Kingdom of the Netherlands

Organic Waste Management in Algeria

Sector Analysis and Business Opportunities

A study by LONO

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1 Context

1.1 Total deposit of organic waste in urban areas

1.1.1 Composition of the waste

It is estimated that the total quantity of household waste that was produced in Algeria in 2020 is around 13.5 million tons. Demographic growth and urban development contribute to a large extent to the increase in quantity of waste produced; between 2016 and 2035, the production of household waste could double from more than 11 MT in 2016 to 23 MT in 2035 (AND 2020)[1]. Hence the concern of the public authorities to set up the most suitable systems for a more efficient management of waste.

The share of organic fraction in the total quantity of waste generated exceeds 50%. Results of a study in 2014 confirmed the predominance of the organic fraction, which represented 54.40% at the time, which justifies biological recovery (composting and anaerobic digestion) as a solution to reduce the quantities ending in landfills (AND 2014)[2]. Another study found contents of organics of up to 62% confirming the high-cost savings potential offered by bio-treatment methods (GIZ 2014)[3]. The results of the last field study in 2018/2019 confirmed that the organic fraction remains the most important fraction of the municipal solid waste, representing 53.61%, followed by plastic (15.31%), and the paper/cardboard (6.76%).

This data excludes the waste from agricultural and animal farming activities that is over 95% organic and managed outside the formal waste management framework currently in place.

1.1.2 Sorting System

Waste treatment and recycling have been important issues in Algeria since 2001. In that year the Ministry of Environment was founded and the national programme Progdem (Programme national de gestion intégré des déchets ménagers) was launched. The aim of the program was to stop uncontrolled dumping and the proliferation of landfills and to better organize the entire waste management sector.

Since that time substantial progress has been made, as the country went from unregulated collection and dumping to a system in which the urban cities collect more than 85% of the waste and the rural secondary towns between 65 to 70% for management in sanitary landfills (Centre d'Enfouissement Technique).

Although progress is evident, the system is not yet fulfilling its goals as sanitary landfills are filling up faster than expected and a lot of towns still did not benefit from the program and as a

[1] AND – Rapport sur l'état de la gestion des Déchets en Algérie – 2020

[2] AND – Caractérisation des déchets ménagers et assimilés dans les zones nord, semi-aride et aride d'Algérie - 2014

[3] GIZ - Report on solid waste management in Algeria, D-waste, consultant for Sweep-Net in cooperation with GiZ - 2014

result, continue to dump the waste in uncontrolled landfills, often within tens of meters of proximity to households.

Sorting of mixed municipal solid waste into its organic and other recyclable fractions has not yet been implemented as far as we have seen during the study.

1.1.3 Organic Waste Management in Urban areas

The potential of the organic fraction of municipal solid waste has long been demonstrated, though its separation and valorisation is yet to be implemented at scale in Algeria. Annually, barely 1% of the organic fraction of municipal solid waste is recorded as ending up in a composting process. The field of green waste recovery in Algeria is limited to a few pilot projects and experiments conducted by operators, citizens, and environmental associations.

One example of organic waste treatment and composting in Algiers involves the processing of green waste from parks and other public spaces. The project is operated by an "EPIC", Établissement Public à Caractère Industriel et Commercial, named EDEVAL (Etablissement de Développement des Espaces Verts de la Wilaya d'Alger) and that is mandated by the Wilaya (the administrative subdivision including the centre of the city Alger and its districts) for this commercial activity.[4] This company, responsible for the green waste produced in the whole city, has access to thousands of tonnes of branches, leaves and flowers that it converts to compost for use in its own nurseries and for sale. The price of the compost was recently brought down from 40 000 Dinar / ton to 25 000 Dinar / ton.

1.2 Agriculture in Algeria

Agriculture is an important sector of the Algerian economy. It covers most of the country's territory and takes up over 90% of the existing 1,541 municipalities. It provides employment (direct or indirect) to 13 million Algerians living in rural areas. In addition, the sector provides employment in the transport and trade sectors as well.[5] In total, Algeria has more than 41 million hectares of agricultural land.[6]

Over the past two decades, there has been a noticeable growth in agricultural activity ranging from irrigated potatoes to the growth of a horticulture sector producing tomatoes, chilli and other vegetables in greenhouses. Not only has the total Utilized Agricultural Area (UAA) increased, also the production per hectare shows a strong boost. This corresponds to a growth in the use of manure (between 400 000 and 600 000 T / year in the Wilayas of El Oued and Biskra), that is applied directly on the land.

[4] https://edeval.dz/index.php/nos-missions/compostage-des-dechets-verts

[5] https://www.fao.org/family-farming/countries/dza/en/

[6] https://www.g-fras.org/en/world-wide-extension-study/africa/northern-africa/algeria.html

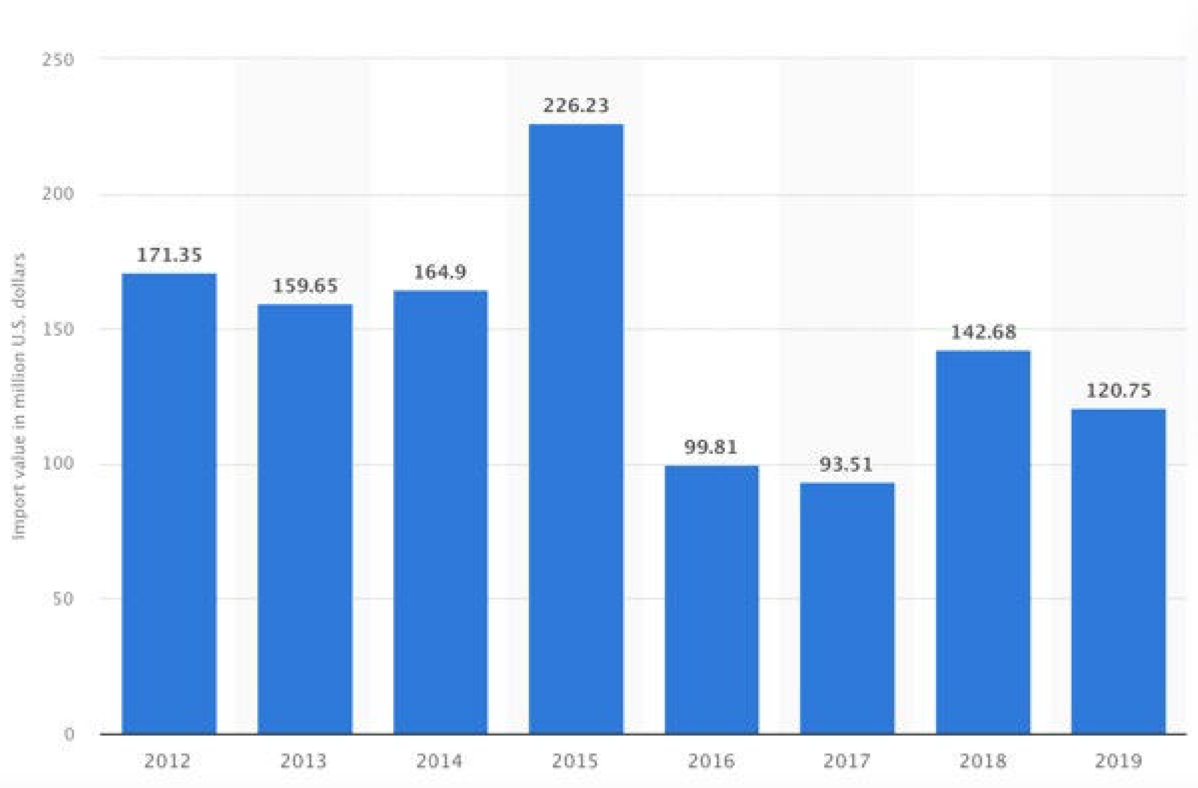

Figure 1 Evolution of annual imports of chemical fertilizers (N-P-K) in Millions USD

Despite the increased agricultural production, the country remains a major importer on the global market of grains/cereals, sugar and dairy products mainly concentrated milk. The current government's policies place an emphasis on increasing the portion of local production of food products. As a result, the consumption of fertilizer is expected to grow.

