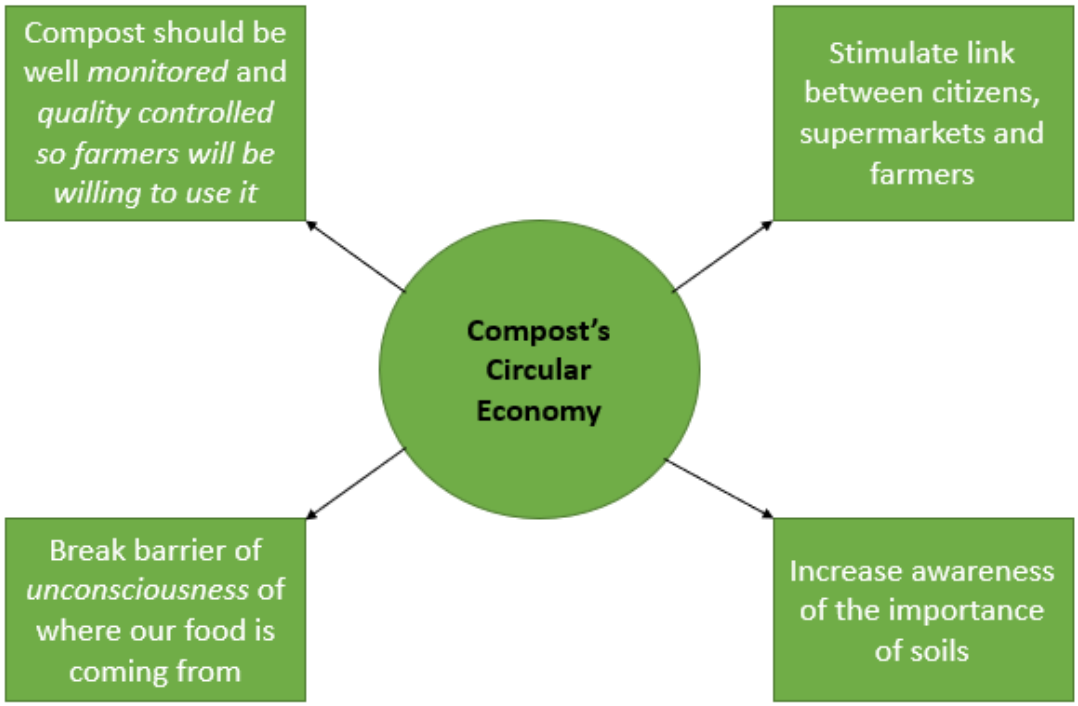

Figure 6 Steps which must be taken in order to create a Compost's Circular Economy

Every neighborhood in cities and towns should install compost places that are of easy access in order to stimulate citizens to compost.
Citizens subscribe in their city/neighborhoods composting team, can use this compost freely for their own use or will be distributed to small scale local farmers in order to boost local agriculture. We also think if you install composts in every quarter/ street, one citizen is more influenced to participate if it's a neighbor that is also participating. In return, citizens will be rewarded by a free amount of food (vegetables/ fruits) or will have lower prizes on the food coming from the small-scale local farmer to boost local agriculture production and consumption. Citizens could also have vermicomposts installed in their kitchen, use it for their own garden or give it the compost team of their quarter. Moreover, on a retail level supermarkets could also be integrated in the compost cycle. We propose that the organic waste from the supermarkets be composted as well and afterwards, given back to farmers. In addition to the concept of having composts in every quarter in the cities, compost heaps could also be placed next to supermarkets. In this way, people compost their waste, farmers can access this compost and sell their products to the supermarket. Supermarket waste can fit in this framework, as supermarkets or markets in general are the core of a neighborhood. People go to the supermarket weekly; they buy and are influenced by what the supermarkets sell. Supermarkets can have the role of creating a trend of how to deal with food waste and people might be more likely to follow the example.

In order to achieve this, in our interviews we asked if composting supermarket waste can be done. When discussing with Alexandru Tudose from The Institute of Permaculture in

Romania, we found out that there is not really an infrastructure for such a development. Mr Tudose is involved in a project which has a partnership with one of the big supermarket brands, Kaufland, of creating urban farms on top of the supermarkets rooftops or in the parking lot. In the interview, different topics regarding soil composting and waste were raised, but in the light of the issues discussed above, it appears that supermarkets might be able to provide a sorted selection of leftovers. It is the issue of transporting and getting to the farm that should be figured out.

