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THE COLLECTION OF STUDY CASES
MADE BY INTERNATIONAL STUDENTS
FOR RURAL BUSINESS IN ITALIA

TITLE OF THE PROJECTS

LOMBRICULTURE AND PHOTOVOLTAIC SYSTEM

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Agrindustria Tecco SRL

Active since 1985, Agrindustria was born from his owner Giuseppe Tecco's intention. He intended to found a firm able to transform secondary vegetal products into industrial products useful for people.

"La intelligenza de la natura al servizio de la industria". - Giuseppe Tecco

The company was born as a "*trait d'union*" between agriculture and industry. This link is reflected on the name of the company that puts together the two terms:

* AGRI, coming from agriculture - from where they buy the raw materials-

* and NDUSTRIA, coming from industry - because the products processed are going to be used by the industry.

The intelligence of nature…

Agrindustria acts as a perfect intermediary between agriculture and industry, between nature's resources and all the uses that man can realize or think of. Nature is a partner for our company, as the production and the obtained products are the result of an accurate survey of the vegetable world. Man needs to draw inspiration from nature: he needs to observe it, to try to get to know it and imitate it as much as possible. Nature and quality are such an essential couple for our company, working with the utmost respect for the vegetable world. It takes the natural cycles and their results as a model, without altering them: Agrindustria observes the nature and learns from it, to produce as simple as practical and useful products for alimentary, industrial, handmade and domestic uses. Our firm intends to transform what is considered secondary in the industrial production's processes (for example almond shells, corncobs, sawdust) to get from it: fibres, meals, grains, fuel material for biomasses. Agrindustria wants to take inspiration from the circular economy of nature, in which the waste of each cycle becomes an input for another cycle. In nature garbage doesn't exist: nothing is unnecessary, even the smallest element has an essential role.

…for the sake of industry

Active since 1985, Agrindustria was born from his owner Giuseppe Tecco's intention. He intended to found a firm able to transform secondary vegetal products into industrial products useful for people. Our company produces pre-cooked food flour, soft vegetable abrasives, bases for cosmetics, supports for the pharmaceutical and animal feed industries, materials and vegetable additives for many uses. Services, such as grinding, micronisation, heat treatments, pelleting process, granulation, drying and cryogenic grinding, are added to this vast range of products. Agrindustria aims mostly at niche products with all the care and seriousness of a "cottage industry". And then the passion for the vegetable world is also an urge for research of new applications in the food we eat, in cosmetics, in the wellbeing of people, in looking after animals, in mechanics, in the production of alternative energy and in all fields where our raw vegetable materials can be employed. All our work is done with the necessary health authorisations, using cutting-edge machinery for grinding, granulometric separation, hygienisation using heat, drying, cryogenic grinding, pelleting process. Agrindustria takes advantage of renewable energy, produced thanks to a significant photovoltaic system. The company has invested in recent years, expanding the processing cycle and rendering it automatic (including customised packaging and integrated logistics) in order to respond quickly to market demands and guarantee customers, on the domestic market and abroad, an increasingly accurate and complete service. Agrindustria is a solid company, well established in this particular market and with good potentials for future growth: its strength lies in the attention it pays to the production processes and to the specific applications of the raw vegetable materials in all the various sectors, always with respect for what nature teaches us and gives us to use.

Website : https://www.agrind.it/

Location : Via Valle Po, 350, 12100 Cuneo CN, Italia

THE DEVELOPMENT OF VERMICOMPOST FROM SOLID WASTE OF THE LOCAL FOOD INDUSTRY

DRAGOŞ COSMIN JUFĂ
ELENA OLMOS CARBONELL
SOFIA PILAR SILVA

Content of the project

Executive summary

The aim of this paper is to expose and highlight the benefits and relevance of the implementation of our proposal. This proposal consists of the development of vermicomposting ("lombricoltura") in part of the terrain of our company, Agrindustria, by using their own discards and the wastes of the local fruit industry. The purpose is the production of worm humus, a biofertilizer with better qualities than the normal biocompost, which is sometimes referred to as "the black gold". This would be combined with the installation of solar trackers (a kind of photovoltaic panels more efficient than the normal ones because they follow the sun), as a way of smart-use of the terrain as well as a way to make profit of the synergies created by its integration.

For the selection of this proposal, research at a macro, meso and micro level was conducted. It was through this investigation that it was possible to recognise the problems present on the different scales. At a global scale 3 main problems were underlined: the high degradation of the soil, the issues with solid waste management and the disposal of discards that could be reused; at a regional level, but with a connection with the aforementioned, we highlighted the intensive monoculture, work labour in agriculture being predominantly masculine and over 60 years old, the issues with humid solid waste management and the high number of workforce and territory devoted to agriculture but low value of this sector on the GDP; finally, at a micro level, we pointed out the two problems that our company wanted to solve the apparent lack of use of the dry discards produced and a major dependency on the general energy network because not enough energy was being produced by their solar energy production, what meant high costs.

Once this was done, it was possible to think about the different alternatives and to choose the solution that could better address these problems. After deciding on a solution, we set about devising its design and working out how to implement it. We concluded that the best course of action was by adopting it in stages. We recognised 3 main phases: the phase of experimentation, the phase of extention and the phase of installation of the photovoltaic panels. This gave the company the possibility of, in the first place, do some modifications if the worms requirements in terms of good conditions were not met and the quality of the humus was not the adequate; and in the second place, to ensure that the project of vermicomposting works well and the enterprise is making some profits before doing a big investment on the installation of the photovoltaic panels.

The design of the first stages has been made taking into consideration the idea that the company had. We think that it may have some limitations because the worm requirements are not always met, and it may result in the need for an investment on infrastructure that ensures these good conditions, but that is why we have foreseen the need of a year 0.

Some of the conditions are met when installing the photovoltaic panels, but this won't occur until the vermicomposting part is executed and profitable for the enterprise. However, not all of the requirements would be met even when the solar panels are installed. For example, the worms need shadow at all times, which by the solar trackers is a condition met, but they also need moderate temperatures, and the shadow of the solar panels is normally hot. To solve this problem, part of our design envisages a system whereby the solar panels would be closer to the earthworms on cold winter days (emitting some of the heat to the earthworms and slowing the impact of the wind), while on hot summer days they would be upper (allowing the wind to flow but still shading them).

Since our proposal will be scaled up through the succession of these stages, it made sense that the indicative budget should also be planned according to the different stages. This section explains in detail how the investment will be made proportionally as the project progresses. Starting with an investment of 10.000 Euros and achieving at the end of the project a profit of approximately 1.000.000 Euros through the combination of vermiculture and solar panels.

The relevancy of the proposal is not only on how it can solve the aforementioned problems but also on its circularity and the benefits it can have at a local level: creating a community through the synergies between the different companies that have in common a philosophy of working sustainably and promoting this philosophy at a higher level.

1.The project overview

1.1 Introduction

At a time in history where our actions have brought us to a situation where the waste production grows at a higher rate than the population, our soil is completely damaged and its capacity to produce is in danger and we have almost depleted the resources of the Earth but fossil fuels still being extracted with all the environmental problems that they cause - all this is exacerbated by a growing population-, solutions need to be applied in order to avoid the catastrophe. This has been highlighted by many institutions, the European Union and its Circular Economy Strategy is one of the frameworks that guides this proposal.

We propose to devote part of the terrain of Agrindustria (around thirty thousand square metres) for the development of "lombricoltura", creating humus from earthworms with better properties than organic compost. This project will be phase-scaled; the first stages will be focused on the implementation of "lombricoltura" or vermicompost, while the last stages will be focused on the installation of photovoltaic panels in that same terrain. This hybrid-system, also known as "Agrovoltaic" means making a smart-use of the territory, and combining both farming (worm farming in this case) and green energy production (photovoltaic energy).

The project is in line with the philosophy of Agrindustria that is serving as a "*trait d'union*" between the industry and agriculture. The key conducting points are:

Collaboration to the transition into a sustainable agriculture, by providing a product that facilitates the replacement of chemical fertilisers with a worm humus, with a quality superior to that of other biofertilizers. Vermiculture biotechnology promises to bring about the "New Green Revolution" by totally replacing the harmful agro-chemicals that, during the "First Green Revolution" of the 1950s to 1960s did more harm than good to both farmers and the soil. Earthworms increase soil fertility, improve agricultural yield and by using their excreta ("vermicast"), sustainable development can increase output.

Smart-use of the territory and installation of green energy production. Both responding to the will of the company to be self-sufficient energetically, and collaborating to the promotion of green energy in the area.

Solid waste management. At a micro level by responding to the need of the company to manage its own dry discards and at a meso level by giving a use to the "wastes" of the fruit industry of Cuneo's province, which can have an impact on a macro level.

1.2. The state of the art

1.2.1. Historical framework of the context

1.2.1.1. Evolution of agriculture in the last years (1940s-today)

Before going more in-depth on the analysis of Cuneo, it is important to build the framework and evolution of agriculture in the last decades. As introduced before, our proposal wants to solve problems taking place both in the agricultural and industrial sector, and our chosen solution is especially relevant for the **continuity of agriculture**. For that reason, before explaining our proposal, the current situation around the food systems needs to be explained.

In Cuneo, in Italy, in Europe and in general worldwide, two phenomena that took place in the last century influenced the evolution of the food systems, one took place at a global level, the Green Revolution; and the other at a European level, with the first CAP.

In order to summarise these phenomena, we will say that the Green Revolution had **two main goals**: to **increase food production** and to e**ncourage self-sufficiency in developing countries**. Its origins can be traced to early 1941, when the Rockefeller Foundation dispatched a team to investigate Mexican agriculture. As a result, the Mexican Agricultural Program (MAP) was created, and Norman Borlaug, who was later awarded with the Nobel Peace Prize, was hired to work there in 1955. He developed what is known as the "miracle wheat" in 1954, and the Rockefeller and Ford foundations disseminated it all over the world. Many nations that embraced the new technology had record crops, with certain countries experiencing spectacular successes. Between 1960 and 1985, the total amount of food produced in the developing nations more than doubled. Food production outstripped population growth, while the global population increased by 110% between 1950 and 1990, global cereal production increased by 174%[1].

The first CAP shared also one of those goals: **increase food production**. This makes sense if we observe it in relation to its context. The Common Agricultural Policy (CAP) was created in 1962 by the six founding countries of the European Communities, after years of hunger and starvation in a Europe hitted by two catastrophic wars. Another aim of this policy was to ensure a fair standard of living for farmers, in order to do that, they ensured a price floor (a minimum price that protected the European farmers from the competition with the farmers of the rest of the world). However, the system was far from fair, a price floor affected people proportionally based on their output of food - the more food you produce, the more money you get from producing it -, which meant that most of the money ended up going to people who owned the largest farms and were the richest farmers.

That premise then seemed to be “the more land you have for a single product and the more efficient you are in producing this single product, the better”. As a consequence, plots of lands were concentrated in intensive, monoculture production, with the **use of pesticides and chemical fertilisers to increase the productive capacity of the land**. After years of “taking from the land and giving nothing back”, we face a situation of soil degradation that threatens crop production in the not so distant future. Paradoxically, the goal of producing more is what has ended up causing the land to produce less.

These two initiatives failed in that by focusing on the growth of food production, they neglected other equally important variables to ensure the availability of food for a growing population. There is no denying that it had some positive effects, but although production grew, this did not mean that world hunger disappeared. Today, people all over the world still suffer from hunger, and at the same time tons of food are being thrown away every day.

These actions have importantly **contributed to climate change**, and at the same time **have finished with the resilience of the food systems** and have made them very vulnerable and difficult to adapt to changes, with the consequent social and economic impacts.

That is why there is a new strategy promoted at a global and regional scale. At a global scale,

[1] Patel, R. (2012). *The Long Green Revolution*. Taylor & Francis. Retrieved July 25, 2022, from https://www.tandfonline.com/doi/full/10.1080/03066150.2012.719224?scroll=top&needAccess=true

the New Green Revolution is proposed, a transition into a climate-smart agriculture that incorporates the planification of sustainable agriculture. Hans Herren, a World Food Prize laureate and the director of Biovision, a Swiss NGO, remarked that what is needed is "a farming system that is much more mindful of the landscape and ecological resources. (...) to change the paradigm of the green revolution"[2]. It is by doing this, by looking at the big picture and applying nature-based solutions, rather than introducing other pesticides and herbicides, that pests can be deterred and yields increased. This doesn't mean a complete rejection of innovation and technology, but that when implementing it, the environmental, social and economic dimensions are taken into account.

At a European level, these ideas are very much highlighted by the latest strategies and plans. On the one hand, a sustainable food system is at the core of the European Green Deal, under the Farm to Fork strategy. The target of the European Commission is that by 2030 at least 25% of the EU's land is used for organic agriculture. In order to meet this goal the Commission has set out an organic action plan for the EU that is divided into three axes: (1) stimulate demand and ensure consumer trust; (2) stimulate conversion and reinforce the entire value chain; and (3) that organics lead by example - an improvement on the contribution of organic farming to environmental sustainability[3].

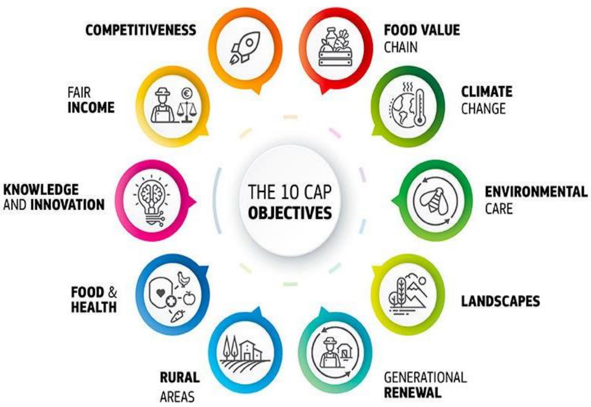

Figure 1- The 10 CAP objectives[4]

A new CAP has been launched for the period 2023-27. It is built around ten key objectives

[2] Folger, T. (2014, October). *The next green revolution*. National Geographic. Retrieved July 25, 2022, from https://www.nationalgeographic.com/foodfeatures/green-revolution/

[3] European Commission (2022). *Organic action plan*. Agriculture and rural development. Retrieved July 25, 2022, from https://agriculture.ec.europa.eu/farming/organic-farming/organic-action-plan_en

[4] Source:European Commission. (n.d.). *Key policy objectives of the new cap*. Agriculture and rural development. Retrieved July 27, 2022, from https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/new-cap-2023-27/key-policy-objectives-new-cap_en

that, as the SDGs of the UN, focus on social, environmental and economic goals. These goals are: (1) to ensure a fair income for farmers; (2) to increase competitiveness; (3) to improve the position of farmers in the food chain; (4) climate change action; (5) environmental care; (6) to preserve landscapes and biodiversity; (7) to support generational renewal; (8) vibrant rural areas; (9) to protect food and health quality; (10) to foster knowledge and innovation.

These strategies do not only favour organic farming, but they also encourage the smart use of the territory. Within the Horizon Europe Framework Programme, related to the topic of sustainable, secure and competitive energy supply, **Novel Agro-Photovoltaic systems are promoted**. This opportunity explains the second part of our proposal.

The exposition of these new strategies helps us to explain the relevance of our proposal, which will be discussed in more detail below. They explain how important it is in its collaboration with the Green Transition, as well as how interesting it may be for our company in particular. The **product that is proposed in this paper, is directly related to organic agriculture** and to the recovery of damaged soil, it replaces chemical fertilisers that modify and harm the soil, with a completely natural worm humus. And at the same time by combining it with the installation of solar panels the part of innovation is also covered.

1.2.1.2. Solid waste management and the transition to circular economy

The other problem that our proposal seeks to address is solid waste management. Our focus would be on the industry since our company works as a "trait d'union" between agriculture and industry, but it can also be applied in other contexts. This is the link to circular economy, especially because the strategy followed on the management of this solid waste is to give a second life to the so-called "wastes".

Ecosystems and human health are seriously at danger due to the growing volume and complexity of garbage produced by the modern economy. The amount of solid waste collected each year is estimated at 11.2 billion tonnes, and the organic waste's decomposition accounts for 5% of the world's greenhouse gas emissions[5]. If business as usual continues in the coming years, it is predicted that by 2050, we will be consuming more than three times the

[5] UNEP. (n.d.). *Solid waste management*. UNEP. Retrieved July 25, 2022, from https://www.unep.org/explore-topics/resource-efficiency/what-we-do/cities/solid-waste-management

planet's available resources while annual waste production would rise by 70% by 2050[6].

More than one-third of the world's food production is wasted. Food waste has negative effects on the environment and the economy and is responsible for 8% of the world's greenhouse gas emissions. 1.3 billion tonnes of food, worth over $9 billion are wasted annually, according to the UN's Food and Agriculture Organization (FAO). Approximately 40% of that waste is generated at the very end of the supply chain, either as food waste from consumers or businesses. However, the remaining 60% of waste occurs further up the supply chain, which means that food companies wishing to boost their earnings, reduce their environmental impact or both, have a significant opportunity to improve[7].

The different institutions at a global, regional and national level have realised the need to act and promote policies and aids that make this solid waste management interesting both for the individuals and for the businesses. The UN remarked that shifting to a Circular Economy is essential to achieve the Paris Agreement[8]. The World Bank finances and advises on solid waste management projects [9]. However, the biggest step until now has been done by the European Union with its Circular Economy Action Plan launched in 2015. The European Commission adopted the new circular economy action plan (CEAP) in March 2020. This plan is also part of the European Green Deal. In the new action plan, initiatives are announced for every stage of a product's life cycle. It strives to prevent waste, focusing on product design, advancing circular economy practices and encouraging sustainable consumption, to keep the

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[6] European Commission. (2020). *COM/2020/98 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A new Circular Economy Action Plan For a cleaner and more competitive Europe*. EUR-Lex. Retrieved July 25, 2022, from https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM%3A2020%3A98%3AFIN

[7] Roughan, G. (2021, July 26). *Sustainable Food Waste Management for food industry SMEs*. Unleashed Software. Retrieved July 25, 2022, from https://www.unleashedsoftware.com/blog/sustainable-food-waste-management-for-food-industry-smes#:~:text=Industrial%20food%20waste%20management%20involves,transforming%20bio%2Dwaste%20into%20fuels

[8] UN Climate Change News. (2021, April 15). *Shifting to a Circular Economy Essential to Achieving Paris Agreement Goals*. Unfccc.int. Retrieved July 25, 2022, from https://unfccc.int/news/shifting-to-a-circular-economy-essential-to-achieving-paris-agreement-goals

[9] World Bank Group, T. W. B. (2022, February 11). *Solid waste management*. World Bank. Retrieved July 25, 2022, from https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management

resources in the EU economy for as long as possible[10]. At a national level, in 2021 in Italy was initiated the National Strategy for Circular Economy (2021)[11].

1.2.1.3. Holistic Diagnosis of the Territory

The province of Cuneo, the "Granda" province, is the largest province of the Piedmont region in the North of Italy. It occupies an area of 6.905 km² and has a population of 587.098[12] .