1.2.1 Staple crops

Cereals occupy a strategic place in the food system and the national economy. From 2000 to 2009 as well as from 2010 to 2017, the area occupied by cereals was 40% of the total UAA. From 2000 to 2009 the total area was estimated at 3 200 930 ha. Durum wheat and barley occupy the major part with 74% of the total cereal area and represent 51% and 29% respectively of total cereal production on average for 2010-2017. From 2010 to 2017, this area increased with 6% and reached an average of 3 385 560 ha. Production during the period 2010-2017 is estimated at 41.2 million quintals on average, an increase of 26% compared to the decade 2000 to 2009 for which production is estimated at 32.6 million quintals on average. A large fraction of national consumption is imported to complement the local production.[7]

1.2.2 Horticulture

The total area reserved for horticulture increased with 44% during the period 2010-2017, compared to the period 2000 to 2009. At the same time a significant increase, 121%, of

[7] http://madrp.gov.dz/agriculture/statistiques-agricoles/

productivity per hectare was measured. For example, the production area of potatoes and onions, which account for more than 36% and 12% of vegetable production, recorded an increase of 68% and 35% respectively. The total production of potatoes and onions increased with 143% and 102% respectively. In addition, the production of tomatoes experienced a strong increase, as yields increased from almost 20 t/ha during the period 2000 to 2009 to more than 50 t/ha in 2010-2017. [8]

Tableau 1 Different systems for production vegetables practiced in El Oued and Biskra region

Système maraîcher / **Caractéristiques**	**Mobile « front pionnier »**	**« Fixe intensif »**	**« Hyper intensif »**
Type de serre	100 à 240 serres tunnel (400 m²)	40 à 50 serres tunnel (400 m²)	Serres canariennes (1 à 6 ha)
Systèmes de culture	Maraîchage sous serre sans rotation pendant 3 ans, puis conversion en palmier dattier par le propriétaire	Maraîchage sous serre en rotation avec cultures de plein champ irriguées (fèves, maraîchage, céréales)	Maraîchage sous serre à forte densité (palissage) sans rotation
Acteurs	Production confiée à des locataires, qui investissent dans des serres et s'associent à des métayers	Les serres appartiennent aux propriétaires qui s'associent à des métayers	Les serres appartiennent au propriétaire ou au locataire ; ceux-ci s'associent à des métayers
Région	Ouest	Est et Ouest	Est
Revenu brut/ha/ saison	Propriétaire : 5 400€ Locataire : 54 000€ Métayers : 13 500€	Propriétaire : 54 000€ Métayer : 13 500€	Propriétaire ou locataire : 90 000€ Métayers : 22 500€

Three systems of greenhouse horticulture in Biskra.[9]

1.2.3 Orchards

The area covered by orchards counted ± 400 000 ha during the period from 2000 to 2009. Olive production covered 39% of this area, fruit trees 30%, date plantations 23% and citrus fruit trees 8%. This area increased during the period 2010-2017 by 47%, with the biggest increase in olive orchards. [10]

Other crops grown in orchards include nuts, such as almonds and pistachios, and fruits, such as apple, that also receive fertilizers and generate a high value per hectare for the growers.

[8] http://madrp.gov.dz/agriculture/statistiques-agricoles/

[9] https://agritrop.cirad.fr/578839/1/2015%20Daima%20Naouri%20et%20al.pdf

[10] http://madrp.gov.dz/agriculture/statistiques-agricoles/

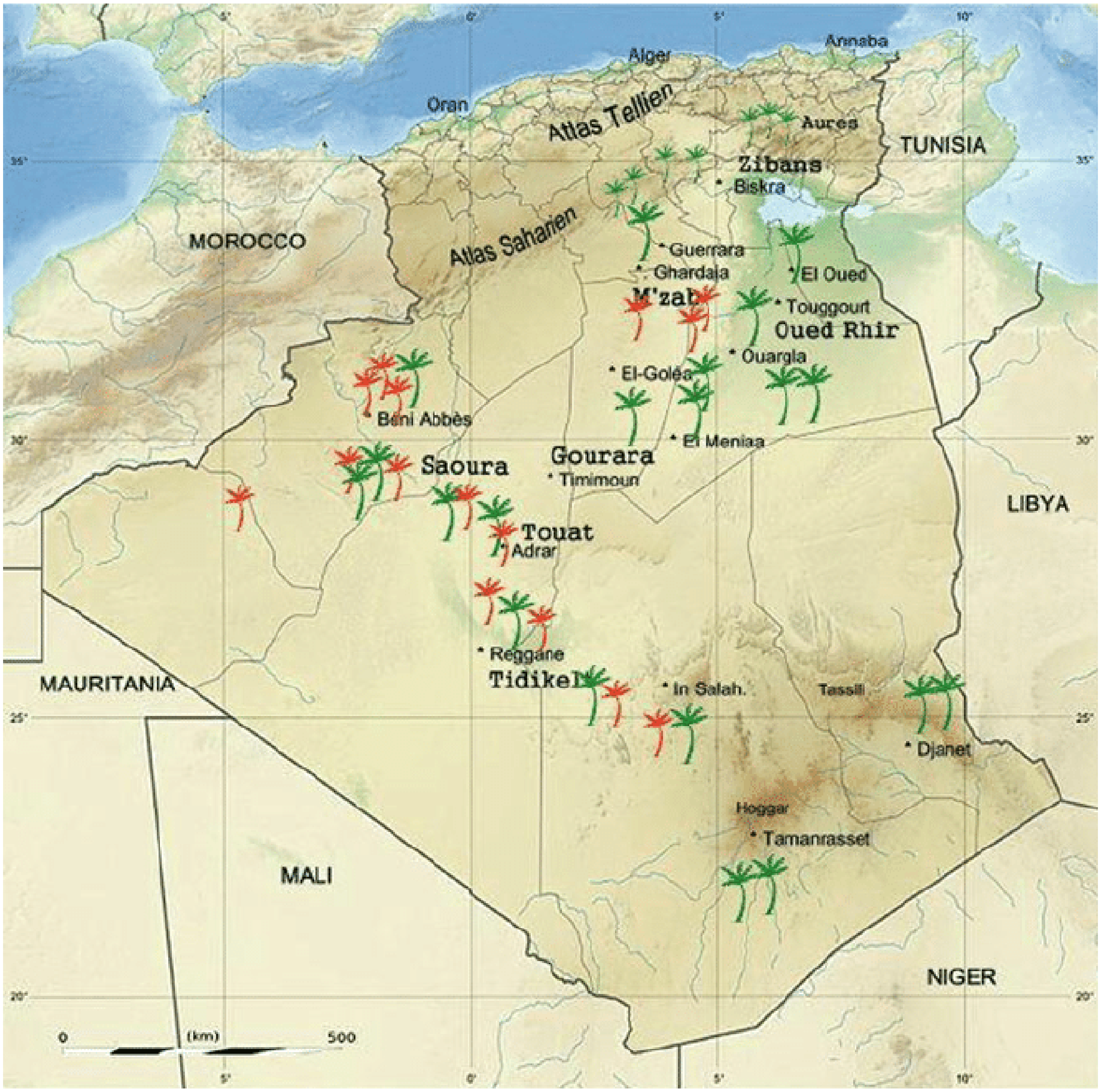

Figure 2 Map of Algeria indicating the different areas with date palms; those in red are bayoud infested, those in green not infested[11]

1.2.4 Livestock

Livestock (excluding poultry) includes five main species: cattle, sheep, goats, camels, and horses. The total number of livestock, during the period 2000 to 2009, was estimated at 24.5 million heads (over the total of the 10 years), for 2010 -2017 this number increased to 33.6 million heads, i.e. a growth rate of 37%. Sheep are the most common livestock (78%), followed by goats (14%).

[11] N. Bouguedoura Research Laboratory of Arid Areas (LRZA)

A second source estimates the sheep herd of around 19 million head, occupying an important place in Algeria. In addition to its contribution of more than 50% to the national production of red meat and 10 to 15% to the agricultural gross domestic product, sheep farming plays an important socio-cultural role. It is practiced in the different climatic zones of Algeria, from the Mediterranean coast to the oases of the Sahara. This pedoclimatic diversity offers Algeria an extraordinary diversity of sheep breeds, with eight breeds characterized by remarkable hardiness, adapted to their respective environments. [12]

Cows and sheep produce respectively 30 and 3 kg of manure daily. Chicken, on the other hand, produce approximately 80 - 120 g per day. Manure of these animals is often sold by middlemen to be used as inputs for the production of fruits and vegetables. The total annual production of manure from sheep and goats is estimated at 19 - 30 million tonnes per year. Part of the feed for this livestock, like barley and grazing, is produced locally. A portion of the required barley is imported.