The problem is that there are some compost associations that want to organize a circular economy already around compost like Eisenia in Lyon, but these are not approved by municipalities because it is not considered as a priority.
Therefore, the European Union, for example through the Green Deal, could incorporate a circular economy of compost in their plan to force municipalities to agree doing it or by giving funds to stimulate the incorporation of this project. Plus, in order for this to be beneficial in Europe, it is mandatory to be quality controlled otherwise farmers will not use it and might cause problems with legislation. This means that the pesticide amount, N immobilization, weed content, potential toxic elements, pH, organic matter and other nutrients should all be regulated and measured so (local) farmers know what they put into their soil. This also means a lot of organization and creation of new jobs in order for it to be well-monitored. Of course, a good marketing strategy should be elaborated.

Why promote small scale farmers first?

It is important to support local production and smart scale farmers because most SOM in soils is lost by small farmers because they cannot afford fertilizers. Furthermore, the distance of transport of material will be reduced, decreasing CO2 emissions.
Afterwards, competition will maybe induce bigger scale farmers to use it too.

How encourage farmers to use compost?

Farmers should be better informed about compost standards and how well monitored composts is beneficial for their soil. Below a reminder of the benefits of compost:

1) Source of organic matter, nutrient rich, retains water
2) Sink for greenhouse gasses: about 1500 Pg of carbon is stored in soils, which is about three times that of vegetation (560 Pg) and twice the amount in the atmosphere (760 Pg). Soils are also sinks for other greenhouses like nitrous oxide and methane.
3) Produces same level soil organic manure in half the time as farmyard manure and using less material
4) Makes the soil structure more resistant (high lignin content)
5) Reduces use of inorganic fertilizers
6) Repeated application over time increases the soil's health. It's effective on the long scale.
7) Enhances microbial activity

These arguments lead to a greater yield potential.

Furthermore, based on interviews with farmers and based on scientific research, composts of different qualities should encourage farmers to use the composts (See the interview in

appendix with *Pierre Ulrich, Coordinator of the Association Eisenia*). For example, leaves are known to be very nutrient rich whereas kitchen waste like coffee grounds are full of nitrogen and calcium (Rodale institute, 2019). Plus, the paper studied previously tackling the properties of different composts. Hence, 3 different compost bins could be installed in every quarter of every city: one for biowaste (leaves), another one for wood and cardboard and finally one with only kitchen waste (peels, egg shells etc.; figure 7) It would look like in the picture below. It is impervious that the bins should be well closed against rain or cats and other animals because that can disturb the good quality of compost.

Figure 7 Potential composting bins

Conclusion and Discussion

In our research we encountered several problems currently going on. First, we had difficulties contacting the big brands of supermarkets. Our main goal was to understand the situation and learn if our concept could be implemented. Yet, every time food waste was mentioned the supermarkets turned us down. Therefore, we concluded that this reaction to discussing food waste should also change. It is not only about shaming, supermarkets have also a lot of experience that can be shared in order to improve the system and we would like to highlight this. Secondly, we also learned that municipalities are not willing to fund such projects as is the case in France (Lyon) and in Romania. Finally, compost is not quality controlled, therefore farmers are very sceptic to use city compost. However, as explained in this paper, if compost were to be quality controlled and incorporated in the daily habits, it could potentially increase awareness about soil health and make our soils healthy again.

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APPENDIX (INTERVIEWS)

Study case composting association Lyon (France) and difficulties they encounter:

Interview with Pierre Ulrich, Coordinator of the Association Eisenia

Eisenia Lyon is an association created in 2013 which consists of citizens with various backgrounds like engineers, social animators or even landscape architects. The goal of this association is to implement sustainable projects concerning ecology, economy and society. This association is currently working on reducing waste, focusing on installation of vermicompost all around Lyon to boost citizens to separate their biowaste. In 2020, they are going to propose to the municipality of Lyon their "Plan B" again, a solution that would collect and process biowaste of houses, restaurants and markets, via vermicompost.

1. "Plan B" is a project you've been working on for several years, can you tell me about "Plan B"?

It's a plan about installing composts a bit everywhere, either agricultural, urban or collective ones. We tested composting processes on different scales and so now we know it's easily applicable. The idea behind this project is to assemble all this knowledge we gained and install different compost all over Lyon in order to limit biowaste.