The territory borders France to the west, with the metropolitan city of Turin to the north, with the province of Asti to the east and with the Liguria region to the south (Figure 2). This position has determined the social, cultural and economic evolution of the region. With a high connection to Europe and with a big influence from France. The province does not have access to the sea, since it is surrounded by the Cottian, Maritime and Ligurian Alps, forming a large U-shaped border that opens a high plain crossed by the Po and the Tanaro rivers (and their numerous tributaries), that favoured the agriculture, and thus the human settlements. Cuneo province is made up of 50,8% of mountains, 26,6% and 22,6% of plains (Figure 3).

Figure 2 - Map of Cuneo (dark green: mountainous area; soft green: plains) and Italy[13]

Figure 3 - Physical geography of Cuneo's territory[14]

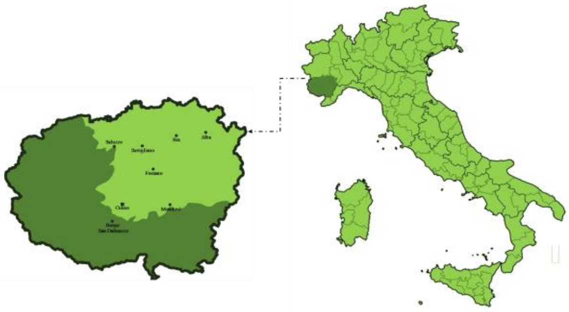
[10] European Commission. (2020). *Circular economy action plan*. EU website. Retrieved July 25, 2022, from https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en#:~:text=The%20EU%27s%20transition%20to%20a,entire%20life%20cycle%20of%20products

[11] Ministerio della Transizione Ecologica. (2021, September 30). *Strategia nazionale per l'economia circolare. Linee programmatiche per l'aggiornamento.* . MiTE. Retrieved July 25, 2022, from https://www.mite.gov.it/sites/default/files/archivio/allegati/economia_circolare/SEC_30092021_1.pdf

[12] Eurostat. (2019). *Data statistics*. Database - Eurostat. Retrieved July 25, 2022, from https://ec.europa.eu/eurostat/data/database

[13] Own Elaboration

[14] Wikimedia Foundation. (n.d.). *Provincia di Cuneo*. Wikipedia. Retrieved July 27, 2022, from https://it.wikipedia.org/wiki/Provincia_di_Cuneo#cite_note-6



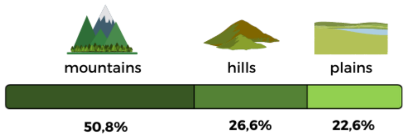
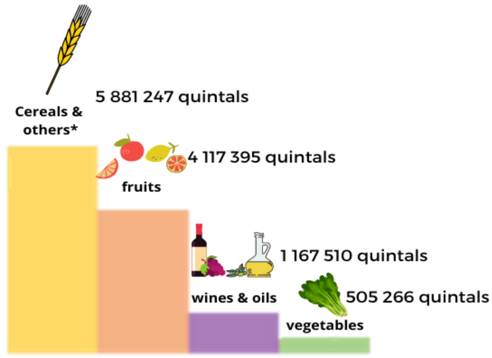


Figure 4 - Crop production in Cuneo's province



Source: Own elaboration[16]

The first sector occupies an important part of Cuneo's territory. According to the 6th General Census of Agriculture in Piedmont launched in 2010 with data from the 2009-2010, the Total Agricultural Area (TAA) was about 417.116 ha while the Total Used Area (TUA) was about 313.071[15] ha. The ranking of what is cultivated in the area is: (1) forage; (2) cereals, legumes, roots and tubers; (3) fruits; (4) grapes for wines and olives for oil; (5) vegetables; (6) industrial crops.

Due to the physical geography of Cuneo and its climate, the **local fruit production is of great importance**. It is carried out by combining past and present, tradition and new techniques. Some have even reached Community certification, obtaining the prestigious denomination of origin: the Cuneo Chestnut, the prized Cuneo Bean and the Cuneo Red Apple, recognized with the Protected Geographical Indication. Also in the area there is a big production of apricots, strawberries, peaches, small fruit plums; Cuneo occupies the second place of the Kiwi production in Italy[17].

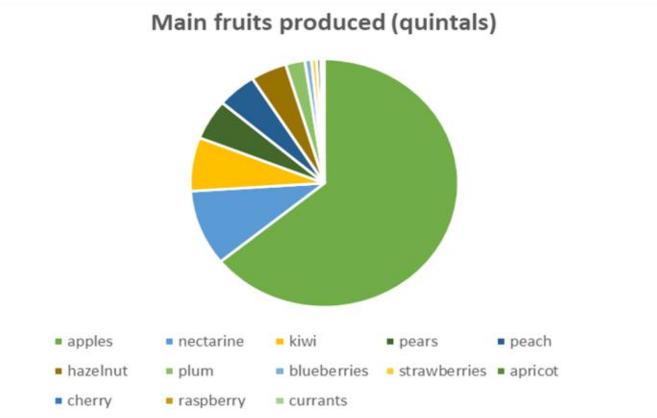
[15] Istat. (2010). *6° Censimento generale dell'agrioltura*. Retrieved July 26, 2022, from https://www.istat.it/it/files//2013/02/Agricoltura-Piemonte.pdf

[16] With Data of Istat. (2022). Crops : Areas and production - overall data - provinces. Retrieved July 27, 2022, from http://dati.istat.it/Index.aspx?QueryId=37850&lang=en

[17] Camera di commercio di cuneo. (n.d.). *Frutta e Ortaggi. Il Cuore dell'ortofrutticoltura nella provincia di Cuneo*. Retrieved July 26, 2022, from https://www.cn.camcom.it/sites/default/files/uploads/documents/Biblioteca/Pubblicazioni/Cuneo%20Frutta%20e%20Ortaggi.pdf

Figure 5 - Main fruits produced in Cuneo's province (quintals)[18]

type of fruit	production (quintals)
apples	2 645 700
nectarine	407 400
kiwi	288 840
pears	216 600
peach	196 560
hazelnut	180 120
plum	96 300
blueberries	32 800
strawberries	25 350
apricot	20 750
cherry	11 200
raspberry	3 680
currant	2350



However, even if the area devoted to fruit production has not changed substantially -in some cases it has even increased-, the production of 2021 was already lower than 2020.

Table 1 - Comparison total ha fruit production in Cuneo's province in 2020 and 2021[19]

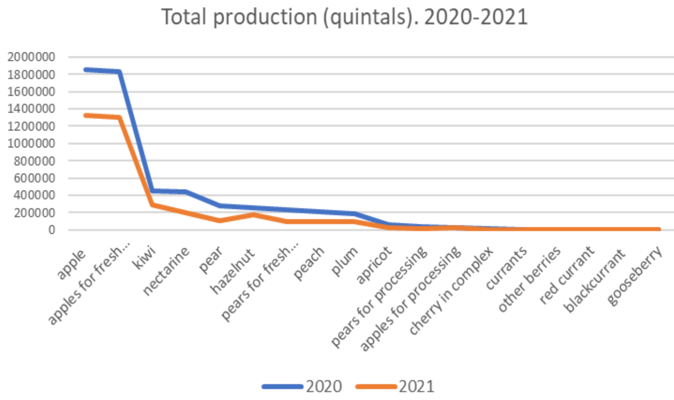
	2020		2021	
type of fruit	total area- hectares	total production (quintals)	total area- hectares	total production (quintals)
apple	5 692	1 858 100	5 692	1 322 850
apples for fresh consumption	5 607	1 835 000	5 607	1 301 250
kiwi	2 640	455 300	2 460	288 840
nectarine	1 980	440 000	1 980	203 700
pear	1 120	274 300	1 123	108 300
hazelnut	15 710	253 000	15 883	180 120
pears for fresh consumption	974	236 800	975	93 060
peach	842	205 200	835	98 280
plum	1 080	190 000	1 095	96 300
apricot	428	58 500	425	20 750
pears for processing	146	37 500	148	15 240
apples for processing	85	23 100	85	21 600
cherry in complex	164	11 500	185	5 600
currants	15	1 080	15	1 175
other berries	20	800	22	800
red currant	10	680	10	800
blackcurrant	5	400	5	375
gooseberry	1	50	1	45

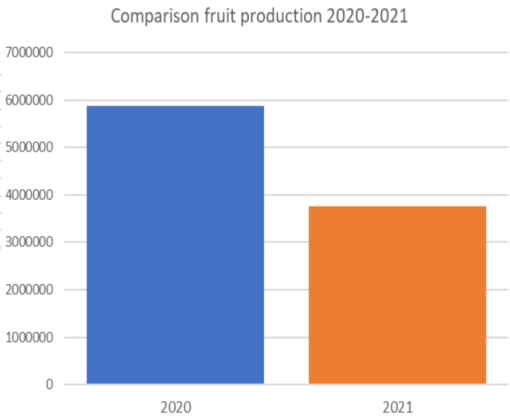
Figure 6 and 7 - Total fruit production comparison 2020-2021[20]

[18] Own elaboration with Data of Istat. (2022). Crops : Areas and production - overall data - provinces. Retrieved July 27, 2022, from http://dati.istat.it/Index.aspx?QueryId=37850&lang=en

[19] *Íbid*

[20] *Íbid*





This year's water shortage is anticipated to become a constant and bigger problem in the coming years. Italy declared the state of emergency in its northern region the 5th of July of this year to combat the country's worst drought in 70 years[21]. By the middle of the century, there will be a decrease in water availability in Europe. In the Piedmont region, the effects of climate change are especially pronounced during dry seasons. Due to this, the porous aquifers at low altitude are under significant pressure due to water deficit and agriculture practices[22].

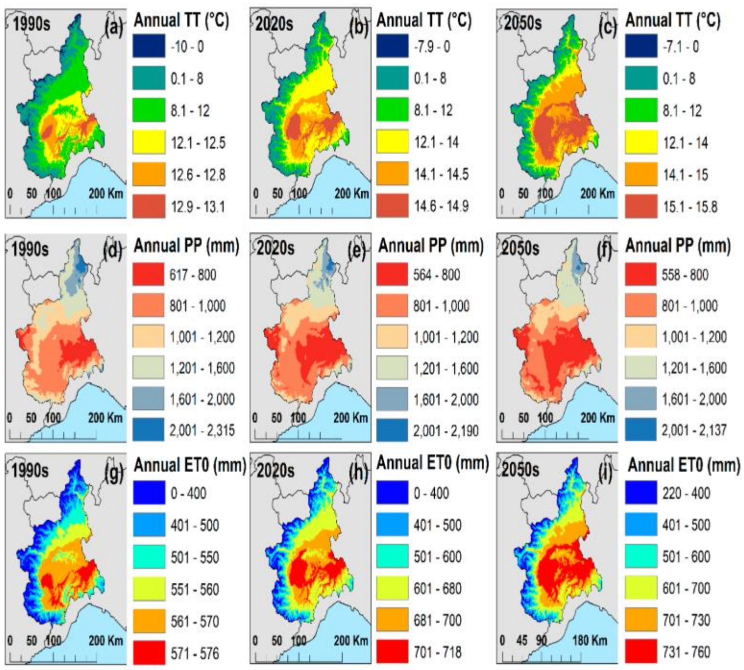


Figure 8. Spatial distribution of temperature, precipitation, and potential evapotranspiration (ET0) in the Piedmont region. (**a**) The average of annual air temperature 1960-1990 (1990s); (**b**) The average of the annual air temperature 2011-2040 (2020s); (**c**) The average of the annual air temperature 2040-2070 (2050s); (**d**) The average of the annual precipitation 1960-1990 (1990s); (**e**) The average of the annual precipitation 2011-2040 (2020s); (**f**) The average of the annual precipitation 2041-2070 (2050s); (**g**) The average of the annual ET0 1960-1990 (1990s); (**h**) The average of the annual ET0 2011-2040 (2020s); (**i**) The average of annual ET0 2041-

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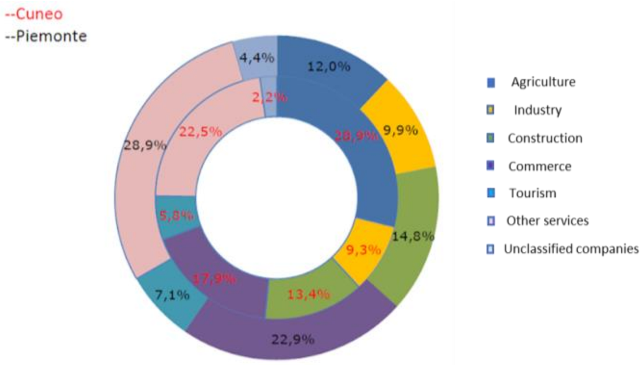
21 Seckin, B. (2022, July 5). *Italy declares state of emergency in northern regions to combat drought*. Anadolu Ajansı.https://www.aa.com.tr/en/europe/italy-declares-state-of-emergency-in-northern-regions-to-combat-drought/2630230

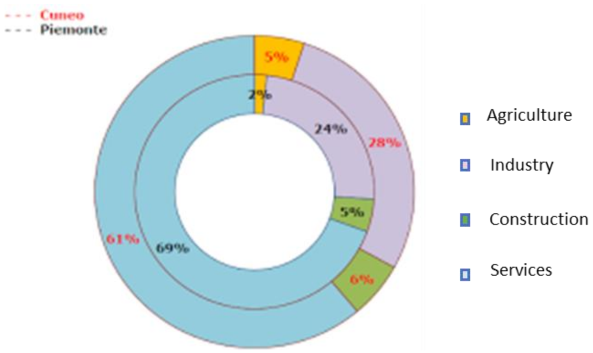
22 Nistor, M.-M. (2020, July 23). *Groundwater vulnerability in the Piedmont region under climate change*. MDPI. Retrieved July 26, 2022, from https://www.mdpi.com/2073-4433/11/8/779/htm

2070 (2050s).[23]

Figure 9 (up)- Registered business locations by sector: comparison of the province of Cuneo and region of Piedmont - 2019[24]

Figure 10 (down) - Sectoral breakdown value added: comparison province of Cuneo and region of Piedmont - 2019[25]





From an economic perspective, even though it is one of the sectors with one of the largest workforce in Cuneo province (28,48% (Annex 1)) and despite having a big number of registered companies (28,9%), its weight in the GDP of Cuneo is very small. It was also interesting at this point to compare the province of Cuneo with the region of Piedmont in general. And here we can really see the importance that agriculture has in Cuneo in comparison. The percentage of agriculture in the value added is low, but however it stills relevantly higher than the percentage of the Piedmont region.

The FAO pointed out that in many cases the development of countries was done by focusing on industry which left agriculture in a secondary position. The conception of agriculture's role as purely supportive of the rest of the economy is being replaced by the view that agricultural development should be pursued for its own sake, and that it can sometimes be a leading sector of the economy, especially in periods of economic adjustment[26]. In fact, some of the remarks

[23] Nistor et al. (2019), cited by Nistor, *op. cit.*

[24] Camera di Commercio di Cuneo. (2020). *Rapporto Cuneo 2020*. Retrieved from https://www.cn.camcom.it/it/rapportocuneo2020

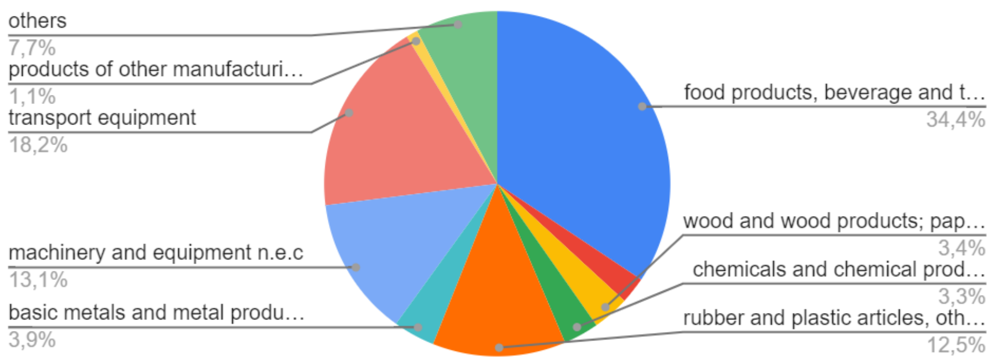
[25] *Íbid*

[26] FAO. (n.d.). *1.2 El Sector agrícola y el Crecimiento Económico*. FAO. Retrieved July 25, 2022, from https://www.fao.org/3/y5673s/y5673s05.htm

that were done by the Istat in July of this year (2022) of the results of the 7th General Census of Agriculture in Piedmont that was initiated in 2020[27] was that the resilience of the agricultural sector in relation to the effects of the Covid-19 pandemic was, overall, pretty good. In Italy just 17,8% of the companies declared having suffered the effects of the pandemy, a share that was higher among the larger companies than the smaller companies.

It is important for the aim of this report to note in which products the industry's share (that is the higher one) is concentrated.

Figure 11 - Products manufactured by the industrial sector in Cuneo (2019)[28]



We easily remark the relevance of the food industry (34,4%). There are two reasons why this matters: first that it is the humid waste of the food industry that we are trying to manage; and secondly that the loss in the percentage contribution to GDP by agriculture is explained by the greater weight of the food industry. This means that many products and activities previously carried out in the territory by the primary sector are now carried out by industry. The theories of development talk about a linear development, moving away from agriculture and towards a more industry-centred economy. This "phased development" was partially explained due to the transfer of activities from agriculture to the industrial sector[29].

[27] Regione Piemonte. Italian government. (2022, July 19). *I Primi Dati del 7° Censimento Agricoltura A Livello Nazionale*. Regione Piemonte. Retrieved July 25, 2022, from https://www.regione.piemonte.it/web/temi/agricoltura/primi-dati-7deg-censimento-agricoltura-livello-nazionale

[28] Camera di Commercio di Cuneo. (2020). *Rapporto Cuneo 2020*. Retrieved from https://www.cn.camcom.it/it/rapportocuneo2020

[29] Van Arendonk, A. (2015, May). *The development of the share of agriculture in GDP. A case study of China, Indonesia, the Netherlands and the United States.* Wageningen University. Retrieved July 25, 2022, from https://edepot.wur.nl/342795

On a legal perspective, the rules for the production of **vermicompost** are established by the **Legislative Decree No. 75 of 29 April 2010, that regulate the use and classification of fertilisers**[30] that defines that vermicompost must only be produced from cattle, pig, horse and sheep manure or their mixtures by digestion by earthworms and subsequent maturation. This Decree classifies vermicompost as a soil improver and also establishes the parameters of nitrogen and organic carbon content. Earthworm humus is authorised in organic cultivation but it must meet additional requirements indicated in the annex to Legislative Decree No. 75/2010 regulating fertilisers authorised in organic farming. When introducing green and/or organic waste, the process becomes more complicated, the business is then compared to that of a composting plant, with procedures and rules that vary according to the amount. This aspect needs to be taken into account before starting implementing the proposal.