The country counts approximately 12 million heads of poultry for which most of the feed, mostly corn and soybean mill, is imported. This imported protein, rich in nitrogen, is currently recycled in soil as manure.

1.3 Transition to a circular economy model

The current model is anchored on the importation of minerals in the form of N-P-K fertilizer or animal feed to produce fruit and vegetables that are consumed locally or exported. The waste from these value chains ends up in landfills and a proportion of the animal manure is recycled for vegetable production. However, the biowaste from agriculture is not being recycled and as a result, the primary input of minerals is imported.

1.3.1 Current linear model agricultural and animal produce

In the current approach, the minerals needed as fertilizer for the agriculture sector comes from two sources:

1. Imports of N-P-K (100 000 T / year)
2. Animal manure (first through animal feed)
    - Imports of corn, soybean meal and barley (>5 000 000 T / year)
    - Local production of barley
    - Grazing

The output of the agricultural production is primarily for the local market:

- Potatoes
- Dates (>90% for the local market)[13][14][15]

[12] http://madrp.gov.dz/agriculture/statistiques-agricoles/
[13] https://www.statista.com/statistics/1182035/production-volume-of-dates-in-algeria/
[14] https://www.iraqi-datepalms.net/assets/uploads/2019/06/دراسة-تحليلية-للتمور-الجزائرية-المصدرة.pdf
[15] https://maghrebemergent.net/exportation-de-la-datte-pourquoi-lalgerie-subit-encore-laffront-tunisien/

- Vegetables (Tomatoes, Zucchini, cucumber, Chilli, Bell pepper, Onions)
- Cereals (Wheat, Barley)
- Olives

In a linear model, new raw material is continuously needed to feed the production system. Figure 3 illustrates the flows of nutrients from the imported and local sources into the agricultural sector and its end of life as solid waste going to landfills or as wastewater sludge. The minerals in the waste are lost and never return to the production cycle.

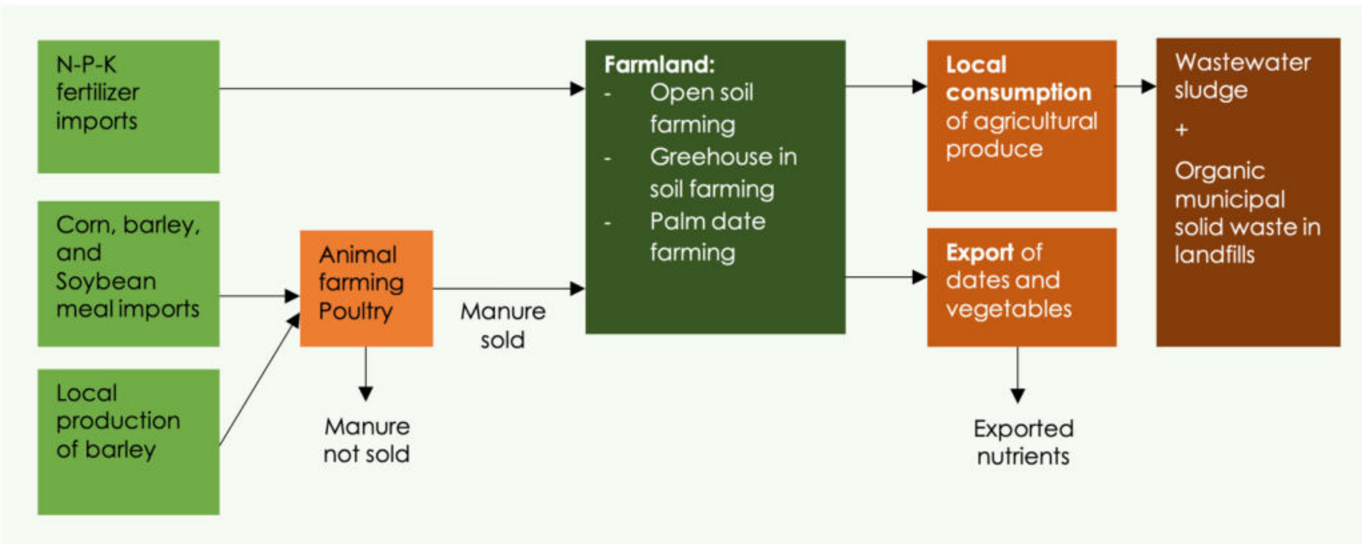

Figure 3 Illustration of the nutrient flows between local and imported sources to become an input for agriculture for the fertilization and ultimately waste

1.3.2 The alternative circular economy model

One alternative to the predominant linear economy model is the circular economy model in which the reusable parts of the waste are recovered and sent back into the production system as a raw material.

One of the main priorities of the Dutch government is to promote and support a transition towards a circular agricultural sector, which aims to close the nutrient cycles by recycling the minerals in organic waste. This approach has additional benefits such as improving soils and water quality and reducing emissions and pollutants.[16] This circularity has been illustrated by the Netherlands Environmental Assessment Agency (PBL) as shown in Figure 2. The Figure shows the streams after the consumption going through a process to recover the nutrients and feed the natural systems that support agriculture.

[16] https://www.government.nl/ministries/ministry-of-agriculture-nature-and-food-quality/documents/policy-notes/2019/11/30/plan-of-action---supporting-transition-to-circular-agriculture

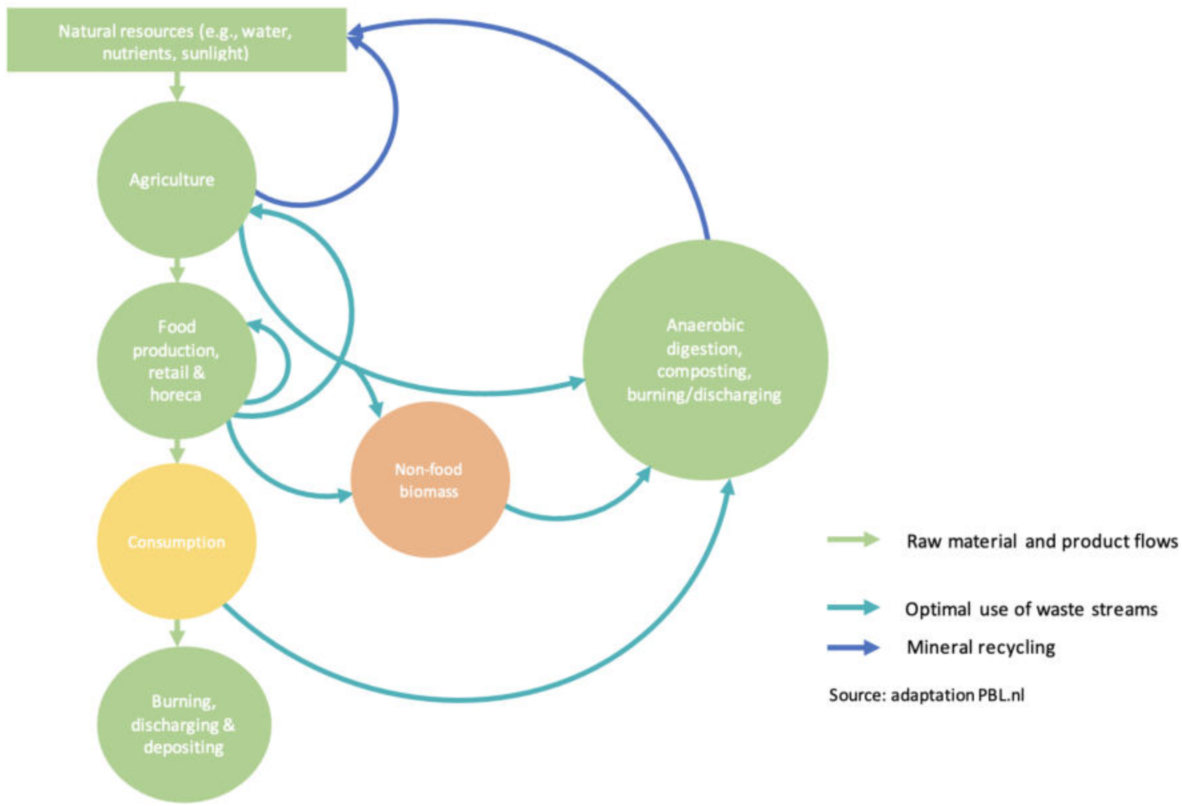

Figure 2 Diagram illustrating a circular economy model using organic waste as a resource

1.4 Composting of manure and OMSW for production of biofertilizer as low hanging fruit

The section 1.3 presents the current linear model and the target circular model. Given the reliance on imported N-P-K fertilizer and animal feed, the local recycling of the nutrients contained in the waste from agriculture and animal farming is a low hanging fruit for the transition to a circular economy.