2. Are there already composts installed in Lyon?

   Yes, we have like 60 vermicompost's installed right now, either in flats or restaurants. Only 3 are on agricultural terrain, for small scale farmers.

3. How does vermicomposting work?

   So, vermicomposting is the decomposition of biowaste by earthworms. In the city, it's closed in order to keep the humidity in if it's warm and to prevent rats or other animals to enter the compost. In our vermicompost, the earthworms migrate horizontally, hence in a closed box. Vertical vermicompost is handful if you have limited space but you have to work with different levels and if it weighs a lot, it's not very handy. That's why we use vermicompost's with horizontal migration. Your vermicompost is constructed in 2 parts kind of. What you do is you add your organic matter using the top lid of 1st part of the vermicompost. Then, you want to use the compost, you stop using the top lid but start adding from the side of the vermicompost in the 2nd part, the earthworms will migrate from the 1st part into the second part. The 1st part of the vermicompost is mature compost and can be collected. It's a simple principle.

Figure 1 Vermicompost in Lyon (eisenia.org)

4. Where are your vermicompost's located and what happens of it?

   Places of easy access. In flats for example. We use our compost mostly for city use, like in small gardens.

5. I read that the city of Lyon doesn't respect the laws about the collection of biowaste, what can you say about that?

Indeed, since 2016 they implemented this law, but it's not respected. The biggest problem in Lyon, is the quantities of waste left on the street after the market. After the market, there are edible fruits and vegetables thrown on the ground, carboards and crates that can easily be reused. This is all collected and incinerated which is a pity because if we sort the waste, we could use it instead of burning it. This is legally not tolerable, Article 204 of "la loi Grenelle 2" states it is mandatory to sort biowaste. I think this law is going to be strengthen because of environmental pressure but we will have to wait until 2025 for its actual application in France.

6. How do you encourage people to do compost?

   It depends on the quarters, in some quarters it's very easy. Advertising through workshops and animation works well. We organize some sessions where citizens can learn to build their own compost. However, in others, those more in the outskirts, you really have to go door to door to explain the use of compost and subscribe.

7. How do you verify the quality of your compost? Presence of pollution?

   It depends on the places. In the flats, it's only the inhabitants of the flat who are going to use it, so it's more trustworthy. In other quarters, we indeed verify if there is for example no plastic in it. We're not doing it that precisely but maybe one day when it's really structured and actual jobs can be created, this could be done better.

8. I went to the market of La Croix-Rousse in Lyon and talked to farmers. They told me that they weren't ready to use this kind of compost because it's not only plastics the problem but also for example, fruits full of pesticides bought in supermarkets, that will be put into the compost and they don't want to use that for their soil. They don't trust the quality of the compost.

   Most farmers use pesticides so it shouldn't matter that much. However, studies have shown, earthworms take up nearly all the pesticides lowering the amount of undesired elements within the decayed organic matter. And even if there is still presence of small amount of pesticides, it's better than to use organic fertilizers because they are transported in big vehicles which pollute.

9. It could be interesting to test and norm the compost to reassure farmers. Did you contact any farmers?

   Only some small-scale farmers but maybe one day the big producers will be open for it.

10. With my team, we thought to attract the attention of farmers to use this compost we can maybe label the compost, grade it or give it different qualities because every soil is different.

    Yes, compost based on just ashes, others just on fruits and vegetables, that would be interesting. But if you grade it, people might want only the good one.

11. Is it difficult to communicate your project with the municipality of Lyon?

Yes, really difficult. They all work "inside", I feel like they don't really have a notion of what's happening "outside". Maybe if we were a big company, they would help us fund our project but, it's difficult to be listened to. Citizens are ready to be involved but the municipality is not. It's been 7 years they keep on rejecting our plan to have funds.

Interview with Jane Gilbert, Vice Chair of International Solid Waste Association (ISWA)

"ISWA's declared mission is: To Promote and Develop Sustainable and Professional Waste Management Worldwide

ISWA achieves its mission through:

- *Promoting resource efficiency through sustainable production and consumption*
- *Support to developing and emerging economies*
- *Advancement of waste management through education and training*
- *Promoting appropriate and best available technologies and practices*
- *Professionalism through its program on professional qualifications."*

1. While we were researching the regulations on the food market, we got the impression that there is not a specific framework country can follow when it comes to retail waste. For example, France and Italy are implementing their own policies. Why isn't there a clear framework to be followed by the EU countries?