On the **agrovoltaic part**, the Council of Ministers of Italy, as a part of the National Recovery and Resilience Plan (that is inside the Recovery Plan for Europe) has launched the "Half-agricultural and half-photovoltaic: the new way to grow crops and create energy" as a part of the Mission of the Green revolution and ecological transition. The total investment cost has been 1.10 billion for 2022. The goal of this big investment is to spread agro-voltaic facilities for sustainable agriculture and energy production from renewable resources, that contribute to the reduction of costs of supplying energy to the sector and improve climate and environmental provisions (a potential decrease of 0.8 million tons of CO_2). The plan has two main stages: the adjudication of contracts for the installation of solar panels by December 2024 and the installation of solar photovoltaic panels in solar parks, with capacity of 1.04 GW for an estimated production of at least 1300 GWh a year[31].

Other interesting funds in the field from the EU include the Innovation Fund that promotes projects contributing to GHG reduction; the Energy Infrastructure: Projects of Common Interest (CEF Energy)

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[30] The Official Gazette. (2010, May 26). *Legislative Decree no.75 of 29 April 2010 "Reorganization and revision of the regulations on fertilizers, pursuant to article 13 of law no. 88 of 7 July 2009"*. Dlgs 75/10. Retrieved July 25, 2022, from https://web.camera.it/parlam/leggi/deleghe/10075dl.htm

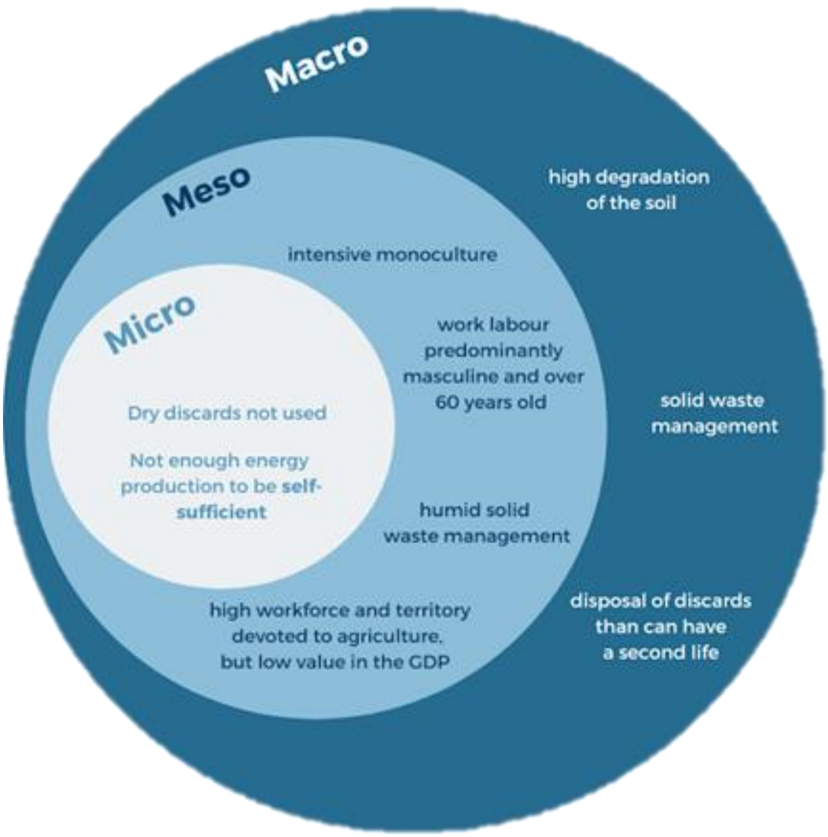
[31] Italia Domani. (2022). *Piano Nazionale di Ripresa e Resilienza. Agro-voltaic development*. Agro-voltaic development. Retrieved July 25, 2022, from https://italiadomani.gov.it/en/Interventi/investimenti/sviluppo-agro-voltaico.html

that support sustainable energy infrastructure projects; the LIFE Clean Energy Transition sub-program (part of the LIFE Programme that is the EU's funding instrument for environment and climate action); and finally, the European Regional Development Fund.

1.2.2 SPECIFIC PROBLEMS - micro, meso, macro analysis

In this section the problems to which our proposal is trying to give a solution will be exposed. Our proposal tries to respond to the local necessities, but at the same time it can easily be replicated and it can have a bigger impact on solving problems at a regional level and even a global one. That is why our analysis will pass by a macro, a meso and a micro level.

Figure 12 - Macro, meso and micro analysis[32]



MACRO:

- **High degradation of the soil.** Soil degradation is the loss of the land to produce in

[32] Own elaboration

terms of loss of soil fertility, soil biodiversity and degradation. Agricultural, industrial and commercial pollution, urbanisation, overgrazing and unsustainable agricultural methods, and long-term climate change are all factors that contribute to soil degradation. Nearly one-third of the world's arable land has vanished in the past forty years, according to a recent study to the UN. It was also reported, that if current rates of loss continue, the world's topsoil might all become unusable in 60 years[33].

- **Solid waste management.** As pointed out at the beginning of this paper, the EU reported that if following business as usual by 2050 we will be using the resources of 3 Earth planets, but we just have one. Part of this waste is **organic waste**, which means that it originated from living sources like plants, animals and microorganisms and that can decompose into more basic organic molecules. Solid organic waste is typically regarded as organic-biodegradable waste and has a **moisture** level of between 80 and 85 percent. Organic wastes are most frequently produced by industrial items, domestic chores and agriculture. It will be pointed out in the following sections the various treatments and practices that have been developed and implemented around the world to address these issues.[34]
- **Disposal of discards that can have a second life**. The FAO estimates that about one-third of the edible foods produced are lost or wasted all over the world. In addition to the environmental impacts of this, the generation of food waste also has an economic and social impact. It does not only lead to loss of natural resources, but also economic losses for farmers, consumers and other stakeholders of the food supply chain. From the point of view of the Circular Economy, this bio-waste should be directed to treatment alternatives that utilise the waste as a source of important assets such as nutrients, organic substances and energy[35] .

MESO

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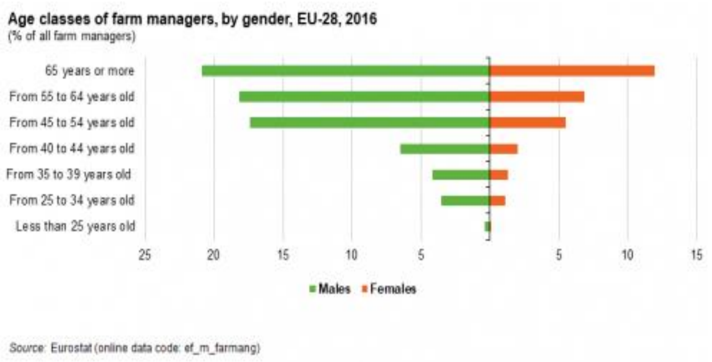
[33] Maximillian, J., Brusseau, M. L., Glenn, E. P., & Matthias, A. D. (2019, March 1). *Pollution and environmental perturbations in the global system*. Environmental and Pollution Science (Third Edition). Retrieved July 25, 2022, from https://www.sciencedirect.com/science/article/pii/B9780128147191000252

[34] Sapkota, A. (2020, November 17). *Organic Waste Recycling (methods, steps, significance, barriers)*. Microbe Notes. Retrieved July 26, 2022, from https://microbenotes.com/organic-waste-recycling/

[35] European Environment Agency (2020) Bio-waste in Europe - turning challenges into opportunities. *EEA Report. No 04/2020*.

- **Intensive monoculture**. As introduced in the first section of this report, the different strategies followed in the last century led to a higher level of intensive monoculture. Growing only one kind of crop in a field allowed farmers to use machinery, and thus increased the efficiency of activities such as planting and harvesting. Expanding the territory and the way of operating, intensively, with this monoculture also meant in the mind of the producers, to increase the productivity rate. However, this way of operating had many drawbacks. On the one side, growing a single crop increases the risk of pest outbreaks due to the lack of other plants and animal species that limit the spread of the disease and control pests through predation. To avoid these pests, a larger amount of pesticides and herbicides were used, products that contaminate rivers and streams and that by diminishing the amount of worms and insects, destroy the biodiversity of the area. On the other side, growing the same crop year after year reduces the availability of certain nutrients and degrades the soil[36].
- **The farmers are predominantly male and over 60 years old**.

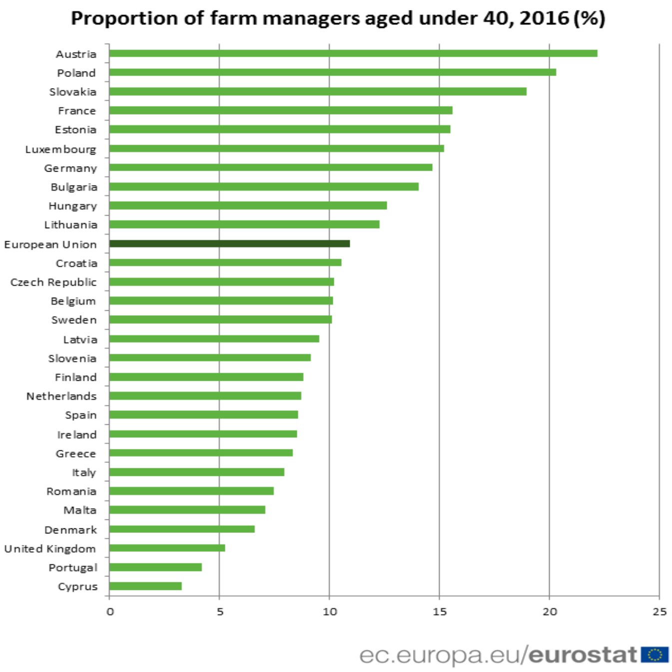
Figure 13 and 14 - Title in the image[37]



[36] Balogh, A. (2021, December 13). *The rise and fall of monoculture farming*. Horizon Magazine. Retrieved July 26, 2022, from https://ec.europa.eu/research-and-innovation/en/horizon-magazine/rise-and-fall-monoculture-farming

[37] Eurostat. (2018). *Farming: Profession with relatively few Young Farmers*. Farming: profession with relatively few young farmers - Products Eurostat News - Eurostat. Retrieved July 26, 2022, from https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20180719-1

In 2016, 10.3 million people worked as EU farm managers. The average age of a farmer is clearly at the upper limit of the age group. One third (32%) of EU farmers were over 65 years old. Only 11% of EU farmers were young farmers under the age of 40. Only about three in ten (29%) of EU farmers were women[38]. And the proportion of young female managers was even lower (23%). **Austria** is the EU-country with a **higher rate of young farmers**, and it is also the country in Europe with a **higher percentage of organic farming (25% (Annex 2))**. That connection gives an opportunity that we try to enhance with our proposal.



- **Humid solid waste management in the area.** One of the points that we realised in our analysis of the territory was that while dry waste was being managed, the wet discards in the area, especially those organic, were numerous but were more difficult to process due to their characteristics, and were being lost. Once more, this problem becomes an opportunity that we wanted to address with our proposal.
- **High worklabour and territory devoted to agriculture but low value in Cuneo's GDP.** This has already been explained and responds partially to the transfer of activities that first were realised by the agricultural sector to the industry. As part of the New Green Deal of the European Union there is a proposal of swifting into a system where organic agriculture has a bigger weight, this kind of agriculture can be enhanced with innovation, and much research is being done in the area that could make agriculture contribute more to the GDP of a region.

MICRO

[38]*Íbid*

Finally, concerning the enterprise, there were some problems that needed to be addressed.

- **Dry discards with no apparent use.** Agrindustria produces around 250 tons of dry discard per year to which they still haven't found a use. Since the company follows a complete circular economy approach -to make an input from all apparent waste- they have been looking for a solution to these discards for a long time.
- **Not enough energy production to be self-sufficient**.

	Kwh		
Anno	Produzione	Cessione	Autoconsumo
2013	716.756	231.045	485.711
2014	706.373	212.496	493.877
2015	776.922	226.605	550.317
2016	787.226	256.104	531.122
2017	811.602	255.957	555.645
2018	717.627	216.411	501.216
2019	747.526	206.127	541.399
2020	767.144	222.327	544.817
2021	727.147	174.258	552.889

Table 2- Production, disposal and self-consumption of photovoltaic energy in Agrindustria[39]

They used to produce more energy than what they needed, and this excess was sold. However, nowadays, the production of energy is not enough to be self-sufficient. And for the enterprise, to depend on the national network means high costs.

1.2.3. EXISTING SOLUTIONS

There were different alternatives to address these problems. All of them had advantages and disadvantages, but in the end, we chose the only solution that responded to all of them.

- ➢ ANAEROBIC DIGESTION. During this process, anaerobic microorganisms convert various types of biomass and other organic wastes into biogas and nutrient-rich residues that can be used for lap applications. Biogas produced by this process contains gases such as methane, carbon dioxide, and trace amounts of hydrogen and hydrogen sulphide.
- ➢ ANIMAL FEED. One of the most common and efficient ways to recycle organic waste is to feed the cattle and other animals with this agricultural and food waste. Feeding animals with this bio-waste is a simple and easy way to recycle waste.

[39] Source: Table facilitated by Agrindustria.

- RAPID THERMOPHILIC DIGESTION. It is the process of rapidly fermenting organic waste by activating fermenting microorganisms at elevated temperatures. In a thermophilic fermenter, the raw material is introduced into the digester with air forced through the material to support the growth of aerobic microorganisms. The product of this process is a biofertilizer that can be used to increase soil fertility[40].
- COMPOSTING - VERMICOMPOSTING. Composting is the process by which soil organisms break down organic matter that acts on it, resulting in the recycling of nitrogen, phosphorus, potassium, and other soil nutrients into humus-rich components. Vermicompost is the process by which these organic materials are converted by the worms into a humus-like material.

Table 3 - Pros and cons of each of the alternatives. Own elaboration

[40] Sapkota, A. (2020, November 17). *Organic Waste Recycling (methods, steps, significance, barriers)*. Microbe Notes. Retrieved July 26, 2022, from https://microbenotes.com/organic-waste-recycling/

EXISTING SOLUTIONS	PROS	CONS
ANAEROBIC DIGESTION	- Cost-effective technology **green energy production** and **disposal treatment** of high moisture and energy-rich material - It can utilise a much **wider range of substrates** than other methods	- **Low processing capacity** and high operating costs - High requirements for the **pretreatment** of food waste and the ammonia nitrogen - There is a **risk of secondary pollution** - difficult to handle biogas residue *
ANIMAL FEED	- **Simple** and **easy** method **- Reduces pressure on landfills** **- Reduces methane productions from fruits and vegetables** - Eliminate the **need** to **convert** organic waste into other forms	- The direct feeding of organic waste to animals might result in **health issues** - Many regulations worldwide on that matter
RAPID THERMOPHILIC DIGESTION	**-Works 6 to 10 times faster than a normal biodigester** -It has an important **role** on the treatment of **sewage sludges** in the wastewater industry	- It is not simple and like the anaerobic digestion, it needs and **investment** on machinery - For using it the source must enter at **high temperature**, thus a high use of energy
VERMICOMPOSTING	- Simple implementation - Fully **organic fertilizer** - **Improvements in soil quality** - It assesses problems in the **industrial** and **agricultural** sector, and **contributes to the promotion of sustainable agriculture**	- **Efficiency** and **quality depends** on the amount of organic waste but also on the climate **conditions** - It requires **more space** and **greater care** than regular composting - **Unpleasant smell**

Table 4- Problems that different alternatives solve[41]

PROBLEMS	ANAEROBIC DIGESTION	ANIMAL FEED	RAPID THERMOPHILIC DIGESTION	VERMI-COMPOSTING
High degradation of the soil			**X** Production of biofertilizer - soil recovery	**X**
Solid Waste Management	**X**	**X**	**X**	**X**
Disposal of discards that can have a second life	**X**	**X**	**X**	**X**

[41] Own elaboration

Intensive monoculture				X Not directly but indirectly by promoting organic farming
Farmers are predominantly male and over 60 years old				X Not directly but indirectly by promoting organic farming, that has a higher percentage of young farmers
Humid solid waste management in the area	X	X	X	X
High worklabour and territory devoted to agriculture but low value in the GDP				X Not directly but indirectly by promoting organic farming that add value to the agriculture production
Dry discards with no apparent use				X
Not enough energy production to be self-sufficient	X It produces biogas			X By the combination of vermiculture and **solar energy production**

1.2.4. CHOSEN SOLUTION

➢ VERMICOMPOST

Our chosen solution is the only one that responds to all those problems at a macro, meso and micro level. "Lombricoltura", earthworm farming, vermiculture or vermicompost are all words that normally refer to the same thing. However, some reports make a distinction between vermiculture and vermicompost. Vermiculture is defined as the culture of earthworms and whose goal is to continually increase the number of worms that can be either used for vermicomposting or sold to customers with the same purposes. Vermicompost is defined as the method by which organic waste is turned into vermicompost, a substance like humus, by using worms, the objective is to process the material as rapidly and effectively as possible[42]. They produce polysaccharides, proteins, and other nitrogenous chemicals into the soil, as well as excrete beneficial soil bacteria. Worm activity can result in an 8-30% increase in air-soil volume. Water penetration in compacted soils improves by 50% when worms are present. It is commonly used with the *Eisenia fetida*, also known as "redworm"or "California

[42] Aalok, A., Tripathi, A. K & Soni, P. (2008). Vermicomposting: A Better Option for Organic Solid

Waste Management. J. Hum. Ecol., 24(1): 59-64. Ecology and Environment Division, Forest Research Institute (FRI), P.O. New Forest.

redworm", because it was in California where they first used it for economic purposes.

Earthworm vermicompost is a very nutrient-dense organic fertiliser that is rich in humus, nitrogen (N, 2-3%), phosphorus (P, 1.55-2.25%), potassium (K, 1.85-2.25%), micronutrients, beneficial soil microbes like "nitrogen-fixing bacteria" and mycorrhizal fungi. Vermicompost is also characterised by a high porosity, aeration, "drainage" and water holding capacity. What is really important is the fact that it contains nutrients that are accessible to plants and seems to boost and store nutrients for a longer period of time[43]. What is also interesting is that the amount of these elements in the final humus can be modified by the feed that is given to the worms.

- **AGROVOLTAIC**

The first part of our proposal is significant itself, but it is with the combination with photovoltaic panels that its relevance increases. With the premise that the agricultural sector is responsible for 10% of Europe's GHG emissions, the combination of agriculture and photovoltaic panels is being promoted both at a European and at a national level. The implementation of this hybrid agriculture-energy production system should not compromise the land use dedicated to agriculture, but contribute to the sustainability of those companies involved. We chose to install solar trackers that are more efficient than the normal photovoltaic panels because they turn (180º) to follow the sun.