The numbers underpinning this potential are:

- The country imports approximately 100 000 T every year of N-P-K fertilizer
- Only 1% of the organic waste is recorded to end up in composting activities
- In the Wilayas of Eloued and Biskra alone, over 400 000 T of animal manure is used every year as a fertilizer in the horticulture and palm production
- Animal manure is transported up to 800 km from where manure is produced to the agricultural regions

1.4.1 Aerobic fermentation (composting process)

The most basic process to stabilise and prepare organic waste for addition to the soil is composting or aerobic fermentation. The output is an organic matter rich product (between 20 – 45% organic matter) containing up to 7% macronutrients made up of N-P-K-Ca-Mg. The concentration of the different nutrients depends on the composition of the initial biomass however an average composition of the 5 macronutrients is respectively (1,2 – 0,3 – 0,9 – 1,5 – 0,4).

Composting is a process in which micro and macro-organisms break down organic molecules in the presence of oxygen and moisture. The result is compost, a stable organic material that only slowly decomposes to form humus. Due to this high content of stable organic matter, compost serves as quality improvement for the soil structure and provides nutrients that are mineralised slowly over 6 – 36 months depending on the climate and soil conditions such as pH and soil biodiversity.

Micro-organisms such as bacteria, fungi, protozoa, convert organic matter into CO_2 and water through oxidation. Depending on the starting material (e.g., N- and S-compounds present) and the aerobic conditions, several residual gases are produced, such as ammonia and volatile sulphur containing compounds. Non-biodegradable organic and mineral fractions remain unchanged in the final material. In simplified form:

Organic waste (C-H-O-N-S-P-K-Ca-Mg) + O_2 → CO_2 + H_2O + Compost (C-H-O-N-S-P-K-Ca-Mg) + residual gases (NH_3, H_2S, CH_4, CO) + energy

Energy released during the decomposition process goes partly to the microorganisms' metabolic processes and the creation of new biomass. Though, most of it is released as heat increasing the temperature in the composting material. This increase causes water to evaporate from the material as well as the death of unwanted pathogens and deactivation of weed seeds.

The mass and volume of the organic matter used as raw material for the composting is reduced to around one-third of its original value due to the evaporation of water and the decomposition of organic material. Besides microbiological breakdown of the material, pure chemical reactions occur during the composting process. For example, microbial decomposition products are transformed into humic acids. These give the compost its typical dark brown colour and contribute significantly to the soil-improving qualities of the compost formed.

The composting process consists of 2 phases that gradually run into each other: the thermophilic phase and the maturation phase. The duration of the entire composting process depends on the starting material, the desired characteristics of the compost and the technical characteristics of the installation. It may vary from a few days or weeks to several months.

1.4.1.1 Thermophilic phase

In the first phase of the composting process, the easily degradable fraction such as fats, soluble and sugars are converted rapidly to simpler molecules. As a result, the microbial decomposition process is fast and the temperature quickly rises to 70 °C and above. As microbial activity declines with temperatures above 65 °C, decomposition slows down, and the temperature stabilizes at a maximum of 55 to 65 °C.

1.4.1.2 Maturation phase

When the fraction of easily degradable material decreases, the decomposition process slows down, and the temperature gradually drops to around 40 - 45 °C. This is when the compost enters the ripening phase where specialized micro-organisms, mainly fungi and actinomycetes take over. These organisms break down the slowly digestible fractions, such as cellulose-rich and woody materials. At the end of this process, the temperature drops to 35°C.

1.4.1.3 Process parameters

The aim of composting is to create such conditions that microbial degradation proceeds optimally. To assure this, oxygen content, moisture content, structure, temperature, C/N ratio and pH need to be regulated.

1. **Oxygen content:** Oxygen is consumed by the microorganisms during the composting and therefore it needs to be replaced. If the oxygen concentration in the pile of waste being composted drops too low, the fermentation process slows, resulting in incomplete oxidation of carbon compounds. Fatty acids and other low-molecular organic acids are formed, causing a drop in pH, and increasing anaerobic decomposition. The proportion of residual gases such as Ammonia and methane increases.
2. **Moisture content:** All of the microbial activity involved in composting takes place in the moisture of the interstitial space between the particles**.** A moisture content that is too high leads to oxygen deficiency, a moisture content that is too low reduces microbial activity. The optimal moisture is somewhere between 35 and 65% in the interstitial spaces. Sludge streams that are mixed in must therefore be dewatered beforehand and thin manure streams thickened or dried.
3. **Structure:** For a good oxygen supply, it is important that the material to be composted is sufficient porosity, 25 to 35%. The addition of coarse structural material, e.g. wood chips, bark, straw, horse manure, etc. can improve this structure. In manure, gypsum is sometimes added to flocculate the colloidal substances and improve the mixture's accessibility to air.
4. **Temperature** The composting process generates its own heat and proceeds optimally at a temperature of 50°C to 65 °C. A too high temperature inactivates a large part of the micro-organisms. On the other hand, a sufficiently high temperature is needed to kill germs and weed seeds. In most cases, this would require a temperature of 55-60 °C for 1 to 3 weeks. Therefore, in intensive composting, one usually controls the process at a

temperature of 50-65 °C, through forced aeration. For highly heat-resistant pathogens such as tobacco mosaic virus (TMV), a longer composting period is required for complete eradication. For TMV, this is e.g. 3 to 7 weeks in case of organic composting and 6 to 11 weeks in case of green composting. The European Animal By-products Regulation requires a minimum of 1 hour at 70°C for manure. For professional composting, the temperature needs to be monitored throughout the process.

5. **C/N ratio:** A C/N ratio of 25-35/1 at the beginning of the composting process is usually considered optimal. When the C/N ratio is too low there is a carbon deficiency and nitrogen might be lost as ammonia gas or ammonium or nitrate salt in the leachate. For this reason, it is important to add carbon-rich material such as straw, wood shavings, roadside grass when composting manure. Furthermore, additives such as bentonite or zeolite can be added to reduce the emission of ammonia by absorption. A too high C/N ratio, on the other hand, limits the growth of micro-organisms due to N deficiency, which in turn prevents complete composting.
6. **pH:** The initial phase of the composting process is accompanied by the formation of organic acids and a drop in pH. Later in the process, the pH will rise again due to the decomposition of organic acids and the alkaline effect of inorganic salts. The pH of mature compost is usually neutral or slightly alkaline.

1.4.1.4 Open air composting (Passive aeration)

This is the most common technique for composting green waste and small-scale composting initiatives such as farm composting. The input material is set up in open air in heaps of 1.5 to 4 meters, on a concrete surface, remaining there for several months. The leachate water and polluted rainwater is collected in a water basin. The aeration in this type of systems is passive without any mechanical aerator.

- Triangular heaps of approx. 2.5 m high and 2.5 to 3 m wide, with driving paths in between. The relatively large outer surface ensures good aeration though regular turning is necessary to expose all the material to sufficiently high temperatures. Weather influence can be limited by covering the heaps with semi-permeable cloths.
- Trapezoidal heaps about 3 m high and with a foot width of 10 m or more. They take up less space than rills and the outer surface is smaller, which makes them less sensitive to weather.

The oxygen level is increased by frequently turning the pile from once a week to once every 8 weeks. Usually, the frequency of turning decreases further in the composting process. The purpose of turning is:

- Oxygen supply
- Improving the structure
- Mixing of moist/dry, nutrient-poor/nutrient-rich material

- Cleaning compost and killing off weed seeds over the whole compost heap

Timing of moistening the compost heap is done based on experience, a measurement of the moisture content, or a "squeeze test". To moisturize the material homogeneously it is advised to spray during the turning stage. Wastewater, including leachate water, condensate water or polluted rainwater from the composting process is most often used. In the final stage of the process, humidification is no longer necessary as the aim is to achieve a maximum of 30 to 45% moisture in the final product.