Article 22 sends a target from biowaste to be collected separately, so I think that is going to be a big driver and couples with the landfill directive as well, especially for some countries. It had a big impact on UK, about landfilling with biowaste, so that countries that rely on landfilling, now they will have an obligation to collect separately and now to reduce landfilling of the biodegradables.

- As I have seen on your website, you are working on waste management with people from all over the world, from different domains. In the light of this, how do you see this "fragmentation" in terms of EU regulations on food waste. What do you think it is needed in order to create a "minimal" framework that could be implemented?

  I think the problem is about interpretation of the current EU law by the different country members and the way it has been implemented in the different countries is very different. Different members are in different parts in the interpretation curve.

2. Do you think this fragmentation caused by the possibility of interpretation can be solved with clearer legislation?

I think Europe has the laws in place now thought the Directive, but with the Directive is up to each individual member to interpret how they will implement the requirements of that directive. So, it is potentially very powerful, I think it is by 2023 the requirement for separate collections will come in, which means that all the members from the European Union will have to separate the collection. So, how they will that will be down to how each nation decides. It is an obligation, so countries which not adept to it could be subject to infraction proceedings.

3.Supermarket food waste is mainly dealt with through donations to NGOs or food banks. However, a big part of the waste still ends up at the landfill, due to the expiration date. Our question is therefore, can there be partnerships between the supermarkets, the municipality and the farmers in a way that the organic leftovers are composted and then "given back" to the farmers as compost? Do you see that happening?

- What kind of framework is needed for that?(What about the transport?)
- Can municipalities provide the necessary steps: collection, transport, etc in order to achieve this?
- In one of our other interviews on the matter, we heard that municipalities get funding from the EU to deal with waste. Is that the case? If so, what is it that they usually choose to invest in and why?

It might be happened on other places around the world. I can give you the details of the program WRAP. They work with retailers, supermarkets and how the food waste/losses are dealt with.

4. In another interview we have found out that municipalities get funding to deal with the waste. For example, the city of Lyon, they had issues of implementing compost in the city, due to the refusal of the municipality. Therefore, we were wondering what kind of frameworks would make compost a priority for the municipalities? How can compost be more integrated in the city?

Now with the directive, that is going to get the attention of the municipalities. It doesn't tell them how to do it or when to do it, it just tells them that they have to collect biowaste, so it depends how they choose to deal with that. A lot of them also depend on local politics and costs. Also, provision of the waste treatment for example incineration and landfilling, so it is very much dependent on what they have in the locality.

5.Do you think that the current directive is putting a lot of pressure in order to have the goal happening?

I think it will be putting a lot of pressure on, because it is now a clear requirement for collection, so that is stated very clearly, a requirement for separate collection is very clearly stated. I think it will change on a macro level and how that is disseminated down to member states to different municipalities will be down to each individual country to decide for themselves, so I cannot comment how it will go down in each different country.

6. Regarding your mission, the ways of achieving your goals are mainly about educating, training and promoting.

- What are the main challenges when it comes to these?
- Are you mainly focusing on supporting experts or also on supporting the large public?

ISWA doesn't really get involved at involving the large public, we just have some projects, but it mostly deals with helping professionals doing their job. Communication campaigns are very different from San Paolo to Amsterdam to a small village in England, because the

populations are different, they all have different structures in place, waste collections, waste treatment facilities, so in terms of communicating with them it is very much down to each member to target it as they see it fit. There are a lot of examples, the Italians are doing a lot about food waste collections. In the year 2015 was the international year of soils, FAO did a lot of very good publicity, which was meant to be used by governments to help implementing food waste measures. They are all different, so the messages are very different as well.

Interview with Mr. Alexandru Tudose from The Institute of Permaculture, in Bucharest

The Institute of Permaculture from Romania is a platform of professionals and entrepreneurs from different domains (permaculture, engineering, economy, anthropology, horticulture, psychology, and environmental engineering) which develops and supports ethical eco-social projects. It sustains the practice of permaculture in Romania from a multidisciplinary perspective through research, consultancy, mentoring, education, and implementation of regenerative projects with a positive impact on the environment and communities.

1.Why is soil important for you?
From a farmer's perspective, plants grow better, healthier, you don't need that much mechanization and you don't need to intervene that much with fertilizers, as there will be a network of microorganisms doing the job for you. A healthy soil keeps water in, has micro-macro organisms and bacteria. An unhealthy soil raises the problem of feeding the whole population.