1.3.2 SWOT analysis

Table 5 - SWOT analysis[44]

[43] Sinha, R. K., Valani, D., Chauchan, K. and Agarwal, S. (2010). Embarking on a second green revolution for sustainable agriculture by vermiculture biotechnology using earthworms: Reviving the dreams of Sir Charles Darwin. Journal of Agricultural Biotechnology and Sustainable Development Vol. 2(7), pp. 113-128, August 2010. Available online http://www.academicjournals.org/jabsd

[44] Own elaboration

SWOT		
	INTERNAL FACTORS	
	STRENGTHS (+)	**WEAKNESSES (–)**
	Availability of solid humid waste	First time working "producing" raw material instead of just receiving it as an input and processing it.
	High productivity of the fruit sector in the region – valuable input	Lack of knowledge in the field
	In line with the EU framework and possible access to European founds that try to promote sustainable development	Need of investment at first – to ensure that the good conditions needed are met
	High percentage of production when the earthworms meet all the conditions (they produce with no stop)	If one of the conditions that characterize good earthworm production is disturbed, all humus can be lost (e.g., excess acid, rotting of organic matter, extreme temperature change)
	EXTERNAL FACTORS	
	OPPORTUNITIES (+)	**THREATS (–)**
	Policies and laws at European and National level promoting this activity – the market of this product will increase	Existing competitors in the region
	National vermicompost network that can support the process of establishment of the vermicompost facilities in the company	Difficult to differentiate from the competition as it is a product that does not require much specialisation
	Potential high profit margins if products are commercialized well	Changing climate conditions can have prejudicial effects on the product
	Potentiality of creating a network and synergies with the other local businesses	Technological developments that make production costs lower for competitors

The **strengths** can be enhanced and we can add value to our project by different methods. Firstly, by not only enforcing its value as an organic fertiliser with better qualities than the normal compost, but also by remarking that it is made out of local discards (km 0) if we import only from industries that work with local inputs. Either way, the waste that we would use would be located in the territory since it has already been imported, but it is better to collaborate with companies that also take into account the sustainability factor. Secondly, by pointing out that the energy needed (if needed, in the future phases) would be green energy from the photovoltaic panels' installation. Thirdly, the creation of a packaging of bio-plastic that is both biodegradable and bio compostable can facilitate the sale of our product. Fourthly, there exists the possibility of educating by showing, and that way becoming a Center to the promotion of circular economy and sustainable farming.

2. Calculation and design of the *system/ installation/equipment*

2.1 Input data of the project

- **Location:**

  -The plot of land is situated inside the terrain owned by Agrindustria Tecco at the following coordinates: 44.45737587801233, 7.52197442146343.

- **Numerical data:**

  - The dimensions of the parcel are N≈155m, S≈155m, E≈170m, W≈200m and the total amount of square meters is ≈33.000m2.

Figure 15 - Location and dimension of the land where our project would be executed[45]

➢ **Other information:**
   ○ INPUTS

Once the holistic diagnosis was made, we could determine which were the best inputs for our warm farming, and we concluded that we should focus on: animal manure, dry discards from Agrindustria and food waste.

- **Animal manure**. Was mandatory for the production of humus. Also, following the national regulations (Legislative Decree No. 75 of 29 April 2010) this manure should be from cattle, pig, horse or sheep. The availability in the area was high and the boss of the enterprise even confirmed to have some contacts that could provide it to him.
- **Dry discards from Agrindustria**. As pointed out at the beginning of this paper, the enterprise was looking for an activity that could give a use to its own discards. These were mainly: wood dust, coco fibber and corn cob. All materials high in carbon so with high value for the earthworms.
- **Food humid waste (especially from fruits)**. This selection responded to two ideas: first, to profit from the high fruit production of the area (the amounts produced have been pointed out in the first section) and give a second life to all those humid discards

[45] Photo: google maps; measurements: own elaboration.

that were not being used; and secondly, give value to our hummus, since the earthworms normally operate better in environments with fruits and vegetables than in those that there are not present[46].

We have analysed some companies of the region to see the possible fruit and vegetable discards that could be used. These companies are 4: Alpenfrucht, Rogelfrut, Archillea and L'orto del gallo. That does not mean that our proposal can just be done importing this "waste" from them, but it is a point of start, it also serves us as a point of reference, since the waste produced by these companies working with fruits, will not vary that much in the area. These enterprises were selected because they are located close to Agrindustria (Alpenfrucht at 6-7 km from the company; Rogelfruit 17 km away; Archillea 37 km away; and finally, L'orto del gallo located just next to Agrindustria), and because of the characteristics of each of them. While Alpenfrucht y L'orto del gallo operate by focusing on the local level, the other two have bigger amounts of production and then waste. The combination of these two kinds of enterprises can be positive for our company. In addition, l'orto del gallo, apart from being just next to Agrindustria which would virtually eliminate the economic but also environmental costs related to logistics, has different retail shops that can serve as points where the humus produced could be sold. These are some of the possible discards that could be used by Agrindustria for vermicomposting.

Figure 16 - Discards from the 4 local fruit companies selected [47]

[46] Lofton, K. L. J. (2020, September 23). *Influence of diet of the red wiggler earthworm (Eisenia fetida) on nitrogen, phosphorus, and potassium (NPK) nutrients, organic matter, and carbon: Nitrogen (C:N) ratio within the vermicompost casts*. Native Science Report. Retrieved July 26, 2022, from https://nativesciencereport.org/2020/09/influence-of-diet-of-the-red-wiggler-earthworm-eisenia-fetida-on-nitrogen-phosphorus-and-potassium-npk-nutrients-organic-matter-and-carbon-nitrogen-cn-ratio-within-the-vermicompost-casts/

[47] Own elaboration

The leaves can also be used, but we have already covered the carbon needed part with the dry discards from Agrindustria, adding leaves could break the balance of the bed. The pits or stones of the fruits are not banned, but the earthworms normally take a very long time to process them, so it is not so beneficial to use them. Finally, there are some foods that it is better to avoid, especially citrus and spicy food.

What is interesting with vermicomposting is that the properties of the humus can be enhanced by choosing the right food.

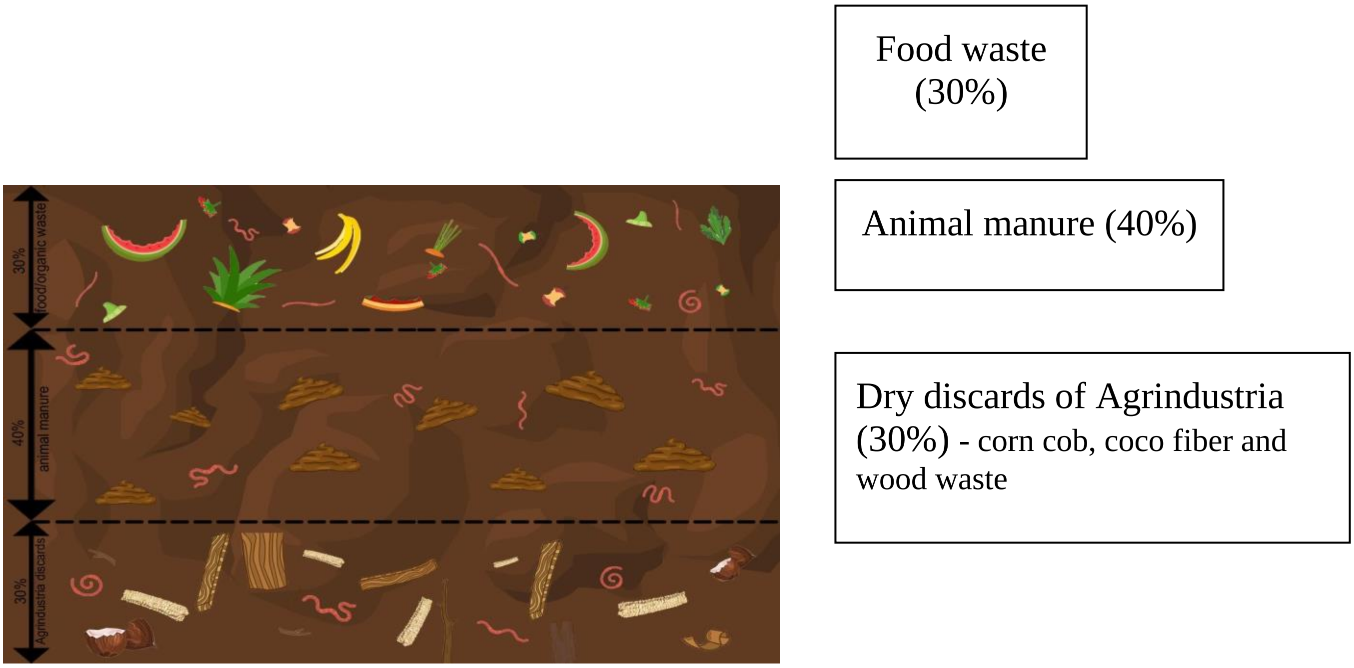
Table 6 - Fruits that can be used

and its properties - Own elaboration

WASTE/ DISCARDS	PHOSPHORUS (P)	POTASSIUM (K)	NITROGEN (N)	CALCIUM (Ca)	CARBON (C)
APRICOT remains	●	●		●	
APPLE remains & peel		●			
POMEGRANATE skin				●	●
PEACH remains & peel	●	●			
PEAR remains, peel & seeds		●			
PLUM remains		●			
KIWI remains & skin				●	
BLUEBERRY, BLACKBERRY, RASPBERRY, ELDERBERRY remains	●			●	
STRAWBERRY remains	●	●		●	
PRICKLY PEAR remains & peel	●	●		●	
ARTICHOKES remains		●			
REDCURRANT remains	●			●	
CHERRY remains				●	
CHESTNUTS skin					●
HAZELNUT skin					●
TOMATO remains		●			
CARROTS remains		●			
EGGPLANT remains & skin	●				
FIGS remains		●		●	
GRAPES remains & pomace	(raisins)	●			
BANANA remains & skin	●	●		●	
PAPAYA skin				●	●
AVOCADO remains & skin	●			●	●

All of those discards could be good options. However, since the aim of this project is to follow the circular economy principles and to be as sustainable as possible, **we will focus on the fruit waste from fruits produced locally**. In this sense, Alpenfrucht and l'orto del gallo are very valuable partners because they only work with fruits and vegetables produced locally and in an organic manner. The other two companies have higher rates of production, which can mean more opportunities to import fruit waste from them, but they also import from different countries so maybe its footprint is not so neutral. Anyways, this is merely a way to create add-value to our product, to make it even more sustainable by collaborating with companies with the same philosophy, but the reality is that the discards of all of them are already in the region, so we will be using inputs from the region either way. Nevertheless, thinking about choosing the fruits produced locally, we have created a seasonal fruit chart to underline the availability of each of them according to the season and the months (Annex 3).

Figure 17- Possible composition of the worm beds - 30% fruit waste, 40% animal manure and 30% dry discards in the bottom so that they get easily wet[48]



- OUTPUTS. When done well, the vermicomposting should not have any remarkable outputs. But if the conditions were to be altered (extreme weather conditions, for example) or if the feeding was not done well (for example adding more organic waste than what the earthworms can process), all the humus could be lost.

[48] Own elaboration

2.2 Calculation and design of the Final solution

As it has already been introduced. Our chosen solution is the development of vermicomposting or "lombricoltura" for the production of humus that can then be used for the agriculture, especially organic agriculture, but also by gardeners or family households; combined with the installation of photovoltaic panels, creating then an agrovoltaic system.

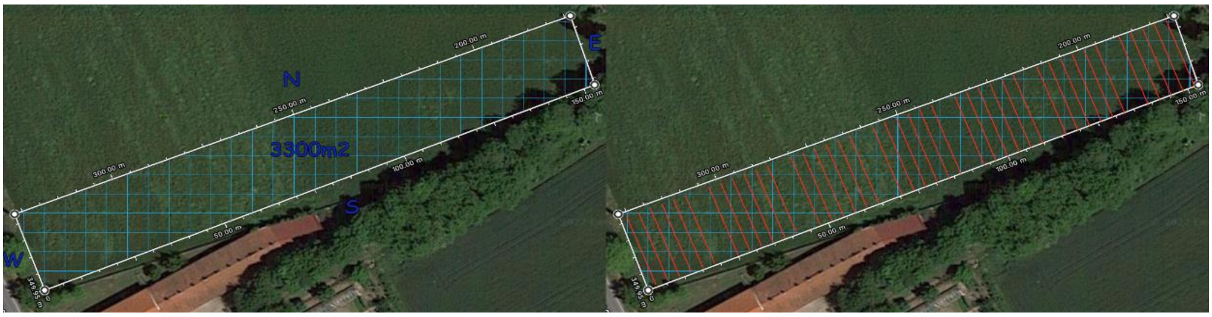
We have decided to divide the implementation of our proposal into a series of phases to ensure the smooth execution of the project. The phases that we have identified are PHASE 1 – PHASE OF EXPERIMENTATION, that would have a Phase 1 (2.0) – Phase of Modifications, if something wasn't working correctly; PHASE 2 – PHASE OF EXTENSION, that would be divided into two sub-phases, Phase 2 – Extension until 50%, and Phase 2- Extension until 91% of the terrain; finally, the PHASE 3 – INSTALLATION OF PHOTOVOLTAIC PANELS.

- PHASE 1 – PHASE OF EXPERIMENTATION (1 year minimum)

In the first phase of the project, only 10% of the land that is equal to 3300m2, will be used for vermiculture. The length of the worm beds, located directly on the ground, will be 15m with 1,5m width, and will have 2 metres of distance from one to another to ensure that the machinery can easily pass between them. This distance has two additional benefits: it prepares the disposition of the worm farming for the future installation of photovoltaic panels, and the separation of worm beds help the company to make sure of the quality of the humus, and that if one bed is contaminated due an alteration on the conditions, the other beds are not affected. Between the nine groups of beds, there will be 5 metres of distance for future implementations.

Figure 18 - Dimensions for the first phase of our project (10% of the terrain)[49]

[49] Photo: google maps; design: own elaboration



The launching of a first experimental phase (or Year 0) responds to the need to further analyse the feasibility of implementing the vermicompost this way or see if modifications are needed. Since for our design we haven't created a real infrastructure, because our boss had in mind to locate the beds and the worms just directly on the ground, we need to examine the feasibility of doing it like this. Throughout our research we have seen cases in which the land planning and the care for the earthworm requirements were quite scarce; but we have also read reports in which the need to maintain a series of conditions for the earthworms to reproduce and "to work" in good conditions was emphasised. Some of these requirements were: they always need good humidity, a temperature about 18ºC to 27ºC, a pH of 6.7, shade at all times, no extreme winds and no predators. In addition, for them to be more productive there is a need for light at all times. Some of these requirements can be solved by the future installation of solar panels, but not all of them.

If during this phase it was evident that some changes needed to be done to ensure those requirements, the **Phase 1 (2.0)- Phase of modifications** would be implemented. An analysis would be done and a decision concerning the need to invest on infrastructure or to change the feed for the earthworms would be taken.

Some of the possible modifications to be applied could be: building of an infrastructure with insulating materials to maintain the temperature inside the enclosure, climatizators that also help in this function; the construction of beds with masonry or similar materials to place the food waste, animal manure and the worms inside (monitoring the entrance and exit of oxygen); or the placing of a tarpaulin or a coverture that covers the beds and allows the good composting (that keeps out other insects that could damage the quality of the humus) and also protects the earthworms from possible predators, the sun and extreme winds.

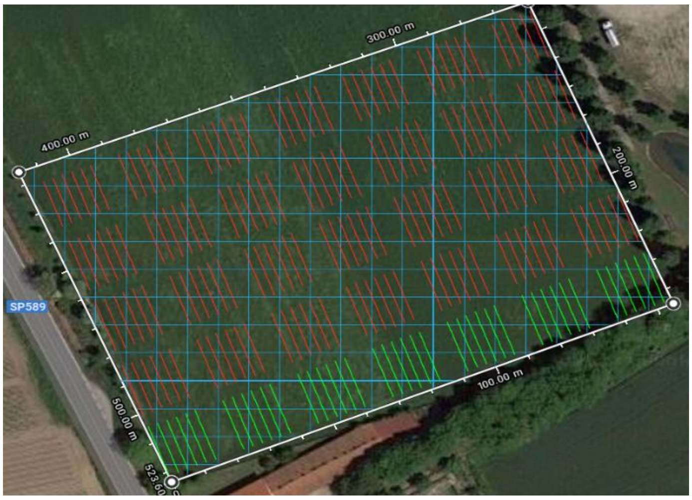
Once the relevant changes are done, the following phase could be initiated.

➢ PHASE 2 – PHASE OF EXTENSION

o Phase 2 - First Extension - Extension until the 50%

Following the same logic as the first phase, if no modifications were needed, the terrain for vermicomposting use would be extended. If modifications were needed, then the extension would be done by applying these modifications (e.g. creation of infrastructure). The terrain will be progressively extended until reaching 50% of the land which is equal to 16.500m2.

Figure 19 - Dimensions for the second phase of our project - first extension (50% of the terrain)[50]



o Phase 2 – Second Extension - Extension until the 91%

If the previous extension (until 30%) was successful and no modifications were needed, then the terrain devoted to vermicomposting will be extended until occupying a 91% of the totality of the plot land, which is equal to 30.030m2. The extension can't be applied until 100% because of the full growth trees and the fences occupying the remaining 9% of the land.

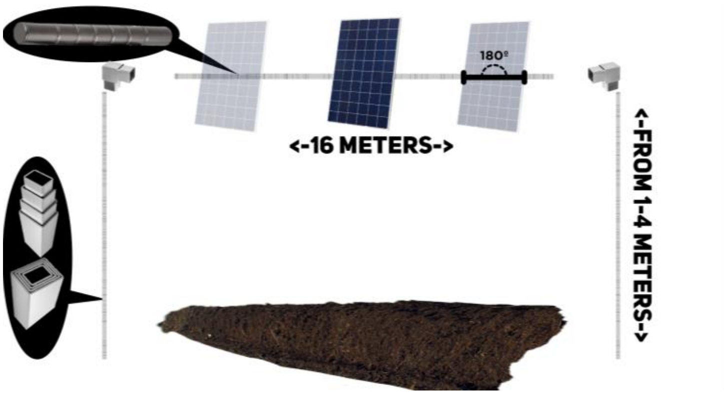
Figure 20 - Dimensions for the second phase of our project - second extension (91% of the terrain)[51]

[50] Photo: google maps; design: own elaboration

[51] Photo: google maps; design: own elaboration

➢ PHASE 3 – INSTALLATION OF PHOTOVOLTAIC PANELS

Figure 21 - Design for the photovoltaic panels installation[52]



After finishing the Phase 2, where the terrain is covered in proportion of 91% because of the full growth trees and the fences occupying the last 9% of the space, the Phase 3 can start, with the installation of the photovoltaic panels.

As pictured in the image, a bar, placed above the worm bed, will hold the photovoltaic panels. This bar, made out of strong treated iron so it can hold on to pressure, will be 16 metres long (in order to cover the 15 metres bed) and leaving 0,5 metres at the beginning of the bed and at the end of it, so the workers have enough space to recover the humus.