1.4.1.5 Heap composting (Forced aeration)

The heaps with a height of approximately 2 to 4 m are in a closed hall and are oxidized via an aeration floor. The heaps are weekly turned, moistened, and forcibly aerated. The aeration floor may consist of a network of perforated tubes or of a grid with an aeration cell underneath. The input material is typically set up in an elongated table heap, consisting of several 'fields'. With each turnover, the composting material moves to the next 'field'. The air from the hall is extracted and partly reused for aeration.

1.4.1.6 Tunnel composting (Forced aeration)

Composting takes place in rectangular concrete tunnels with a length of 30 to 40 m and a height and width of 3-5 m. Filling takes place using a wheel loader or an automatic conveyor belt system. During composting, the material is moistened and intensively aerated via an aeration system, with automatic climate control. Conversion of the material does not take place during the stay in the tunnel. However, 2 or more composting cycles can be carried out. The material is then taken out of the tunnel and, after mixing and possibly moistening, is taken into another tunnel (re-tunnelling).

Photos 1 Heap composting using tractor pulled compost turners

Photos 2 Heap composting using loaders to move the windrows

Photos 3 Closed composting platform where gas emissions can easily be captured and cleaned

1.4.2 Anaerobic fermentation (Anaerobic digestion process)

Anaerobic fermentation, is entirely driven by microorganisms that convert the organic matter to a stable compost containing the nutrients along with a methane rich biogas in 4 stages:

- Hydrolysis
- Acidogenisis
- Acetogenisis

- Methanogenisis

These four stages result in a stable organic digested product that contains almost all the nutrients in the original waste and that has proven agronomic potential. Another product of anaerobic digestion is a methane rich gas called biogas that can be used to cover the energy needs of the process.

Organic waste (C-H-O-N-S-P-K-Ca-Mg) + Bacteria → Methane (CH_4) + Carbon Dioxide (CO_2) + Digested organic matter (C-H-O-N-S-P-K-Ca-Mg) + Residual gases (NH_3, H_2S, CO, H_2O)

1.4.2.1 Process parameters

The aim of anaerobic digestion is to create such conditions that microbial degradation proceeds optimally. To assure this, pH, C/N ratio need to be regulated.

1. **pH:** Anaerobic digestion requires a neutral pH. As a result, the pH of the feed mixture needs to be known in order to adjust the total amount added daily and avoid an excessive drop in pH in the digester.
2. **C/N ratio:** A C/N ratio of 25-35/1 at the beginning of the anaerobic fermentation process is usually considered optimal. When the C/N ratio is too low there is a carbon deficiency and excess of ammonia in the solution to inhibit the fermentation. A too high C/N ratio, on the other hand, limits the growth of micro-organisms due to N deficiency.
3. **Presence of active bacteria:** Having sufficient active bacteria to perform the different stages of decomposition is a prerequisite for efficient anaerobic digestion. Anaerobic digesters are therefore seeded with an active sludge.

Photos 4 Biodigester for the anaerobic fermentation of green waste into compost

Photos 5 Spreading of the digestate (liquid output of an anaerobic digestion process) into the land

2 Business opportunities for the use of organic waste in agriculture

The promotion of an organic waste recycling sector thrives under the listed conditions:

- Excess biomass is generated with varying C/N ratios
- Steady demand for organic fertilizers and organic soil improvement solutions
- Logistics companies and infrastructure that reduces the cost of moving large volumes of organic waste and biofertilizers between the production hubs and the consumption hubs
- A legal framework is in place that obliges or incentivises the proper management of organic waste
- Access to finance for entrepreneurs in the green sector
- Certification agencies that control the quality of organic fertilizers and label products with a reduced consumption of chemical

2.1 Biomass potential from the agricultural value chains

The primary value chains looked at during the study as producers of green waste are date palms and pruning of vegetable greenhouses.

2.1.1 Date palm production

The date palm production requires annual pruning of the trunk and palm leaves. This pruning produces between 7 – 10 tons per hectare planted. With an estimated farmed surface of 169,380 ha, the total biomass available is between 1 – 1,5 Million tons. [17]

Unfortunately, this abundant biomass has a C/N ratio in the range of 200 which makes it unsuitable for biofertilizer production without the addition of more mineral (nitrogen) rich waste.

[17] Bouguedoura Nadia, et al. 2015, Date Palm Status and Perspective in Algeria

Photos 6 Biomass from the pruning of palm dates

Photos 7 Powdered waste from palm dates

2.1.2 Vegetable production (pruning)

Renowned for its production of high-quality dates (the Deglet Nour variety), the Biskra region has experienced rapid development of greenhouse horticulture, from 1,370 ha in 2000 to 3,524 ha in 2013, to 6000 ha in 2018. [18] [19]

[18] https://agritrop.cirad.fr/578839/1/2015%20Daima%20Naouri%20et%20al.pdf

[19] https://www.agroberichtenbuitenland.nl/landeninformatie/algerije/achtergrond/bedekte-teelten_sp

With a production of 2 – 3 Tonnes of vegetative biomass per cycle, the available nitrogen rich biomass can be estimated at 14 000 Tonnes per year assuming that there are 2 production cycles per year.

Photos 8 Green waste from pruning of crops grown in greenhouses

2.2 Regulatory framework

2.2.1 Urban domestic and industrial waste

Institutional framework

According to the law 01-19 on management, control and disposal of waste, two ministries are directly involved in the management of municipal waste

1. The Ministry of Environment and Renewable Energy (MEER) through its various instruments. The institutions that fall under the MATE:
    - The National Waste Agency (AND)
    - The National Conservatory in Environmental training (CNFE)
    - The Environment Directorates of the 48 Wilayas

2. The Ministry of Interior and Local Authorities and Regional Planning (MICLAT) gives financial support to the wilaya's. The MICLAT is responsible for implementation of the national program Progdem. [20]

Other ministries that are involved in the field of waste management are the Ministry of Fisheries and Fishery Resources for marine waste, the Ministry of Health and Hospital Reform, for hospital waste, the Ministry of Industry, for special and hazardous special waste, and the Ministry of Agriculture for phytosanitary waste.

[20] https://www.rvo.nl/sites/default/files/2018/06/Business-opportunities-in-waste-management-in-Algeria.pdf

The country profile published by GIZ on the waste management sector in Algeria, although dating back to 2014, gives a good overview of the legal and institutional framework.[21]

Legal framework

- Law No. 01-19 of 12/12/2001 relating to the management, control and disposal of waste, defines the basic principles that lead to an integrated waste management, from their generation to their disposal;
- Law No. 03-10 of 19/07/2003 on the protection of the environment and sustainable development sets out the general principles of a rational environmental management;
- Law No. 04-20 of 25 December 2004 on the prevention of major risks and disaster management in the context of sustainable development clearly defines the responsibilities of each actor involved in the field of prevention in industrial areas and centers.
- Law no. 85-05 of 16/02/85, as amended and supplemented, relating to the protection and promotion of health;
- Law no. 87-17 of 01/08/87 on plant protection, including Title IV;
- Law no. 01-19 of 12/12/2001 relating to the management, control and disposal of waste, defines the basic principles that lead to an integrated waste management, from their generation to their disposal;
- Law no. 03-10 of 19/07/2003 on the protection of the environment and sustainable development, sets out the general principles of a rational environmental management;
- Law no. 08-16 of 3/8/2008 on agricultural orientation;
- Law no. 09-03 of 25/02/09 relating to consumer protection and fraud prevention;
- Executive decree no. 95-405 of 2/12/1995 on the control of pesticides for agricultural use, as amended and supplemented by Executive Decree No. 99-156 of 20 /07/1999;
- Executive decree no. 06-104 of 28/02/2006 on the nomenclature of waste (Annex III), it classifies wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing as well as those resulting from the preparation and processing of food.

Financial provisions and cost recovery

- Infrastructure funded primarily by the State;
- Management fees partially funded by the junk removal tax, fixed between 500 and 1000 AD / household;
- Cost recovery: Supported by the common fund of local authorities (FCCL);
- Average cost of treatment and disposal: between 1500 and 2000 AD (excluding depreciation).