2. What is the most difficult problem you encountered when it comes to your soil?
The lack of knowledge regarding how we protect and invest in the soil. Soil is treated as support for growing plants and the other functions are negligible. Other problems are raised due to the lack of cover on soils. What I learnt from my permaculture course is 100% cover 100% of the time. When I was in Morocco, I saw the obvious effects of erosion and when I came back home, in Romania and I saw that after each rain, the weeds come immediately, I realized that we have techniques for weed control, but not for protecting against erosion.

3. What practices do you use to make soils healthier, to increase the organic matter?
In Romania, there is not a lot of regulation regarding the compost. Not many people are doing compost and the people who are doing it are using an old way of composting, due to the lack of knowledge.

4. What do you do to get compost?
To collaborate you must create a platform, which is costly, as any new big change. Especially if we want to switch from deep-till agriculture to minimal till. I see this process quite slow.

5. What about organic matter? How do you increase it?
The city has been built and rebuilt, therefore the soil in the urban farms of Bucharest is sandy, silty and coming from the construction sites, hard to cultivate as a new gardener, you need to bring something on the soil to make it fertile. It is the first step towards farming in the city. As the process of creating organic matter takes a long time, the first solution is covering the soil in order to not lose what you already have. The more

diversity, the better. However, the best solution is composting, putting back organic matter on the soil through different ways: food waste, animals or wastewater.
We can put ecological fertilizer, but if you don't cover it, it will leak away.If you mulch while doing intensive agriculture, a seedling system will not allow you to grow the whole year, as they don't have enough light.

6. When you talk about covering, do you refer only to mulching or do you also use cover crops or green manure for example?
Yes, there are some traditional techniques here, but again there is not a system or regulation. In Romania there is a problem with burning the rests from plants, even if it is illegal. There is not much composting, they usually use different types of fertilizers (eg foliar).

7. When it comes to the longevity of a soil and seeing the effects of long term, how do you assess the quality?
There is a sustainability assessment, where you calculate how much energy you put into soil and how much you get out, there is quite a lot of calculation. Agriculture is one of the most polluting domains and it is profitable, in Romania, because of government grants. It is sustained by a lot of actors, eg taxpayers. So, soil is also about politics and people. Another way is to measure the carbon stored and released. One of the "gurus" of permaculture used to say that when he sees a compost that is uncovered or that doesn't have enough carbon in order to fix the 3 times the N, he sees dollars in the atmosphere, as the fertility goes into the air.

8. What would you like to know about soil?
I would like to know more about the activity of the microbiology of the soil. I don't necessarily feel that I want to know more about the soil, I feel that it is enough to know some principles. The details regarding the microorganisms are my own curiosity, as I would like to know more about how to increase their activity.

9. You have a partnership with the supermarket, is it possible to collaborate also in terms of composting? For example, to make compost from the organic waste the big shops have.
Yes, it is possible. The big shops produce a lot of waste that can be composted. They have the capacity to separate it. At the end of the day they can have it in separate boxes for compost. It is just not their domain to process waste, therefore there needs to be some operators to process it. I don't see it very efficient/professional, even though it would be nice for them to open a site to process their waste. Their waste needs to be processed by the municipality. This is my point of view. I proposed to them to make a project, but it was quite complicated, and it doesn't make sense. Someone should go to them to bring the service and the municipality who has grants from the EU to implement zero waste solutions should come with this service. It would be to a larger scale, the same it is with plastic and paper. My opinion is that the infrastructure should be created as the supermarkets are ready.
For example, in Luxembourg, at a farm, they were putting paper (karton) on the soil and then they were provided compost made by the municipality. It would make it easier. We need to prepare the soil, to till, to seed quickly. They didn't have much trouble, only the seeds from the compost which were not much, as the compost was of good quality, which decreases the number of techniques of management.
The cost of transporting the waste is a lot. There was a project in Romania, where people were getting the compost from a supermarket and they were storing it in a

container, but they lacked the technology to create compost. At the end they managed, but for a long time the compost stayed uncovered.

10.Back to compost, what is your opinion about vermicompost?
We have vermicompost. We have 4 cafés next to us from where we get the coffee grounds. As for the food waste we take it from the block we live in. Just imagine that at each building there is a compost. Every building has a garden in Bucharest, both in front and on top, you could do a lot.