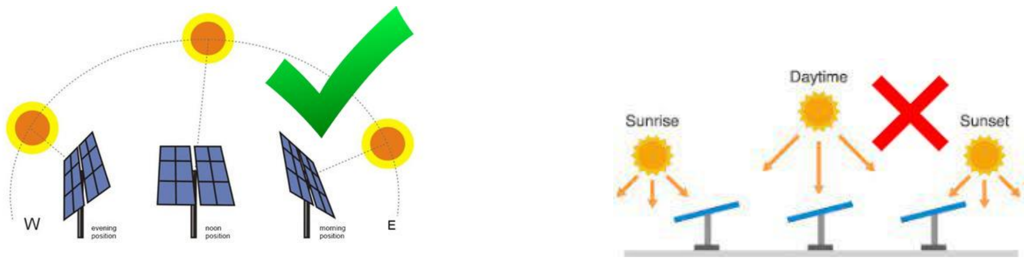
The two lateral bars have a **hydraulic system** that allows them to go from 1 to 4 metres up. The idea behind this hydraulic system is that the shadow produced by the photovoltaic panels

[52] Own elaboration

is not fresh, but hot, and if they were to be too close to the bed during the hot months of summer, that could suffocate the worms. In winter, on the contrary, this heat that is emitted can be good for the worms and it can also serve as a shell that protects them from the low temperatures or extreme winds.

The horizontal bar has implemented a hydraulic pivot together with a **sun tracking system** that will allow the photovoltaic panels to rotate at 180°, constantly following the sun, moving from East to West. The reason behind choosing these solar trackers is that they can produce within 10-30% more than a static one, since they spin from the sunrise until the sunset.

Figure 22 - Comparison between solar trackers and static photovoltaic panels[53]



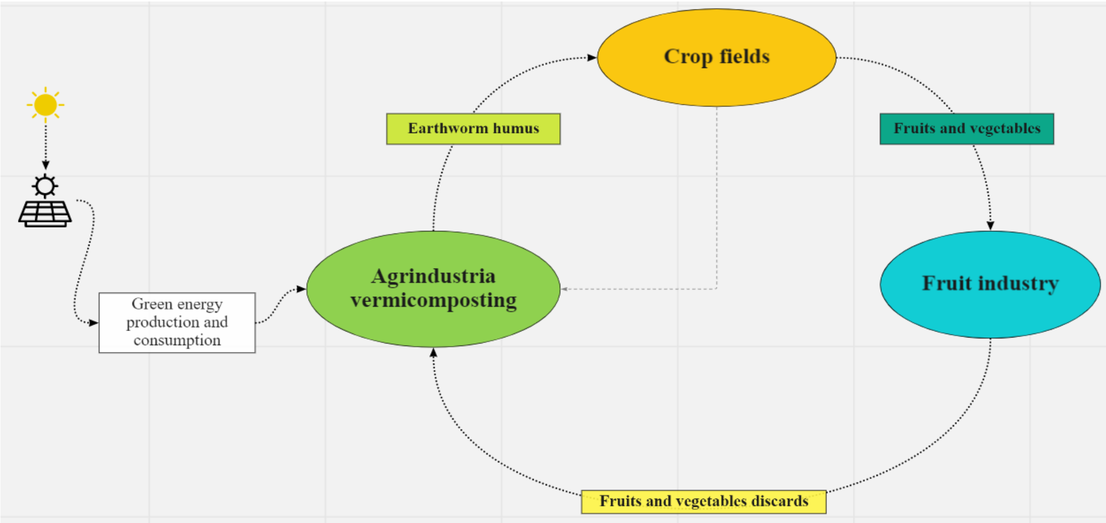
2.3. Benefits of the solution from the point of view of Circular Economy

2.3.1. Relevancy of the proposal

Figure 23 - Circularity of our proposal[54]

[53] Google images

[54] Own elaboration



The relevance of creating a worm farming or “lombricoltura” is its **circularity**: wastes from the food industry (more particularly of the fruit industry) directly connected to agriculture, are collected, and at the same time the product obtained can then be used in those fields. It also responds to the general way in which the company operates by using a circular economy approach and valorising by-products that otherwise would be lost when they still can be profitable. At the same time, by doing “lombricultura”, our company high-scales an activity that is generally done on a small scale like in family farms or in the backyard of normal households, and makes it “industrial”.

The execution of this project would, in addition, place the company in a position to **promote not only the circular economy, but also sustainable agriculture**. Moreover, this role could be highlighted if the company decided to work as an **educational centre**, and visits and lectures on the subject could be given. At the same time, it **could create a precedent** that could be replicated in other parts of the territory, but also in other locations, since like the boss of Agrindustria always says “there are byproducts waiting to be used all over the world”.

By combinating the vermicomposting part with the installation of photovoltaic panels, they will create a hybrid-system that still is very rare not only in Italy but also around the world, and could easily be the pioneers on doing that in their region.

Finally, from the perspective of the territory, the implementation of this project could help to **create connections between the different companies** in the area. This would be enhanced by the synergies that can arise between these enterprises. Both Alpenfrucht and L’orto del gallo work with products produced locally and with organic farming, so they could facilitate the entry of our product, the worm humus, into that niche. All these actions would create a more united community worried about the principles of circular economy and sustainability.

For the company it is relevant because the implementation of vermicomposting does not have high costs while its benefits can be very important. When this is combined with the installation of solar panels the benefit is even greater, because even if there is an initial investment, this investment could really quickly be recovered by eliminating the costs that today the enterprise has because of its dependency on the general energy network. And by the creation of energy surpluses they would get a supplementary profit.

3. Investment cost and profitability analysis

3.1 Introduction

Our project is based on the multilateral development of vermiculture and the installation of solar panels to save energy. Therefore, we consider it best for Agrindustria and, in accordance with our proposal of phased development, to split the budgets into 3 phases.

In this way, provide an overview of the initial investment, the cost of the expansion phase and finally the budget for the third part. This also includes an estimate of the expected profit from the sale of Humus as the company's own product.

3.2 Cost of the proposed solution

First of all, the initial investment for the first year of vermiculture experimentation. We present this prototype budget; as income we count on the dry discards that Agrindustria owns and in which we would not have to invest anything. On the other hand, the land on which the experimentation will be carried out is also owned by the company. On the cost side, a rough calculation of the investment in earthworms, fruit discards and animal compost has been made in proportion to the size of the land to be used, as direct cost.

Table 7- Budget for the Phase 1- Phase of Experimentation (10%)[55]

[55] Own elaboration

BUDGET FOR THE FIRST STEP OF THE PROJECT
Project: Lombriculture first phase
MULTITRACES PROJECT
Duration of the project: 1 year

COST		INCOME	
DIRECT COST	(in euros)	Self-financing (own resources)	
- Worms	1.000	- Dry discards	0
- Fruit discards	50	- Land	0
- Animal Compost	100	-	
INDIRECT COST		Government subsidies	
- Labour force*		- University project for experimentation	*
· Earth preparation	5.940		
· Water installation	1.000		
Estimated cost	9.090€		
TOTAL			9.090€

Inicial worms → 60.000 / * 1m² x 1,80 = 1,80€/m2 /

In this case, a total area of 33,000m2 and 10% of the land is used for the first phase (3,300m2). 1,000 euros will be invested in earthworms, being these 60.000. 50 euros in fruit discards that are approximately 5,000kg and 100 euros in animal compost that correspond to 20,000kg.

These quantities correspond to the initial division we have made for vermiculture in which we have established that 30% dry discards, 30% fruit discards and the remaining 40% animal manure will be used. The amount of animal compost is higher because this discard is the only one with nitrogen, and it is also the one commonly used to cover the agricultural lane. In this way, it will serve as a protector for the worm farm until the solar panels are installed.

As an indirect cost we have water, with a price of 1,000 euros established for the implementation of the drip system that will go beyond vermiculture, and the preparation of the soil to start the humus creation process, at 1.80 €/m².

Lastly, for this first budget, an agreement could be reached with the Politecnico di Torino from which funding could be drawn for the experimental year.

Table 8- Budget for the Phase 2- First phase of extension (30%) and Second phase of extension (91%)[56]

[56] Own elaboration

BUDGET FOR THE THIRD STEP OF THE PROJECT
Project: Lombriculture second phase; Expansion time
MULTITRACES PROJECT
Duration of the project: 1 year

COST		INCOME	
DIRECT COST	(in euros)	Self-financing (own resources)	
- Worms	1.000 → 2.000	- Dry Discards	0
- Fruit discards	50 → 100	- Land	0
- Animal Compost	100 → 200		
INDIRECT COST		Sales	
- Labour force		- Humus	1.170.000
· Water	1.000 → 2.000		
· Earth preparation	11.880 → 36.180		
· Salary remover	560 → 1.120		
· Packaging	3.000		
Estimated cost	44.600	Estimated income	1.170.000
TOTAL			1.125.400€

*20kg humus = 15,60€

The expansion phase is marked by the increase of land under vermiculture. This is why it gradually increases from 10% of the territory to 50% and finally to 91%.

Thus, in the direct costs, an investment in worms, fruit discards and animal compost is made again. It is divided into 50% investments followed by the investment for 91%.

On the other hand, in the indirect costs, the cost of land preparation and the cost of the implementation of the drip system are calculated as before.

In this case, the indirect cost of the worker's salary is also included, since the land will already be 100% occupied and it will be necessary to hire a person to manage the controls of the land on a daily basis.

In addition, the revenue would already talk about the benefits of selling the humus. We have set the price at 15.60 euros per 20kg bag of humus.

Approximately 25 kg of humus is produced per square metre over a period of 4 to 5 months. This calculates to two batches of humus per year. Our usable land is 30,000m2. If we calculate 1,500,000 kg of humus per year at the fixed price, this gives us a net profit of 1,170,000 euros per year.

In this section we have also included the cost of packaging. This is an indirect cost as Agrindustria already has the machinery for packaging. But it will still involve a cost in materials and energy, which we have set at 3,000 euros.

This is a rough calculation from which the estimated costs of the expansion phase (44,600€) are subtracted, giving a net profit of 1,125,400€.

Figure 24- Design of a possible packaging for the worm humus[57]

Table 9 - Budget for the Phase 3- Installation of the solar panels[58]

BUDGET FOR THE THIRD STEP OF THE PROJECT
Project: Lombriculture third phase; solar panels
MULTITRACES PROJECT
Duration of the project: 1 year

COST		INCOME	
DIRECT COST	(in euros)	Self-financing (own resources)	
- Worms	1.000	- Dry Discards	0
- Fruit discards	50	- Land	0
- Animal Compost	100		
- Solar Panels	374.500	Sales	
INDIRECT COST		- Humus	1.170.000
- Labour force			
· Water	500		
· Earth preparation	500	Government subsidies	*
· Solar Panels Installation	3.000		
Estimated cost	379.650	Estimated income	1.170.000
TOTAL			790.350€

Finally, we developed the budget for the third phase, when the solar panels will be installed over the whole territory at a height of 3 or 4 metres covering the worm beds. This will be used

[57] Own elaboration

[58] Own elaboration

for self-consumption and as a temperature protector for the generation of humus.

In direct costs, the solar panels of 2 x 1.5 metres are included in this step. Each vermiculture way needs 7 solar panels, which applied to the total of the territory adds up to 2.675 panels at a price of 140€ per panel gives the amount of 374.500€.

In addition, the indirect cost is the price of the installation, approximately 3.000 euros. The investment in earthworms and discards is maintained in this budget, as they will have to be renewed or added on a weekly basis. As well as the maintenance of the soil and water, an indirect cost of 500 euros has been left in case of unforeseen events.

On the other hand, the possibility of receiving help from the government or the European Union is added to the income, as renewable energies are on the rise and their use is being promoted by these organisations, as mentioned in the first section of this paper.

3.3 Benefit of the proposed solution

As reflected in the budgets explained above, a net profit of approximately 1,170,00 is expected to be generated from the sale of the humus.

At the same time, as the first year with the solar panels passes, the possibility of selling the electricity can be studied as a possible source of income as well.

3.4 Payback period

During the expansion phase, if the humus starts to be sold, funds could be raised to finance the installation of the solar panels. If there were any complications, during the following year the profits from the humus would be sufficient to recoup the full investment in the two projects.

4. Conclusions

Throughout this report we have justified and demonstrated the relevance of our proposal. At the level of our company, the benefits that the implementation of this proposal brings are not only the use of its dry discards and the production of energy so as not to depend on the general energy network and to be self-sustainable, but the benefit goes far beyond that.

Economically speaking the profits are remarkable. On the one hand, the investment costs are not too high, while the resultant product is really valuable in an environment like that of the Province of Cuneo, with such a high agricultural production, and therefore the market we are targeting is relatively high. Moreover, even if there are competitors, the number is not so high, and we have already highlighted different ways in which the company can differentiate its product from that of its competitors. On the other hand, although the initial objective of the company is to be self-sufficient in terms of energy, the installation of the photovoltaic panels on such a large terrain (30,000 m2) means tripling the area devoted to photovoltaic panels. And consequently tripling (at least) the energy produced. This will mean having a large surplus, which the company can then shell to the public grid and charge a profit for it.

As a result, the significance of this proposal is not only the benefits that it can have on the company, but also in its local territory and even as a part of a movement on a global scale. This is, by creating a product that makes possible the substitution of chemical fertilisers, it contributes to the transition into a more sustainable agriculture, the direct impact is on a local scale, but it ends up having an indirect impact on the global scale. In addition, it promotes a circular economy approach because it reuses waste that otherwise would be disposed of. And with a similar logic, having a direct impact at the local level, it also contributes to the global transition into green energy production and consumption. In short, this proposal contributes to **sustainable development**.

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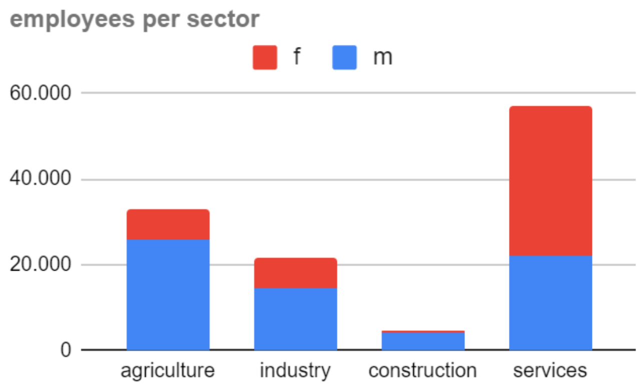
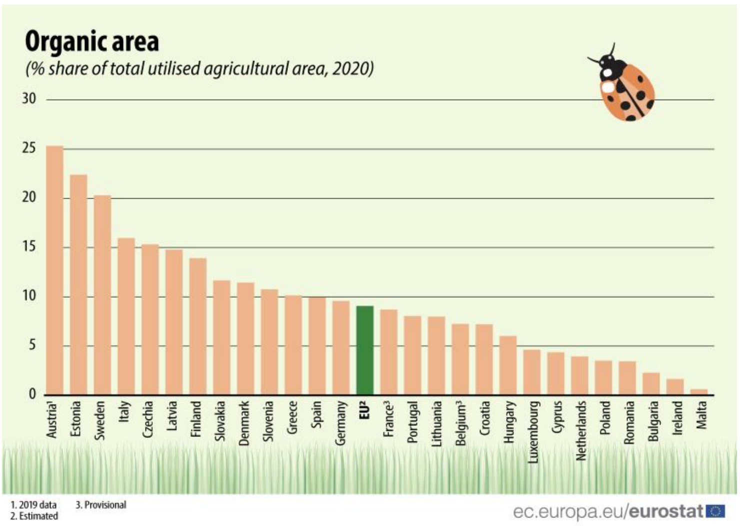
Annexes

- **Annex 1**



Source: Own elaboration with data from Regione Piemonte - Settore Politiche del Lavoro su dati Sistema Informativo Lavoro Piemonte.

- **Annex 2**



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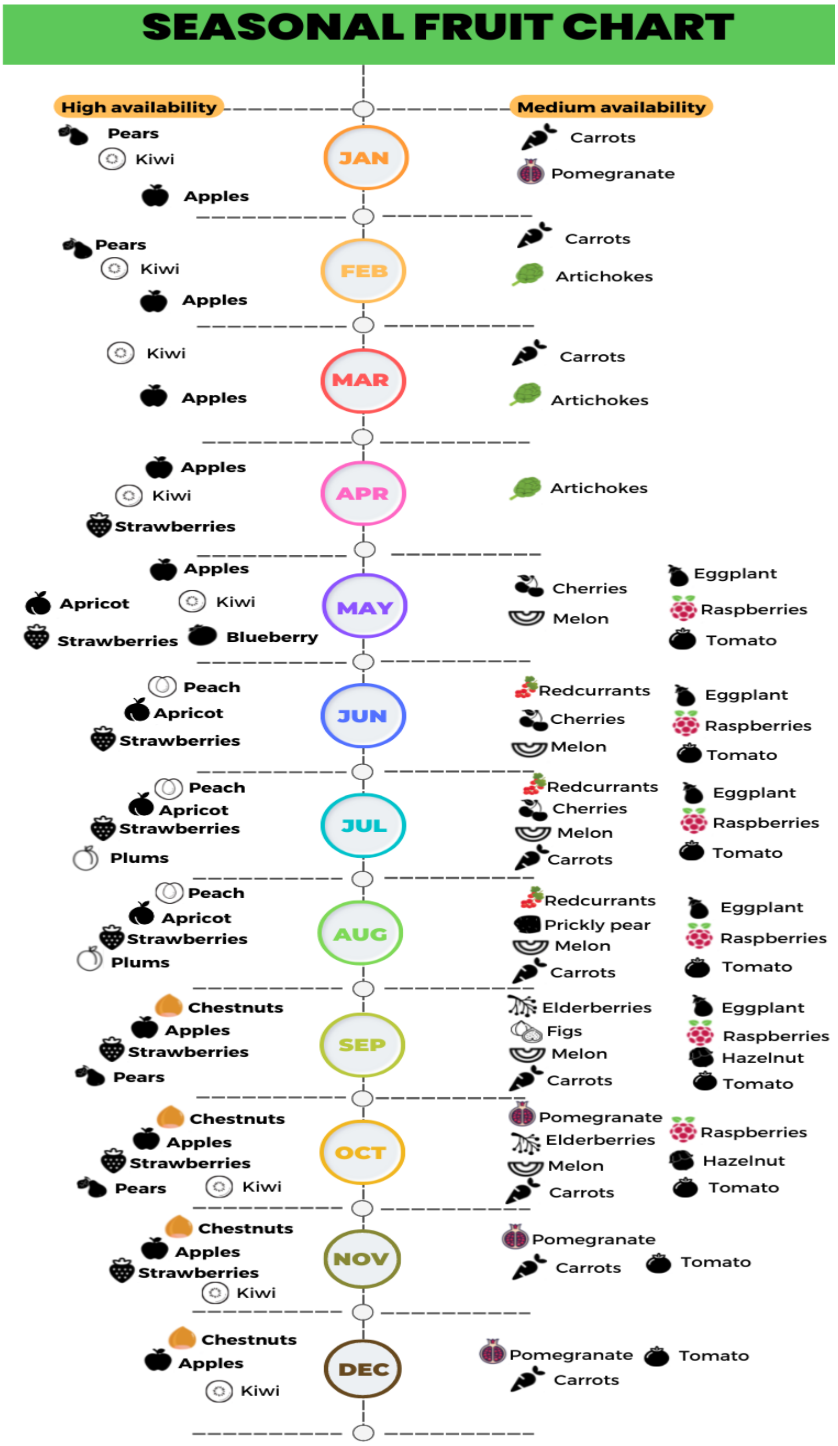
- **Annex 3**



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WOOD CHOPPING MACHINE

LUCA VLAD-CONSTANTIN

SIDROPOULOU EFTHIMIA

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Annexes

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1. Memory of the project

1.1 Executive Summary

At the base of our research is the design, invention, the idea to creat a new industrial machine that can cut and grind scraps of wood, so we can make a powder which agrindustria is going to use it in order to produce another products destined for customers.Agrindustria wants this machine because they would not have to buy any powder from other producers, this way they could double the quantity they can own.But, to produce this powder, we had to think about the machine in the most economical way, it has to be easy to use, easy to produce, and to be friendly with the environment, and how we can feed it energetically. To be able to start everything, we first analyzed the climatic, zonal, territorial data of the Cuneo area where we want to proceed after a strict analysis of these data, only then could we start the work, so we thought and looked for materials that we can we use the cheapest and best ones. We relied on the EU strategy in order to be able to bring the best project we could possibly made, we analyze the circular economy.Then we made an analysis about how we can have it and we took every opportunity, we thought it down to the smallest thing so that we were sure that the final choice would be the right one, so we detailed about hydropower, photovoltaic system and bioenergy. We have analyzed each of these in detail with the SWOT analysis. About the machine, we have mostly detailed the main parts of this machine, initially having two such machines in mind, then analyzes which of them could be the easiest and fastest to use so as not to exceed the budget granted. Having all the cards on the table, only then could we made a final decision choosing the best and most advantageous solution for Agrindustria Tecco SRL.