[21] https://www.retech-germany.net/fileadmin/retech/05_mediathek/laenderinformationen/Algerien_RA_ANG_WEB_0_Laenderprofile_sweep_net.pdf

Private sector participation

- The private sector is absent, with the exception of the transport of agricultural waste (green waste and waste from fruits and vegetables) to landfills.

Since the new government was installed in 2019, new measures have been put in place for start-ups and foreign investment in Algeria. Until 2019, the participation of a foreign investor in an Algerian company was limited to 49% and foreign contractors are forced to find local partners for public tenders. Today the government promotes private investments to the country by simplifying the rules and regulations for foreign investments. This change was symbolised by the first investment conference which focused on the attraction of foreign investment to Algeria on the 6th and 7th of November 2021.

2.2.2 Dedicated support for seed stage companies

A dedicated Ministry for start-ups was appointed and the current government is creating an environment in which it is easier to create a new business. To do so, in 2020 three different business type labels were put in place: the “innovative project” label, for entirely new companies with an innovative idea, the “start-up” label for young companies that meet a specific number of criteria and the “incubator” label, for structures aiming to guide and support start-ups (www.startup.dz). These enterprises benefit from tax reliefs such as 0% taxation on profits during the first four years, instead of 28% for regular businesses. Also, a better link is created between investment funds and these young businesses by the creation of the Algerian start-up fund. Today, six Algerian banks are investing in the fund.

2.2.3 Role of the Centre d’Enfouissement Technique (CET) in Municipal Solid Waste management

Since 2001, the Algerian government has made the choice to eliminate waste by landfill, it has thus launched an ambitious program of Technical Landfill Centers (CET) throughout the national territory. One of the objectives of PROGDEM is to coordinate the transition from the traditional way of waste disposal by illegal landfill to a method based on technical landfill centers.

The operation of these CET is entrusted to public for profit entities, locally know as ‘EPICs’, which are mandated by the Wilayas. EPICs and CETs are therefore at the center of current municipal waste management practices, all fractions combined.

2.3 Market demand

The demand for organic and affordable sources of minerals was confirmed in all the agricultural value chains investigated during this study. The main driver for the demand was either:

- the lower comparative costs (mineral fertilizers costs went up to 84 000 DZD per ton for DAP
- the observed or perceived better product quality when using organic based fertilizers (this is in particular the case for date farmers)

In total we recorded a consumption of over 400 000 tons per year of manure in the El Oued region alone sold by local distributors at an average cost of 11 000 DZD per ton. As a result, the manure market in the region of Biskra and El Oued is valued at a minimum of 4,4 billion DZD per year.

2.4 Current practices

All farms visited during the study had a pile of manure on site as part of their fertilization plan. In addition, the country currently imports +/- 100 000 Tonnes of mineral N-P-K fertilizer per year.

The farmers fertilisation practices vary according to their experience and the crops they grow. However, they all use manure as part of the land preparation prior to planting. The manure comes from sheeps and goats as well as chicken production and can be sourced as far as 800 km away from the point of use.

For farmers operating greenhouses, the manure is applied before planting and the chemical fertilizers are applied by fertigation techniques of drip irrigation during the growth and flowering stages.

For potato and onion farmers the addition of chemical fertilizers during the grown stages of the crops varies between farmers, but some farmers chose to combine the two sources of minerals as they have observed better yields and profitability in that way.

All date palm farmers visited in Biskra and El Oued have stated a marked preference for organic fertilizers as they improve the product quality. Two farmers have even invested in composting equipment to reduce their reliance on manure.

2.5 Availability of the raw material

The most widely available raw material is biomass from the pruning of date trees (see section 3.1.1). However, this waste has a C/N ratio of between 150 and 200 whereas the ideal range for fermentation is between 25 – 35. As a result, this raw material is not suited unless it is mixed with other biomass rich in nitrogen such as manure or kitchen waste.
The availability of nitrogen rich waste at a low cost is the primary limiting factor for scaling composting for two reasons:

i. Up to 2/3 of the initial mass can be lost during the fermentation process. Therefore, the cost of the raw material is a major contributor to the total cost of production
ii. Manure is a commodity sold at a relatively high price

The business opportunities must therefore provide or include a solution to the short supply of nitrogen rich organic waste that affects the total cost of production of compost.

2.6 Ecosystem maturity

Comparing to reference countries in that sector, the ecosystem needed to foster a mature biofertilizer production sector includes:

- Farmers with a habit of using organic fertilizers anchoring the demand side
- Waste management inspectors that enforce the proper management of animal farm waste
- Sorting of Organic Municipal Solid Waste
- Logistics companies specialising in the collection of transport of green waste
- University and soil science labs that build strong knowledge of the effect of different manures and biofertilizers on the soil
- Certification agencies that certify organic fertilisation practices
- Start-ups or SMEs that provide agricultural assistance services to farmers to optimize the return on investment in different inputs (precision agriculture)
- Commercial labs providing low-cost analysis services for soil and organic fertilizers
- Financial institutions with an appetite to invest in “green” projects
- Local manufacturers of machinery to grind biomass, mix composting piles, dry, pelletize and bag compost

The ecosystem is still in its infancy with very few of these components in place. However, two of the key components are in place: the farmers with a habit of using the organic fertilizers as well as local manufacturers. The universities in the Wilayas of Biskra and El Oued both have programs dedicated to this subject.

3 Viable Business Cases

Four business opportunities were identified after an analysis of the market demand, the supply and the regulatory conditions in place. These opportunities cover specific gaps in the value chain for organic fertilizers, such as the well-balanced supply of waste at a low price and the competitiveness with the current practice of direct manure application.

3.1 Business case 1: Collecting and pre-processing date palm waste for use as raw material in compost production or as substrate for nursery

All organic waste is a potential raw material for biofertilizer. However, the dry matter content and the Carbon to Nitrogen ratio are two parameters that need to be known to assess how effectively it can be fermented.

The most abundant carbon rich biomass identified during the study is the various parts of date palm trees that are removed during their annual pruning. However, this biomass has some challenges:

- It has a C/N ratio of 200, far above the target of 35 for rapid composting
- It is dispersed over the different farms and therefore collecting it has a cost

- It can't be used as raw material for composting without a mechanical pre-treatment (chipping or grinding)

The proposed business case is for small companies to specialize in the collecting and grinding of this abundant carbon rich biomass. The product will be a homogenous raw material for different processes such as composing, horticulture nurseries and mushroom production.

3.1.1 Business model

In this business opportunity, the target market are compost producers and other companies looking for a woody substrate either for nurseries, mushroom production or biochar production.

The highest value market is that of nurseries for the greenhouses that produce vegetables in the regions of El Oued. With over 3000 ha of greenhouses, nurseries are a growing business that is fully integrated in the value chain of green houses that need the highest quality plants for transplanting in the greenhouses. These nurseries use substrates to which they can add the fertilizer over the 3 – 4 weeks of development of the plant.

The lower value market is for compost producers that can therefore receive a raw material ready for use at a lower cost than if they had to finance the collection directly. The growing manure market is driving a supply for compost as well, which is marketed as a better version of manure to the farmers. As an example, PROFERT, a local fertilizer importer, is now operating a compost facility with a capacity of 15 000 T of waste per year. As more entrepreneurs enter this supply chain, the demand for the raw material (woody and moist) will grow.

Other markets for the substrate include mushroom and biochar production.

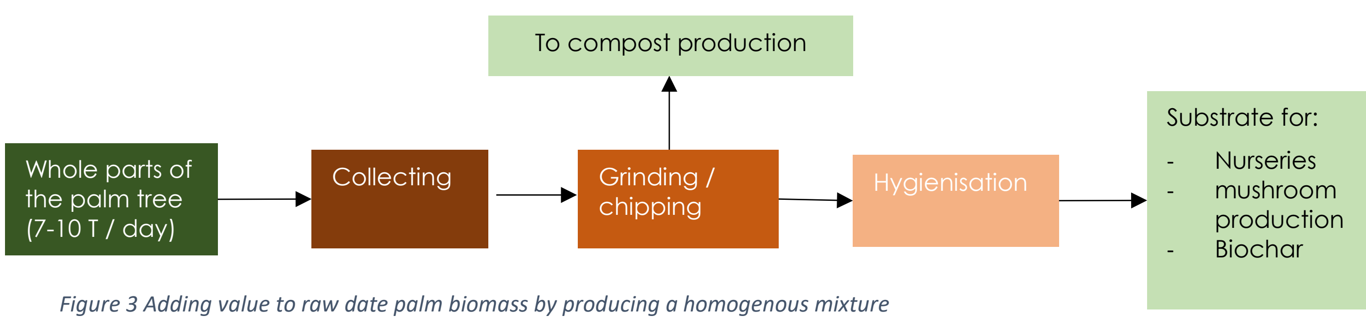

Figure 3 Adding value to raw date palm biomass by producing a homogenous mixture


Figure 4 Woody biomass chipper installed at a compost facility in Biskra

The recommended operating model is:

- the processing site must be located near many date palm plantations combining a total surface of 500 hectares. This will ensure that the cost of the raw material is minimized.
- In addition, the entrepreneur must secure off-takers for the chipped or grinded biomass at a price between 3000 – 4000 Dinars / Tonne.
- The expected annual gross income for the business is 5 250 000 Dinars / year
- The expected annual operation costs for the business is:
    - Electricity for the grinder (56 000 kWh / year)
    - 2 laborers + 1 driver
    - Fuel for the truck (1000 L / year)

3.1.1.1 Recommended investment

The recommended investment is:

- Mobile Chipper / grinder with a capacity of 500 kg / h
- 500 m2 of space including 100 m2 covered with electric access
- Optional: Truck with a capacity of 10 T

3.1.2 Required skills and potential job creation

This business activity is expected to require 3 low-skilled staff and 1 skilled staff for process and quality control.

- No specific technical skills are required as the main task will be feeding the grinder and moving the finished product into storage and packaging

- However, all staff will have to be trained in the operation of the grinder / chipper
- The raw material can be collected from palm plantations using rented trucks or a truck owned by the entrepreneur.

3.2 Business case 2: Collecting and distribution of organic fraction of municipal solid waste to compost producers

One of the identified barriers to making compost competitive is the high current costs of the necessary nitrogen rich organic waste stream (ratio C/N below 25) that is needed with the abundant carbon rich date palm waste to produce compost.

The most *accessible* source of nitrogen rich organic waste is animal manure whereas the most *abundant* source of nitrogen rich organic waste is the organic fraction of municipal solid waste. However, it remains inaccessible as there hasn't been a profitable model for sorting and delivery to recycling plants.

The proposed business case is for a small company to specialise in setting up innovative models for sorting and collection of a purely biodegradable stream of waste from municipal sources with low skilled workers. These companies can significantly unlock the potential for waste recycling as they are the missing link to tap into the most abundant source of biomass.

3.2.1.1 Business model

In this business opportunity, the target market are compost production facilities that need a predictable and low-cost supply of organic waste as a raw material to mix with the carbon rich waste from date palms.
The required investment will be to purchase dedicated bins and the vehicles that will collect the organic waste and deliver it to the client compost facilities. This business case is most attractive in towns with universities and hotels able to generate predictable streams of organic kitchen waste and where there is more than one customer for the sorted collected organic waste.

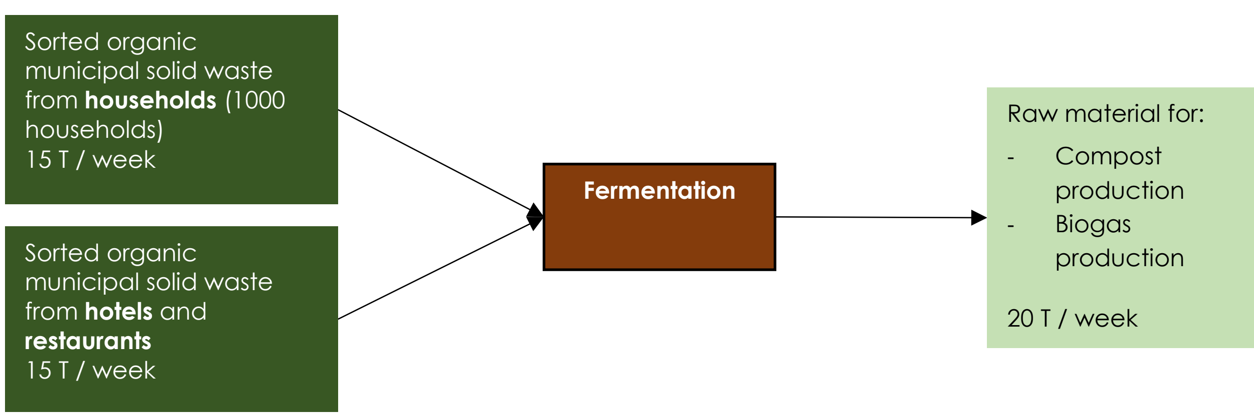

Figure 5 Adding value to organic municipal solid waste by introducing sorting and providing it as an alternative nitrogen rich raw material for compost producer

Given the current organisation of the sector, this activity may require authorisations from the Wilayas or the creation of a dedicated EPIC. However, this fermented organic matter has a market value of 5000 – 6000 Dinars per Tonne.
In any case, in the recommended operating model:

- The waste will have to be obtained at no cost (only the bins are installed at the locations without any additional monetary incentive for sorting)
- The off takers will have to guarantee a demand above the collection capacity of company
- The sorted waste must be fermented for 5 days to add some value by reducing the C/N ratio and stabilising partly the organic waste
- The end-product must be sold at a price of 5 000 – 6 000 Dinars / tons as a raw material for the lengthier composting process (40 days fermentation and maturation)
- The annual expected income is 5 000 000 Dinars / year.
- Off takers pay for the cost of delivery of the organic matter to their site

3.2.1.2 Recommended investment

The recommended investment is:

- Dedicated bins for selected locations:
    - Restaurants
    - Hotels
    - Canteens
    - Households
- A small truck with a capacity of 5 tons
- A 1000 m^2 site to coordinate the quality control and delivery to the composting factories

3.2.1.3 Required skills and potential job creation

This business activity is expected to require 3 low-skilled staff and 1 skilled staff for process and quality control.

- No specific technical skills are required as the main task will be collecting the sorted waste from the chosen locations
- One technical staff will be hired to monitor the fermentation process.

3.3 Business case 3: Collecting and preprocessing manure for use as raw material for compost production

As stated in section 4.2, one of the identified barriers to competitive compost is the limited access to a cheap nitrogen rich organic waste stream (ratio C/N below 25) that can be mixed with the abundant and easily mobilised carbon rich date palm waste to produce biofertilizers.

Manure is known for its high nitrogen content. As a result, it is already a traded commodity that farmers purchase to fertilizer their soils and compost manufacturers. Given the negative effects of directly applying manure, the proposed business opportunity is for a medium-sized SME to invest in industrial dryers to reduce the moisture content and improve the profitability of transporting manure to farmers and compost producers.

3.3.1 Business model

For this business opportunity, the target markets are similar to the previous case as they are both specializing in the production of raw material for biofertilizer production. However, they can also sell the pretreated manure directly to farmers as nitrogen rich organic fertilizer. Currently, this market is supplied by manure resellers that offer truckloads of raw manure. This raw manure has high mineral content, but it also has a high load of fly larvae and contains seeds of weed grasses that become a nuisance in the areas where the manure is applied.

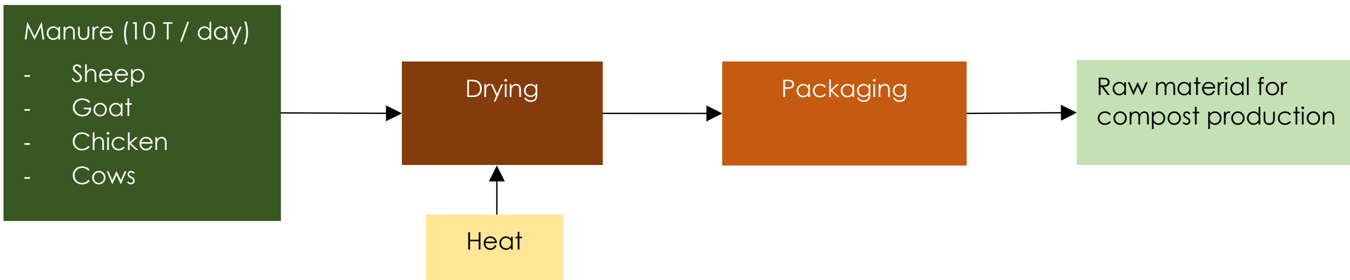

Figure 6 Adding value to manure by drying and reducing the water content before transport to end users in different Wilayas

Figure 5 Manure drying plant to supply the agricultural sector in Côte d'Ivoire

The recommended operating model is:

- the company will have to be located in a high-density animal farming area that generates at least 10 000 T manure per year.
- the manure will need to be acquired at zero or close to zero cost from the farms that generate them.
- the heat source will have to be the cheapest source of energy available, namely natural gas
- the dried manure will need to be sold for 7000 – 8000 Dinars / Ton
- The expected annual income from the activity is 7 000 000 Dinars / year.