1.2 Introduction

At the base of this project, the principal areas which we would adress are the renewable energy, the energetic efficiency, the recuperation of wastes, and the production of a new product as well.

Renewable energy is energy derived from natural sources that are replenished at a higher rate than they are consumed. Sunlight and wind, for example, are such sources that are constantly being replenished. Renewable energy sources are plentiful and all around us.[1]

Fossil fuels - coal, oil and gas - on the other hand, are non-renewable resources that take hundreds of millions of years to form. Fossil fuels, when burned to produce energy, cause harmful greenhouse gas emissions, such as carbon dioxide.[1]

Generating renewable energy creates far lower emission than burning fossil fuels. Transitioning from fossil fuels, which currently account for the lion’s share of emissions, to renewable energy is key to addressing the climate crisis.[1]

So, in search of this new renewable energy, we approached 3 big topics trying to find the most suitable one:

- Hydropower energy
- Photovoltaic system
- Bioenergy

Hydropower energy

First of all, we had to see what hydropower energy is , so we started to search.

Hydropower harnesses the energy of water moving from higher to lower elevations. It can be generated from reservoirs and rivers. Reservoir hydropower plants rely on stored water in a reservoir, while run-of-river hydropower plants harness energy from the available flow of the river.[1]

Hydropower reservoirs often have multiple uses - providing drinking water, water for irrigation, flood and drought control, navigation services, as well as energy supply.[1]

Hydropower currently is the largest source of renewable energy in the electricity sector. It relies on generally stable rainfall patterns, and can be negatively impacted by climate-induced droughts or changes to ecosystems which impact rainfall patterns.[1]

The infrastructure needed to create hydropower can also impact ecosystems in adverse ways. For this reason, many consider small-scale hydro a more environmentally-friendly option, and especially suitable for communities in remote locations.[1]

How Does Hydropower Work?

Hydropower technologies generate power by using the elevation difference, created by a dam or diversion structure, of water flowing in on one side and out, far below, on the other. The Department of Energy's "Hydropower 101" video explains how hydropower works and highlights some of the research and development efforts of the Water Power Technologies Office (WPTO) in this area.[2]

What is the cost of Hydropower energy?

Hydropower is an affordable source of electricity that costs less than most. Since hydropower relies only on the energy from moving water, states that get the majority of their electricity from hydropower.[2]

Compared to other electricity sources, hydropower also has relatively low costs throughout the duration of a full project lifetime in terms of maintenance, operations, and fuel. Like any major energy source, significant upfront costs are unavoidable, but hydropower's longer lifespan spreads these costs out over time. Additionally, the equipment used at hydropower facilities often operates for longer periods of time without needing replacements or repairs, saving money in the long term.[2]

The installation costs for large hydropower facilities consist mostly of civil construction works (such as the building of the dams, tunnels, and other necessary infrastructure) and electromechanical equipment costs (electricity-generating machinery). Since hydropower is a site-specific technology, these costs can be minimised at the planning stage through proper selection of location and design.[2]

What are the benefits of Hydropower energy?

The benefits of hydropower have been recognized and harnessed for thousands of years. In addition to being a clean and cost-effective form of energy, hydropower plants can provide power to the grid immediately, serving as a flexible and reliable form of backup power during major electricity outages or disruptions. Hydropower also produces a number of benefits outside of electricity generation, such as flood control, irrigation support, and water supply.[2]

Photovoltaic system

A photovoltaic (PV) system is composed of one or more solar panels combined with an inverter and other electrical and mechanical hardware that use energy from the Sun to generate electricity. PV systems can vary greatly in size from small rooftop or portable systems to massive utility-scale generation plants. Although PV systems can operate by themselves as off-grid PV systems, this article focuses on systems connected to the utility grid, or grid-tied PV systems.[3]

How do these System work?

The light from the Sun, made up of packets of energy called photons, falls onto a solar panel and creates an electric current through a process called the photovoltaic effect. Each panel produces a relatively small amount of energy, but can be linked together with other panels to produce higher amounts of energy as a solar array. The electricity produced from a solar panel (or array) is in the form of direct current (DC). Although many electronic devices use DC electricity, including your phone or laptop, they are designed to operate using the electrical utility grid which provides (and requires) alternating current (AC). Therefore, in order for the solar electricity to be useful it must first be converted from DC to AC using an inverter. This AC electricity from the inverter can then be used to power electronics locally, or be sent on to the electrical grid for use elsewhere.[3]

System Components

In addition to the solar panels, there are other important components of a photovoltaic system which are commonly referred to as the "balance of system" or BOS. These components (which typically account for over half of the system cost and most the of maintenance) can include inverters, racking, wiring, combiners, disconnects, circuit breakers and electric meters.[3]

Solar Panel

A solar panel consists of many solar cells with semiconductor properties encapsulated within a material to protect it from the environment. These properties enable the cell to capture light, or more specifically, the photons from the sun and convert their energy into useful electricity through a process called the photovoltaic effect. On either side of the semiconductor is a layer of conducting material which "collects" the electricity produced. The illuminated side of the panel also contains an anti-reflection coating to minimise the losses due to reflection. The majority of solar panels produced worldwide are made from crystalline silicon, which has a theoretical efficiency limit of 33% for converting the Sun's energy into electricity. Many other semiconductor materials and solar cell technologies have been developed that operate at higher efficiencies, but these come with a higher cost to manufacture.[3]

Inverters

An inverter is an electrical device which accepts electrical current in the form of direct current (DC) and converts it to alternating current (AC). For solar energy systems, this means the DC current from the solar array is fed through an inverter which converts it to AC. This conversion is necessary to operate most electric devices or interface with the electrical grid. Inverters are important for almost all solar energy systems and are typically the most expensive component after the solar panels themselves. Most inverters have conversion efficiencies of 90% or higher and contain important safety features including ground fault circuit interruption and anti-islanding. These shut down the PV system when there is a loss of grid power.[3]

Racking

Racking refers to the mounting apparatus which fixes the solar array to the ground or rooftop. Typically constructed from steel or aluminium, these apparatuses mechanically fix the solar panels in place with a high level of precision. Racking systems should be designed to withstand extreme weather events such as hurricane or tornado level wind speeds and/or high accumulations of snow. Another important feature of racking systems is to electrically bond and ground the solar array to prevent electrocution. Rooftop racking systems typically come in two variations including flat roof systems and pitched roof systems. For flat rooftops it is common for the racking system to include weighted ballast to hold the array to the roof using gravity. On pitched rooftops, the racking system must be mechanically anchored to the roof structure. Ground mounted PV systems, as shown in figure 4, can also use either ballast or mechanical anchors to fix the array to the ground. Some ground mounted racking systems also incorporate tracking systems which use motors and sensors to track the Sun through the sky, increasing the amount of energy generated at a higher equipment and maintenance cost.[3]

Other Components

The remaining components of a typical solar PV system include combiners, disconnects, breakers, meters and wiring. A solar combiner, as the name suggests, combines two or more electrical cables into one larger one. Combiners typically include fuses for protection and are used on all medium to large and utility-scale solar arrays. Disconnects are electrical gates or switches which allow for manual disconnection of an electrical wire. Typically used on either side of an inverter, namely the "DC disconnect" and "AC disconnect" these devices provide electrical isolation when an inverter needs to be installed or replaced. Circuit breakers or breakers protect electrical systems from over current or surges. Designed to trigger automatically when the current reaches a predetermined amount, breakers can also be operated manually, acting as an additional disconnect. An Electric meter measures the amount of energy that passes through it and is commonly used by electric utility companies to measure and charge customers. For solar PV systems, a special bi-directional electric meter is used to measure both the incoming energy from the utility, and the outgoing energy from the solar PV system. Finally, the wiring or electrical cables transport the electrical energy from and between each component and must be properly sized to carry the current. Wiring exposed to sunlight must have protection against UV exposure, and wires carrying DC current sometimes require metal sheathing for added protection.[3]

Biomass energy

Bioenergy is produced from a variety of organic materials, called biomass, such as wood, charcoal, dung and other manures for heat and power production, and agricultural crops for liquid biofuels. Most biomass is used in rural areas for cooking, lighting and space heating, generally by poorer populations in developing countries.[5]

Energy created by burning biomass creates greenhouse gas emissions, but at lower levels than burning fossil fuels like coal, oil or gas. However, bioenergy should only be used in limited applications, given potential negative environmental impacts related to large-scale increases in forest and bioenergy plantations, and resulting deforestation and land-use change.[5]

Biomass can be defined as any organic material or waste that contains chemical building blocks like carbon, hydrogen, and other components that are vital to our modern energy and materials economy. Biomass is the single largest supply of carbon on planet earth and is a sustainable and renewable source for the products that are currently made from petroleum. Here's how it goes from waste to watts.[4]

Trees and plants absorb energy from the sun through photosynthesis. The energy is trapped inside until the organic material is converted into other products that are used as sources of energy and materials.[4]

There are several kinds of biomass such as agricultural residues, purpose-grown energy crops, and wood.[4]

For hundreds of thousands of years, humans have used wood, or charcoal made from wood, for fuel to heat homes and cook food.[4]

To make bioenergy from wood, scraps or sawdust can be collected from farms and forestry manufacturers. There are several ways to convert biomass into usable energy. It can even be turned into fuels to power cars, trucks, and airplanes![4]

To make fuels, wood is converted first to an intermediary gas or liquid that can be upgraded to make a final product such as gasoline, diesel, and jet fuel. It's almost like putting a tree trunk in your gasoline tank![4]

Biomass also includes wastes, and there are processes that work for many types of waste biomass, like animal waste. That's right, poop! Believe it or not, poop can be used to make electricity. [4]

Manure from farm animals, mostly cows, is put into a big tank called a digester. Like your own gut, a digester has bacteria that eats waste and turns it into methane gas. The methane is burned to heat water, and the water creates steam, the steam creates pressure that spins a rotor inside a turbine, the turbine powers a generator and the generator produces electricity. That's it! [4]

Methane can also be captured from landfills. When biomass decomposes it emits a gaseous product called bio-gas. Bio-gas is rich in methane and after some cleanup and upgrading, the methane gas can be captured and burned in the same process to make electricity or to heat your home and cook your food. [4]

Biomass can also be used to make products like polymers and plastics that are made from renewable sources of carbon and are either recyclable or biodegradable. This will help solve the problem of plastic waste. [4]

Yes, biomass isn't so glamorous, but it is a clean, renewable source of energy and materials that are essential to our modern society. [4]

Energy efficiency

Energy efficiency is the use of less energy to perform the same task or produce the same result. Energy-efficient homes and buildings use less energy to heat, cool, and run appliances and electronics, and energy-efficient manufacturing facilities use less energy to produce goods. [6]

Energy efficiency is one of the easiest and most cost-effective ways to combat climate change, reduce energy costs for consumers. Energy efficiency is also a vital component in achieving net-zero emissions of carbon dioxide through decarbonization. [6]

Energy Efficiency Benefits

Energy efficiency saves money, increases the resilience and reliability of the electric grid, and provides environmental, community, and health benefits. [6]

Cost savings

Energy-efficient buildings cost less to heat, cool, and operate, while industry and manufacturing plants can make products at lower cost. Energy-efficient transportation results in fuel savings. [6]

Community benefits

Energy-efficiency programs improve community resilience and address energy equity by bringing efficient, cost-effective technologies and infrastructure to underserved communities, including communities of color. [6]

These communities are disproportionately affected by air pollution and have a higher energy burden, which is the percentage of gross household income spent on energy costs. [6]

Environmental benefits

Reducing energy use is essential in the fight against climate change, because traditional power plants burn fossil fuels that release greenhouse gases and contribute to air pollution. Energy-efficient homes and buildings are also better equipped to switch to renewable energy, which does not produce harmful emissions. [6]

Resilience and reliability

Energy-efficiency improvements reduce the amount of electricity on the grid at one time. [6]

We think about energy efficiency in order to optimize the way the machinery works and not to use too much and to be able to reduce consumption so that we can use exactly as much as is needed and recycle to be able to reuse. [6]

Recovery of “wastes”

What happens when a product reaches the end of its useful life? Waste recovery can grant a new life to this waste by recycling, recovering, reusing, or transforming it into energy. Discover how this innovative waste management model works and how it serves as a key element for the economy of the future. [7]

In the past few years, the circular economy has become the main alternative for achieving a long-term and environmentally-friendly development model. Waste recovery, one of the major pillars of this strategy, makes it possible to extend the life cycle of products and transform waste into energy or raw materials, thus eliminating it from landfills. [7]

The European directive 2008/98/CE, of November 19, defines "recovery" as any operation in which the main goal is that the waste serves "a useful purpose by replacing other materials which would otherwise have been used to fulfill a particular function ." [7]

Wood recycling : From waste to resource

Wood is omnipresent.

Have you ever asked yourself how many everyday items are made of wood? It is probably much more than you think, and for good reason: wood is a highly versatile resource, used to create a variety of industrial and consumer products, ranging from furniture, panels, construction materials, paper-cardboard, and others. One of its main applications lies in particleboard manufacturing, an industry that is very promising and experiencing high demand but is facing challenges at the same time.[9]

With today’s skyrocketing prices for fresh wood and raw material bottlenecks, money is no longer growing on trees but can be found in recovered lumber and recycled wood content. Given the current virgin material prices in the wood segment and increasing environmental concerns, we need to turn to wood waste as a resource and gateway to new, sustainable business opportunities. Waste wood comes in huge quantities around the world and holds potential as a secondary raw material source for the wood industry. [8]
High-purity recovered wood chips offer the panelboard industry undeniable advantages. First and foremost, recycled wood is up to 40% cheaper than fresh wood and generally dryer, leading to energy savings during the drying stage of the particleboard manufacturing process. Moreover, recycling waste wood prolongs material circulation and reduces the need for additional lumbering. While higher grades of wood chips can be used for material recycling,

lower-grade waste wood can replace conventional fossil energy sources. If we keep recycled wood in continuous reuse, we can close the loop in particleboard production, therefore supporting the transition from a linear to a circular way of waste wood management. [9]

The benefits outlined previously are no stranger to the industry. [9]

Wood-based panel manufacturers are on the quest to increase recycled content in their production processes to ensure economic viability and reduce their dependency on virgin material. At the same time, they are looking to maximise output and keep, or even extend, their margins that have gotten increasingly thin because of the historic-high prices for fresh wood. Consequently, they are asked to expand their production volumes to cover their costs and operate profitably. [9]

Unfortunately, this is easier said than done. The lack of infrastructure in some countries, combined with material shortages, makes it hard for producers to access material and drive up production. While the waste wood collection, sorting, and recycling in central Europe are more developed, there is still a lot of room for improvement. Countries outside of Europe can use these best practices as a beacon to develop and invest in waste wood recycling. [9]

Establishing a well-functioning and smooth supply chain that includes waste wood recycling is vital to the future of wood-based products and the circular economy. [8]

In order for this to be possible, we want to use these scraps as they would be considered by the sellers, so we can purchase them at a very low price and we can use them fully to produce what we need, so we combine the useful with the pleasant also save the planet and get what we want. [9]

Circular Economy(CE)

In our current economy, we take materials from the Earth, make products from them, and eventually throw them away as waste – the process is linear. In a circular economy, by contrast, we stop waste being produced in the first place.[11]
The circular economy is based on three principles, driven by design:[10]

- Eliminate waste and pollution
- Circulate products and materials (at their highest value)
- Regenerate nature

It is underpinned by a transition to renewable energy and materials. A circular economy decouples economic activity from the consumption of finite resources. It is a resilient system that is good for business, people and the environment.[11]
The circular economy is a systems solution framework that tackles global challenges like climate change, biodiversity loss, waste, and pollution.[11]
We must transform every element of our take-make-waste system: how we manage resources, how we make and use products, and what we do with the materials afterwards. Only then can we create a thriving circular economy that can benefit everyone within the limits of our planet.[10]

EU strategy

A European Union (EU) macro-regional strategy is a policy framework which allows countries located in the same region to jointly tackle and find solutions to problems or to better use the potential they have in common. [12]
EU macro-regional strategies are initiated and requested by EU and non-EU Member States located in the same geographical area via the European Council. These strategies deal with common challenges and opportunities identified in each macro-region. [12]

The needs of the company in line with the wood chopping machine

The company, Agrindustria Tecco SRL, is interested in thinking and designing such a machine because it currently owns such powder, but it is bought in a limited quantity from another manufacturer, this quantity being 10-15 tons. but the agricultural industry wants to produce this powder itself, and to be able to do that, it needs such a machine, but this company wants to be as eco-friendly as possible, so it wants an eco-friendly machine, and here we intervened, where we came up with such an idea initially with 2 prototypes of which only one was chosen, the agricultural industry wants the amount of wood powder to be 30 tons of wood, this being produced from wood scraps which are much cheaper.

The objectives

Our goal was to make this machine exactly to their taste, so we had to respect some important criteria that they mentioned, which is that they want a wood-cutting machine :

- as compact as possible,
- as cheap to produce
- as possible easier to use
- as eco friendly as possible
- as efficient as possible

And in order to achieve this we thought that in addition to the way it will be built it must also have an energy supply that is eco friendly so then we I thought of three options that we discussed, these being the energy from :

- the photovoltaic system,
- the energy from biomass
- hydropower.

Then we could set everything up and start the detailed design.

1.3. State-of-art

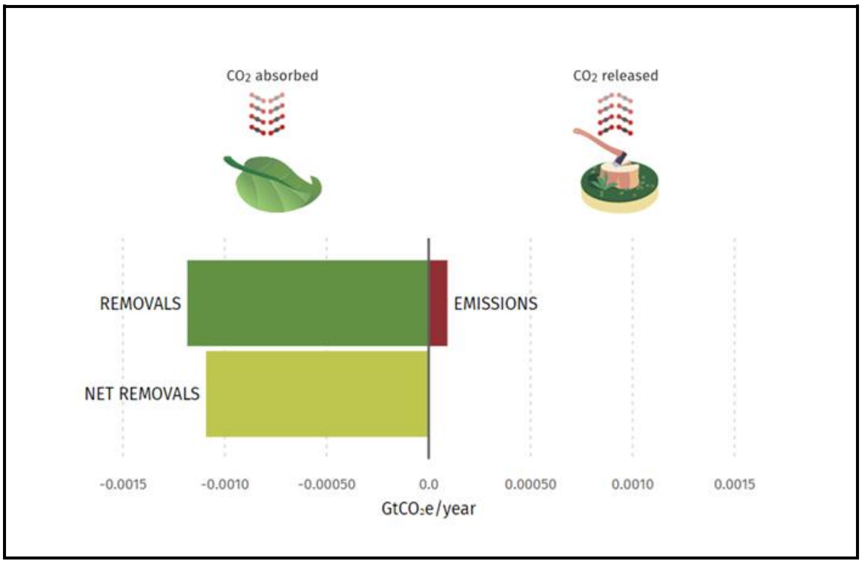
1.3.1 Historical framework of the context

A problem that we had to analyze was the one in which we had to analyze after seeing what the agrindustria wants was to see if it is also feasible and we can use these ideas that we have for the area in which it is located the company more precisely in the area of Cuneo, the region of Piemonte, so we did a detailed analysis of the climate of the land and the forests, then an analysis of the energy source, that is, more precisely of the photovoltaic systems, the energy from biomass as well as the hydropower

Analysis of the climate

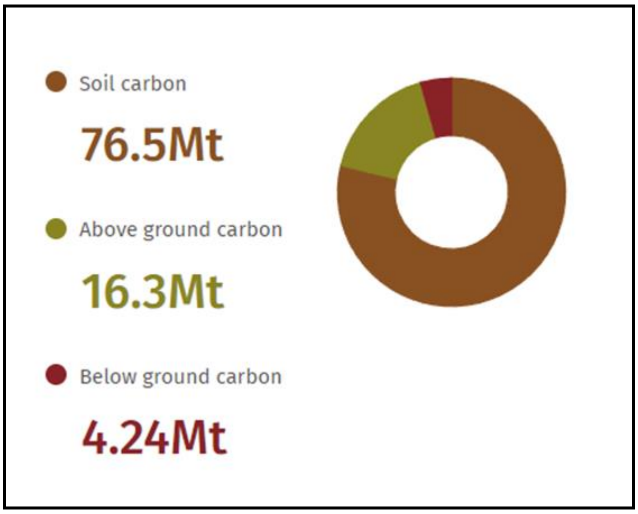
Explore interactive charts and maps that summarize the role forests play in climate change in Cuneo, Piemonte, Italy. Forest carbon statistics – including how forests store, emit and sequester (remove) carbon – can be customized, easily shared and downloaded for offline use. [13]

Between 2001 and 2021,forests in Cuneo emitted 92.0ktCO_2e/year, and removed -1.18MtCO_2e/year. This represents a net carbon flux of -1.09MtCO_2e/year.[fig.1.1.3.1] [13]



FOREST-RELATED GREENHOUSE GAS FLUXES IN CUNEO, PIEMONTE, ITALY[1.1.3.1] [13]

Cuneo has a total carbon store of 97.0Mt, with most of the carbon stored in soil.[fig.2.1.3.1] [13]



CARBON STOCK IN CUNEO[2.1.3.1]

In 2000, Cuneo had an aboveground live woody biomass density of 140t/ha, and a total aboveground biomass of 34.7Mt.[fig.3.1.3.1] [13]

1	Cuneo	34.7Mt
2	Torino	32.9Mt
3	Verbano-Cusio-Ossola	19.5Mt
4	Alessandria	11.4Mt
5	Vercelli	9.14Mt

ABOVE GROUND LIVE WOODY BIOMASS IN CUNEO, PIEMONTE, ITALY [3.1.3.1] [13]

In 2000, Cuneo had a soil organic carbon density of 112tC/ha, and a total carbon storage of 76.5MtC.[fig.4.1.3.1] [13]

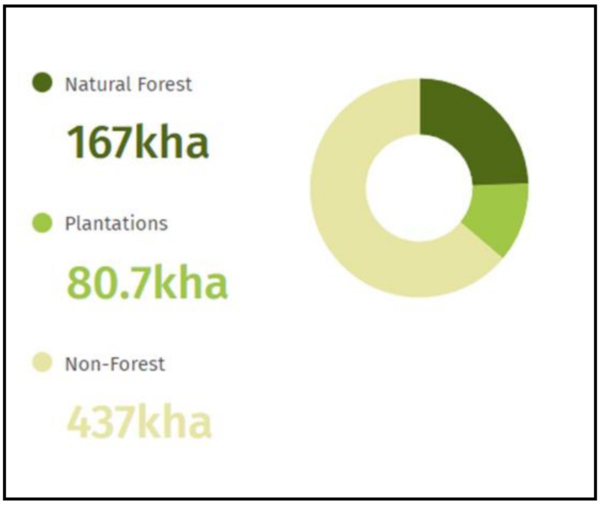
1	Torino	76.6MtC
2	Cuneo	76.5MtC
3	Verbano-Cusio-Ossola	34.7MtC
4	Alessandria	30.8MtC
5	Vercelli	22.7MtC

SOIL ORGANIC CARBON IN CUNEO, PIEMONTE, ITALY[4.1.3.1] [13]

Analysis of land cover

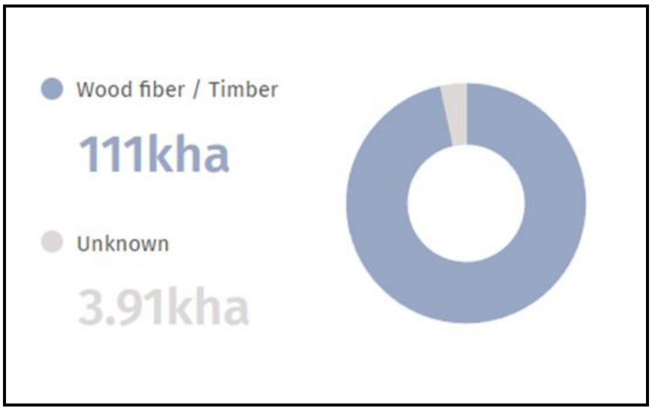
Explore interactive charts and maps that summarise forest extent in Cuneo, Piemonte, Italy. Statistics – including types of forest cover – can be customised, easily shared and downloaded for offline use. [13]

As of 2000, 24% of Cuneo was natural forest cover.[fig.5.1.3.1] [13]



TREE COVER BY TYPE IN CUNEO, PIEMONTE, ITALY[5] [13]

In Cuneo, wood fibre / timber represent the largest plantation area by type, spanning 111 kha and 16% of land area.[fig.6.1.3.1] [13]

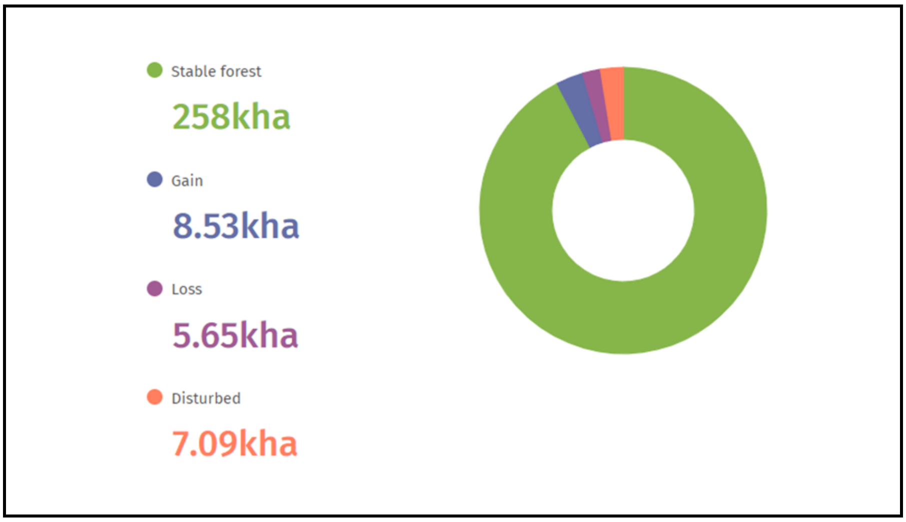


PLANTATIONS IN CUNEO, PIEMONTE, ITALY[6.1.3.1] [13]

Analysis of net forest change

Explore interactive charts and maps that summarize rates of forest change in Cuneo, Piemonte, Italy. Forest cover change statistics – including rankings of regions with the most forest loss and gain – can be customized, easily shared and downloaded for offline use. [13]

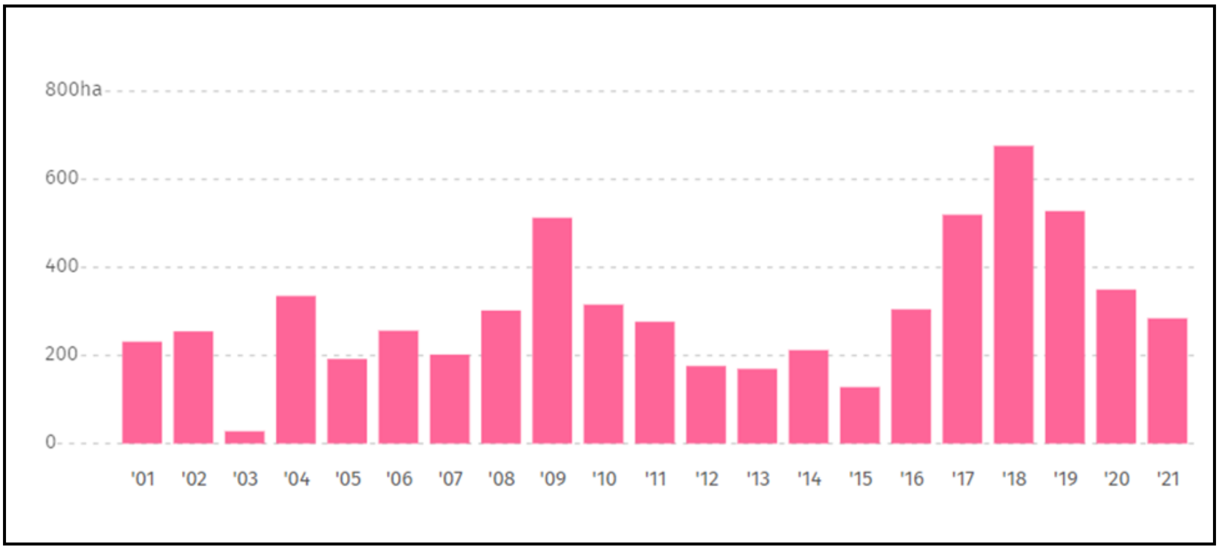
From 2000 to 2020, Cuneo experienced a net change of 2.88kha (1.1%) in tree cover.[fig.7.1.3.1] [13]



COMPONENTS OF NET CHANGE IN TREE COVER IN CUNEO, PIEMONTE, ITALY[7.1.3.1] [13]

Analysis of forest loss

From 2001 to 2021, Cuneo lost 6.25kha of tree cover, equivalent to a 2.5% decrease in tree cover since 2000.[fig.8.1.3.1] [13]



TREE COVER LOSS IN CUNEO, PIEMONTE, ITALY[8.1.3.1] [13]

From 2013 to 2021, 61% of tree cover loss in Cuneo occurred within natural forest. The total loss within natural forest was equivalent to 646kt of CO_2e emissions. [13]

From 2001 to 2021, Cuneo lost 6.25kha of relative tree cover, equivalent to a 100% decrease since 2000 and 39% of the global total.[fig.9.1.3.1] [13]

1	Cuneo	6.25kha
2	Torino	4.10kha
3	Alessandria	1.36kha
4	Asti	1.34kha
5	Novara	1.05kha

TREE COVER LOSS IN CUNEO, PIEMONTE, ITALY COMPARED TO OTHER AREAS[9.1.3.1] [13]

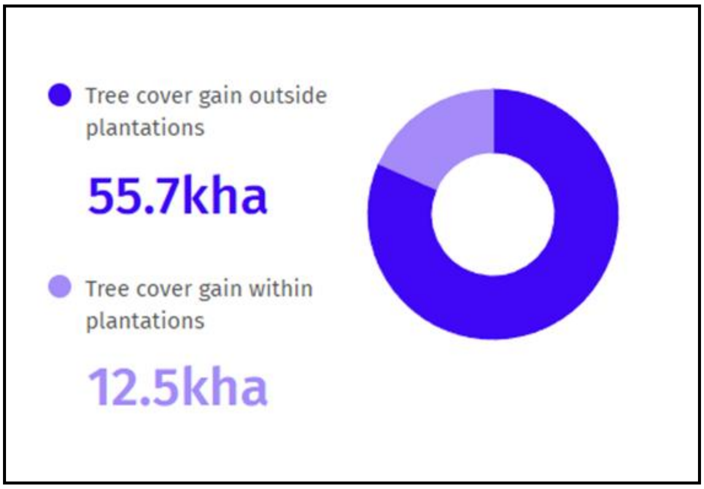
Analysis of forest gain

From 2000 to 2020, Cuneo gained 8.53kha of tree cover region-wide equal to 32% of all tree cover gain in Piemonte.[fig.10.1.3.1] [13]

1	Torino	8.64kha
2	Cuneo	8.53kha
3	Alessandria	3.02kha
4	Asti	2.53kha
5	Vercelli	1.25kha

TREE COVER GAIN IN CUNEO, PIEMONTE, ITALY COMPARED TO OTHER AREAS[10.1.3.1] [13]

In Cuneo between 2000 and 2020, 82% of tree cover gain occurred outside of plantations.[fig.11.1.3.1] [13]



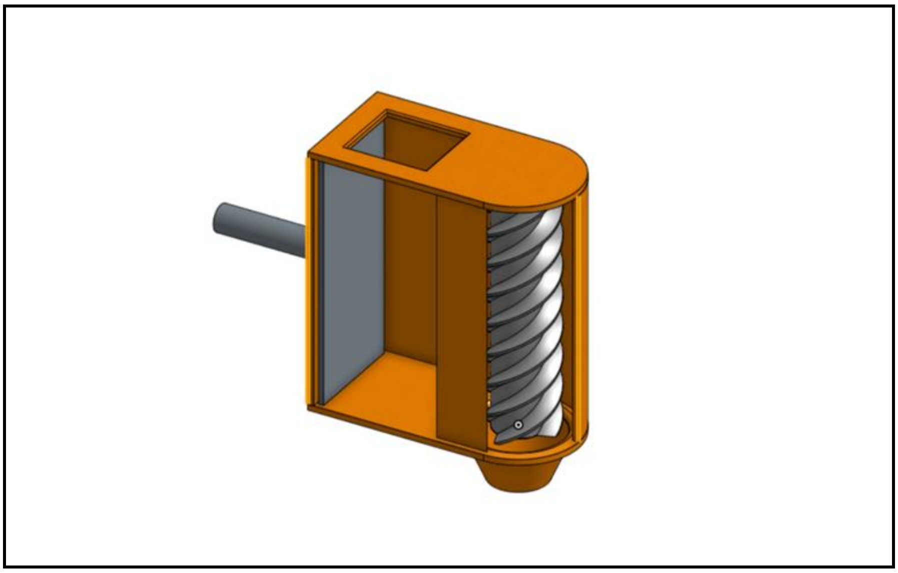
TREE COVER GAIN OUTSIDE PLANTATIONS IN CUNEO, PIEMONTE, ITALY[11.1.3.1] [13]

1.3.2 Existing solutions

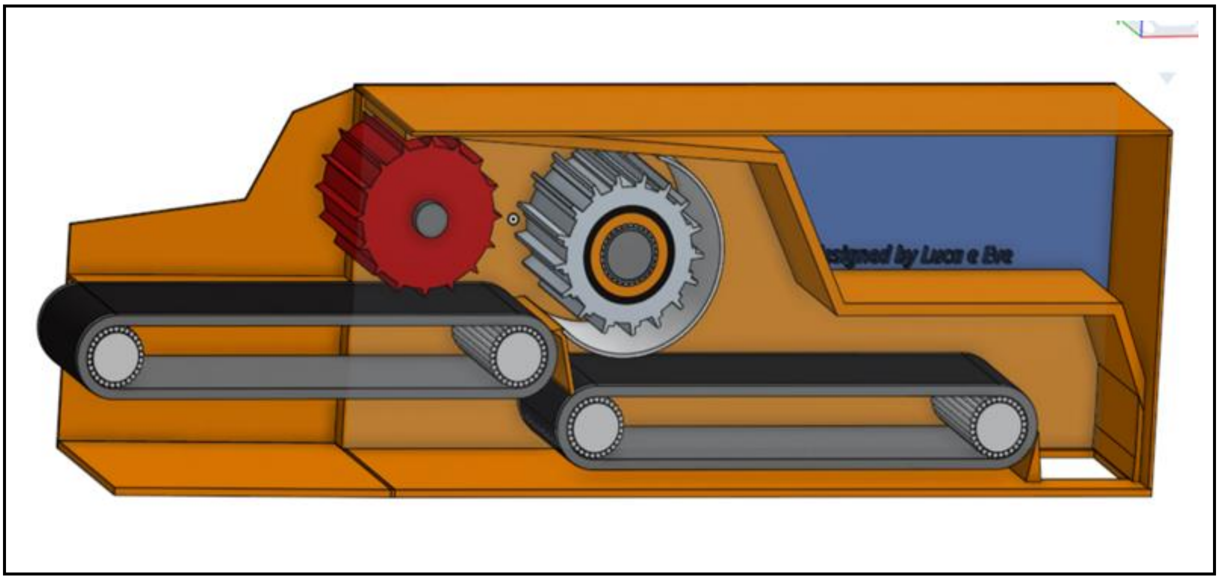
Having all the technologies and all the analytical data in front of us, we can look for the advantages and disadvantages of each one, this way choosing exactly the option that would suit us the most. analysing the analytical data related to the Cuneo area where agrindustria tecco srl is located, we can say that it is a good idea to choose this new production that uses wood because there is a lot of wood around, which means a lot of wood waste that we can and in relation to the energy we will use, analysing the results, we can produce energy from solar panels, which the agricultural industry already does in large quantities, so we can increase the number of photovoltaic panels, obtaining even more energy, or build a mini-hydropower plant or use the biomass making energy that we can use.