3.3.1.1 Recommended investment

The recommended investment for 10 T manure per day

- A truck with a capacity of 5 T
- A drying space for the manure
- A dryer able to supply enough thermal energy to dry 10 T of manure per day (evaporate 1 T of water per hour)
- Bagging equipment to package the dried manure before its transport to the compost factories

3.3.1.2 Required skills and potential job creation

This business activity is expected to require 3 low-skilled staff and 1 skilled staff for process and quality control.
The main activity of this business is to reduce the moisture of the manure and increase its value before transport. No specific technical skills are required for this task. However, all staff will have to receive training in the operation of the dryer (Gas powered or otherwise).

3.4 Business case 4: Compost production as a stabilization process for the manure

The final business case is the production of a mineral rich (N-P-K) biofertilizer for sale as a substitute for the raw manure currently traded.
This model requires more significant investments in machinery to move large volumes of biomass during the fermentation process.
The value addition is in the stabilization of the manure to:

i) deactivate weed seeds
ii) reduce flies and odors and
iii) have a more durable impact on the soil structure over time.

Business model

For this business opportunity, the target market is farmers currently using manure as one of the sources of nutrients added to their soils. The aim of the process is to provide a more beneficial and stable alternative for a price competitive with the current price of chicken manure (20 000 Dinars / ton). Two technologies can be used to achieve this, anaerobic fermentation and aerobic fermentation.

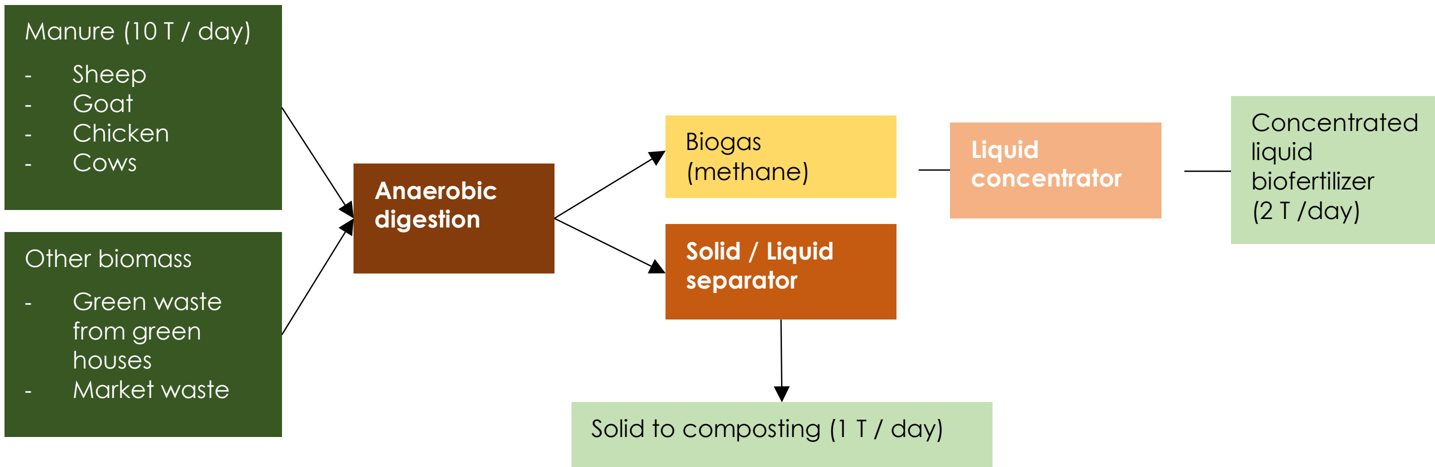

Figure 6 Adding value to manure by an anaerobic fermentation process

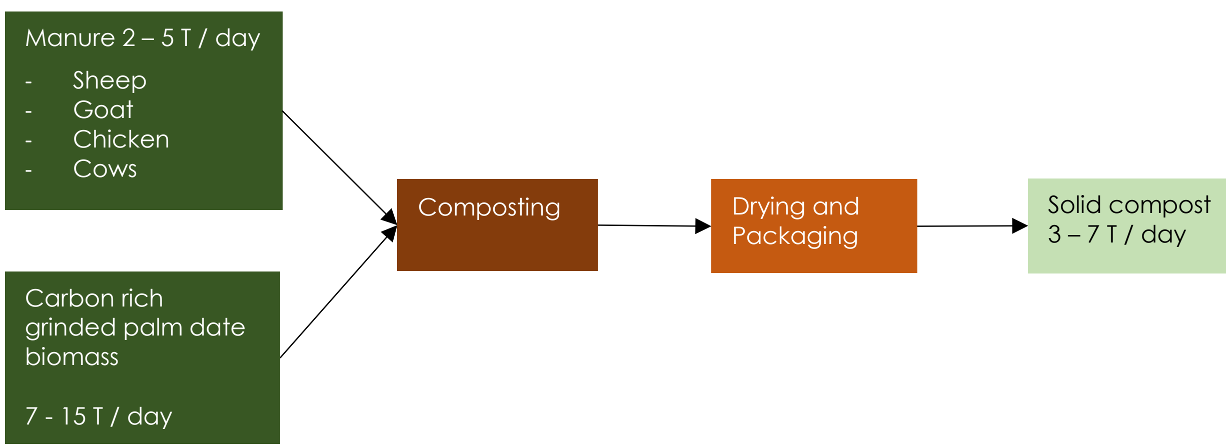

Figure 7 Adding value to manure by an aerobic fermentation process

Figure 8 Anaerobic digester for the fermentation of manure into compost and biogas

Figure 9 Composting surface in Biskra

The recommended operating model:

- The raw material (carbon rich and nitrogen rich biomass) must be obtained for an average price of 5000 - 6000 Dinars / ton
- The agronomical properties of the compost compared to raw manure need to be demonstrated so that the market value can be confirmed at 15 000 – 25 000 Dinars / ton
- The company should seek an internationally recognized certification for the compost
- The estimated annual turnover is 27 000 000 – 40 000 000 Dinars per year

3.4.1.1 Required investment

The required investment for 10 T of raw manure combined with other biomass treated per day includes:

- Anaerobic digester 200 m^3 or 2000 m^2 platform for composting

- Tractor
- Front end loader
- Truck to collect the biomass

3.4.1.2 Required skills and potential job creation

This business model requires both skilled and non-skilled staff. In total we expect between 8 – 10 jobs created as:

- 2 Drivers for the trucks and other engines
- 3 Labourers
- 1 – 2 Technician managing the fermentation process
- 1 – 2 Administration and sales to manage relations with clients and the different public services

Annex 1: List of Abbreviations

AND / NDA	Agence Nationale des Déchets
CET	Centre d'Enfouissement Technique
C/N	Carbon to Nitrogen ratio
CNFE	National Conservatory in Environmental Training
DAP	Di-ammonium Phosphate, a fertilizer that contains both Nitrogen and Phosphorus
EDEVAL	Établissement de Développement des Espaces Verts de la Wilaya d'Alger
EPIC	Établissement Public à Caractère Industriel et Commercial
FCCL	Fond Commun des Collectivités Locales - Common Fund for Local Authorities
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
MEER	Ministry of Environment and Renewable Energy
MICLAT	Ministry of Interior, Local Authorities and Regional Planning
NPK	nitrogen (N), phosphorus (P) and potassium (K)
OMSW	Organic Municipal Solid Waste
Progdem	Programme national de gestion intégré des déchets ménagers
PUM	Programma Uitzending Managers
UAA	Utilized Agricultural Area