In terms of the machine, as possible solutions we have two concepts of machines one which has two parts in the main component, these being the following: an hydraulic press that is made to send the pieces of wood to be cut and the spiral cutter [fig.1.1.3.2] and the second concept with four main components and main technology : 2 conveyor belts, one for transporting wood and one for transporting powder, a dynamic roller that rises depending on the size of the wood to you could also catch it still to enter the next process,

The cutting process and another roller that has blades attached to it to be able to perform the cutting, these having an easy maintenance.[fig.2.1.3.2]



First concept machine[1.1.3.2]



Second concept machine[2.1.3.2]

1.4 Description of the final solution

Analysing all the analytical data related to the energy source components with the most advantageous raw components of this innovative project, I made the decision that a machine that has as main components a hydraulic press and a spindle on which knives are attached meant to shred the wood we produce, the wood remains, it will go through cutting which is also the second step of this operation, the first being the procurement of the raw material, this being the wood remains, it will go to re-phase the filtration which it is already incorporated in the company by the agribusiness, going to the last phase of processing and packaging of the final product, of the perfect powder as we called it. all this mechanism being energetically powered by photovoltaic panels, they are the best part of this company, offering the most power and being the easiest to implement.This is the process we must do to obtain the powder[fig.1.1.4]

STEPS THAT THE PROCESS MUST DO [1.1.4]

Phase 1 ~ Introduction of wood

The first phase through which the wood passes in this machine is that through which the wood is carried on the conveyor belt to the first wheel which has the role of pressing the wood and immobilising it so that it cannot go out and pass and follow the next phase.

Phase 2 ~ Wood chopping

The second phase is the one through which the wood passes, forced by the first phase, through the cutter that has caught by it blades that can cut the wood with a screw and a force so great as to produce powder from this wood then passing through a sieve going to the third phase of this machine.

Phase 3 ~ Powder filtration

The third phase is that in which the wood powder reaches the mobile filter which is made and has the mission to filter and obtain only the "perfect" powder that we want to get to use, and the "bad" powder it will be refined until it becomes a "perfect" one, and the good powder will move on to the fourth phase, this being the last.

Phase 4 ~ Product packaging

The fourth phase, the last one, is the one in which the finished product is packed and prepared to be sent for export, for sale, it will arrive in a machine that will fill a bag with this finished powder and will seal it.

1.4.1 SWOT analysis

In order to be able to decide, we had to do a detailed SWOT analysis, taking each source separately, extracting and exploiting all the information so that we can make the final decision.

Hydropower energy:

Various models have been developed to get insight into the impact caused by hydropower dam construction and operation. However, within the range of approaches that have been implemented and described in the literature, no best practice for model development, validation and use could be found. Model selection in the reviewed papers was based on the preference of the model developers and on objective parameters (e.g., Cohen's kappa, Akaike Information Criterion (AIC)). Often, site-specific criteria decide which approach is most suitable. In order to select the right model, a holistic approach is needed, considering the interplay between many elements such as the purpose of the model, the type of data present, the available knowledge [14] and the model outputs that are required [16]. Hence, the selection of an appropriate model should not only depend on statistical considerations [15,14,17]. Overall, good modelling practices include: the formulation of a clear purpose and research question; making adequate assumptions and considering their impact on the results; and an appropriate model evaluation [19]. Modelling results should be easy to present to different stakeholders and should be widely applicable [18]. We used a Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis to discuss the challenges and opportunities of applying ecological models to assess the impact of hydropower dams.[25]

Strengths:

- Suitability for exploring various types of dam impacts
- Explore water quality and habitat suitability for different dam management strategies
- Enabled syntheses of expert knowledge and empirical data
- Applicable at different scales

Weaknesses:

- Does not take into account the relevant biotic and abiotic interactions
- Non-transparent variable selection
- Lack of clear statistical criteria to assess the models and related thresholds
- Lack of model validation
- Predicts biotic responses (e.g., abundance, survival) using a limited number of variables.
- Model assumptions may not be valid in some situations
- Some models are either too complex or overly simplified.
- Models a low number of data

Opportunities:

- Increasing environmental data quality and availability
- Growing interest and technical advances in ecological modelling

- Integrated models become better and more reliable

Threats:

- Over- or under-prediction
- Expenses for data collection
- Extrapolation of the model to other regions, biotic element and spatial scale

Strengths

One of the main strength of using models in hydropower dam impact assessment is to perform scenario-based analyses to explore the change of water quality and habitat suitability under different dam construction, management and operation strategies. Kunz et al.found for instance that daily discharge data could be used to evaluate the effect of future changes in riverine sediment and nutrient concentrations on water quality. Hatten and Batt used depth and velocity simulations to predict the distribution of fish under different management scenarios and selected the most successful restoration actions. To explore the potential effects of flow variation related to hydropower on amphibians, Yarnell et al. used two-dimensional hydrodynamic modelling to simulate how hydraulic conditions vary between distinctive flow scenarios. In the next step, the output from the flow simulation was used as an input variable for a habitat suitability model to quantify biodiversity loss under several pulsed flow scenarios. A major advantage of model simulations is that they can detect specific adverse effects on the aquatic biota, allowing restoration strategies to be focused. Habitat modelling is a suitable tool to explore the impacts of for example hydropeaking flows on habitat availability, thus improving the understanding of long-term effects of hydropeaking on different life-stages of organisms and their abundance [22]. Models can be used to quantify the ecosystems' disturbance level compared to a given reference state [22]. They can be used for generating baseline data (e.g., simulation of conditions without dam) and predicting the habitat losses or habitat recovery. In addition, models can identify which restoration strategy is best under a variety of alternative management actions. As a consequence, predictive tools allow managers to assess potential outcomes before making costly decisions . The second strength is the possibility to integrate data originating from different monitoring campaigns and knowledge from literature and experts. For instance, meteorological information is easily obtained from meteorological stations, whereas river characteristics such as depth, substrate composition and water temperature can be measured in the field using a standardised sampling protocol with relatively low cost. However, challenges are often encountered when data are collected in large rivers, remote locations and under extremely high flow conditions . In cases where data are lacking or no data are available (e.g., inaccessible location, no pre-impact data available), knowledge-based models are useful tools because information can be obtained from the literature or from local and academic expert knowledge. For example, Boavida et al. [22] developed a fuzzy logic model to investigate the effects of hydropeaking on the habitat of fish in the Ocreza River, Portugal. This synthesis of expert knowledge and river engineering allows the use of simulated environmental conditions (e.g., depth, velocity) as predictors. Additionally, data-driven models can be integrated with expert knowledge-based approaches and hence improve model reliability. A final strength of most models is that they can be applied to a wide range of spatial scales varying from small creeks [21] to whole river basins or for different time scales [21]. [25]

Weaknesses

A notable weakness of existing ecological models used in hydropower dam impact assessment is that they are, as ecosystem-conceptualizers, often not able to accurately simulate interactions among physical-chemical properties and biological responses. In aquatic ecosystems, there are complex interactions between organisms and their biotic and abiotic environments. Therefore, ecological models should be constructed based on the good understanding of the reactions and the processes of ecosystems . However, the models presented in the selected papers often disregard the complex processes of ecosystems .

Although a few models combined two or more model types, no integrated protocol for model development was proposed. Overall, each modelling technique will be able to answer a specific set of research questions, and thus, the selection of the modelling technique is something that should happen prior to taking the in situ samples. The selection of a particular type of models will delimit the expectations one can have from a hydropower dam impact assessment. Understanding which factors are important, as well as being able to describe the interaction between factors will help managers to determine the potential management strategies [20]. For instance, flow alteration causes changes in water temperature [20], and this change in temperature also affects other variables such as pH and dissolved oxygen. These relational shifts can influence the survival, growth and reproduction of aquatic species . Most of the models reviewed in this paper have not taken important ecological control mechanisms into consideration (such as nutrient competition or the effect of zooplankton feeding on phytoplankton concentrations). Hydrodynamic models and water quality models only predict the changes of the physical-chemical water quality of the river,but often lack biological components. Several water quality models considered the impact of discharge on water temperature, but did not elucidate how temperature changes influence aquatic biota or how fluctuations in flow determined the habitat of aquatic biota. To assess the effect on aquatic biota, these water quality models should be coupled with habitat suitability models. Most papers often just represented one piece of the complicated processes related to the impact of hydropower dams and may have left out other relevant processes and interactions. For example, Sinokrot and Gulliver studied the impact of changing flows on river water temperatures, but they did not address the impact of temperature changes on aquatic habitat or the impact of flow fluctuations on the aquatic habitat or aquatic species. Although Yarnell et al. determined habitat suitability based on the abiotic or biotic conditions for a single target species or life stage, their models were not able to analyse the interaction of environmental variables on the survival, growth and successful reproduction of a particular species. Moreover, Null et al. [23] used estimates of suitable fish habitat for an entire river; however, habitat segments were not all connected in their analysis. Therefore, model prediction may be an overestimation of the habitat for anadromous fish or other migratory species. Moreover, Null et al. [23] estimated fish habitat that is linked to fish population dynamics as single measures of population response. However, population-level changes can have interactions with habitat modification. The model, therefore, fails to represent this aspect. Several models were not able to predict future densities of populations because the models did not account for the effect of non-hydraulic factors (e.g., temperature, riparian conditions and food availability) on the survival and ultimately future population dynamics of aquatic species . Another weakness occurring when using ecological models for hydropower dam impact assessment is the non-transparent variable selection. In the reviewed papers, models often used just a few hydraulic (velocity, flow) and hydromorphological (water depth, substrate) characteristics to define habitat suitability. For instance, Pert and Erman simply used water depth and average velocity in a 20-m reach of the river to define habitat preference for rainbow trout due to the difficulty in collecting information on other habitat characteristics. Although the outcome of the model was valid, the authors suggested considering other factors related to hydropower dam operation such as the time during the day (morning, afternoon) and long-term changes in discharge. When using models, challenges in exploring the effects of hydropeaking remain because it is strongly site-specific and also depends on the highly dynamic interactions between hydrology, hydraulics and morphological changes that can be hardly simulated [22]. Boavida et al. [22] have illustrated that hydropeaking impact is strongly dependent on river morphology in fish habitat simulations. Furthermore, Li et al. suggested that the variation of hydrologic frequency, as well as the maximum and minimum amount of water release from dams due to hydropeaking, should be taken into account in model development. In many cases, there will be an overlapping effect of general river regulation and hydropeaking impacts; thus, stressors are difficult to disentangle [22]. Environmental impacts of dams affect different life stages and different groups, which requires a different level of detail in model development. Nevertheless, most model approaches base their assessment on physical-chemical water quality or the habitat suitability of adult fish , including often purely the most common and economic valuable species (e.g., trout, salmon) or endangered species. One publication considered the impact of flow regulation on algae ; one paper focused on the effect on habitat suitability of amphibians ; and just three papers considered macroinvertebrates in their assessment. Another weakness is the lack of clear statistical criteria to assess the model fit. In addition, baseline data quantifying the ecological status prior to the building of the dam are often not available, which can result in lack of data for model development and model validation. Moreover, there is no standard sampling protocol available to allow a standardised assessment to investigate the potential impact of a hydropower dam, which is crucial for international comparability.[25]

Many models made assumptions and simplifications that may not be always valid in a certain condition. For instance, Rheinheimer et al. assumed that gains and losses were neglected from groundwater and from precipitation and evaporation on water bodies, respectively. Grand et al. [21] also assumed that backwater morphology remains constant; however, in reality, flood events can typically occur in the spring and may also occur later in the year. Furthermore, they simplified the calculations of invertebrate production by assuming that the entire invertebrate community can be represented by a single species. Moreover, Vezza et al. did not take into account the effect of biotic interactions. Knowledge of these assumptions provides caution to the model users. These assumptions may result in model uncertainties; thus, documenting these uncertainties, whether quantitatively or qualitatively, allows the model users to propose meaningful strategies for risk management. Moreover, the model's assumptions and simplifications may affect the model's predictability. Therefore, the model should always be evaluated through model validation . We, therefore, recommend that future studies should perform appropriate model validation and document the uncertainties coupled with the model. Furthermore, models can be improved by dealing the relevant assumptions. However, this may result in a complex model that eventually may require additional data. Models reviewed in this study ranged from very complex to overly simple. Fullerton et al. used numerous model outputs as input data to other models. As the modelling approach is complex, there are many layers of uncertainty (e.g., propagation of error) that are coupled to it. Furthermore, the model requires many different data. However, due to the models' complexity, the model is able to assess various outcomes as there are a variety of metrics that help assess a particular course of action. Conversely, Zhang et al. predicted the water flow using only the rainfall data and included a cyclic function to take into account the evaporation effect.

They developed a very simple model that oversimplifies the numerous hydrological processes. As a result, details of other hydrological processes could not be inferred. Examples of relatively simple ecological models were developed by Garcia et al.and Li et al.wherein a limited number of variables was used to predict biotic responses. However, variables not included in the model may have a relevant influence on the biotic responses. Thus, we recommend that careful variable selection should be performed during model development. The choice between a simple and complex model mainly depends on the purpose of the model and the preference of the end users. Although the users are interested in models describing water systems in a detailed manner, the model's functionality and user-friendliness are of paramount importance . Thus, during model development, it is important to take into account the preference of the final users. Some models were developed based on a relatively low number of data . This may result in poor model performance and/or model output covering a narrow range of environmental conditions. Future studies should consider standardizing data collection and incorporating additional data to increase the model's reliability[25]

Opportunities

An important opportunity related to the improvement of model prediction capacity is the increasing environmental data availability and data quality. The development of advanced environmental monitoring technologies could result in datasets with a large number of variables with high quality in order to deal with data scarcity and variability when developing models . Many European countries have established environmental monitoring networks to report on their river water quality. Another opportunity is the use of remote sensing methods for data collection. Apart from increased data availability, there has been substantial progress made in ecological modelling with regard to low quality or quantity data. When the amount of data is limited, datasets could be split into a training and validation set in order to test the robustness of the models. Moreover, independent experts could check model performance or the prediction of the model could be evaluated if the model output lies within the reliable ecological limits . Furthermore, the combination of lab results and ecological models and integration of data-driven models can be used to support decision-making in water management. When models are used for different scenarios' analysis for which no data exist, a possible way to validate predictions may be through creating different models of the same system and then comparing predictions between models , something that is typically applied for the assessment of environmental impact before hydropower dam construction. To solve the problem of the single impact approach, an integrated model can be applied. For instance, an integrated model that considers physical-chemical, hydraulic and hydro-morphological characteristics could be used to assess the multiple effects related to flow variation on the river ecosystem [24]. Using an integrated model allows gaining insight into the processes that occur on the river besides the direct impacts observed related to dam construction or wastewater discharges [24]. Models can be used qualitatively and quantitatively to consider climate change impacts on hydropower systems for hydropower relicensing . Given their numerous strengths and opportunities, their use to assess the impact of hydropower dams deserves further investigation. Future studies should explore the potential use of integrated models and the improvement of data collection to reduce the disadvantages of existing models or modelling techniques. Based on the above-mentioned opportunities in combination with technical advances in modelling, it is believed that ecological models can be widely used to support research on hydropower dam impact assessment[25]

Threats

Despite the clear strengths and opportunities of using ecological models in hydropower dam impact assessment, there are also some related threats to their use, especially if the most optimal sequence of the scientific method (i.e., firstly, the formulation of research question, then the selection of modelling techniques, then data collection, subsequently, the model development, then the model validation and, lastly, the interpretation of model outcome) is not followed. The management strategies solely developed based on model results could potentially pose a threat because the output derived from a model can sometimes be inaccurate or deviate from reality. Furthermore, models' outcomes can be overor under-predicted. Li et al. pointed out that the physiology of organisms varies over different life stages, and caution is needed when applying year-round data. Therefore, using one model for different life stages and for the whole-year conditions may lead to incorrect prediction results. Besides hydraulic characteristics, ecological components (e.g., riparian vegetation, present of predators, life stage of organisms), morphological characteristics (e.g., the spectrum of large river systems of the river) and physical conditions (e.g., temperature, turbidity, substrate, seasonal variation) are important factors that should be taken into account. The study of complex systems thus requires a multi-scale approach, in which it is necessary to consider the interactions occurring across many scales of space, time and organisation . Modellers should consider all relevant disturbances and predict various types of impacts before presenting the model output. Nevertheless, stakeholders involved in decision-making processes (e.g., policy makers, water managers, modellers) need to be aware of the uncertainties of the model outputs and the risks/impacts these entail for actions considered. Most of the models to study hydropower dam impacts were developed for particular organisms or a specific location. The habitat suitability criteria used might be suitable for a specific case, but they may not be useful for other locations; therefore, validation of the habitat suitability model on independent data originating from different geographic locations is required. For instance, models developed to assess the impact of small hydropower dams in mountainous streams might not be applicable to assess the impact on large lowland rivers . As a result, the choices of input variables and derived ecological indicators need critical review and validation by local experts before being reliable for model development. Finally, an assessment of hydropower dams based on model simulations has to be carried out with great care because models cannot always separate the dam impact from other anthropogenic influences .[25]

Photovoltaic system SWOT :

A. Strength

1) Limitless: Solar energy originates from the sun, and it is one of the main source of unlimited free energy available on Earth. Theoretically solar energy has the capacity to fulfill the energy demand of the world. Annually the amount of solar energy reaching the earth is approximated to be four million exajoules (1EJ = 1018J), of which 5 × 104 EJ is claimed to be easily harvestable. Despite this huge potential and increase in awareness, the contribution of solar energy to the global energy supply is still insignificant . Theoretically the amount of solar energy that touches the earth is 4200 times the energy that human population would consume in the year 2035. In few hours the earth can get the amount of solar energy that covers the annual energy consumption . Hence, developing an efficient and effective capacity of collecting solar energy could potentially solve the energy demand of the world without requiring additional sources of energies. The amount of solar energy that can be collected depends on the location. For example, India receives 4 to 7 KW/hr of solar radiation per square metre per day for more than 250 days per year .[26]

2) Environmental Friendly: The energy from the sun is collected and stored to generate electricity. This method is considered as a renewable alternative to non-renewable technologies. Thus, the usage of solar energy greatly reduces the negative impact of carbon emissions. In California USA, an average of 696,544 metric tons of carbon emission was reduced through the installation of solar system onto 113,533 households. In addition, solar energy does not release other harmful gases that could harm the environment. The solar panels used on household can be recycled. It can then be concluded that solar energy is a non-polluting, reliable and clean source of energy . [26]

3) Ease of usage/harvest: Solar energy is collected mostly using solar panels that generate electricity by using photovoltaic technology. Installation of solar energy system can be done anywhere. For instance, solar panels are now easily placed on the rooftops of houses and commercial buildings . However, one could say that it would be impossible to install solar system on their homes especially if they are not the sole owner or due to lack of space or shade requirement by others. In countries like America with the introduction of shared solar

energy there is no more problem with space unavailability. Homeowners can obtain electricity from the community solar garden without having solar panels on rooftop. [26]

4) Less overall cost: At first the investment of solar system seems expensive. Once solar system is installed the running cost is very low. Hence, in the long-run the cost benefit of using solar energy would be better than other sources of energy . Solar panels have low maintenance cost and can serve for 10 to 15 years with minor service. In addition, solar power benefits us in various ways such as tax incentives and added property values. Particularly when solar energy is used for specific purpose such as in draying of different products, the benefit obtained will be significant. In certain countries like USA, Germany, Denmark, UK and France drying of food products consumes 7-15% of industrial energy which can be done simply by solar energy .

Thus, for such processes solar energy is being used as an alternative source to reduce the high cost associated with drying. [26]

5) Versatile: Solar power is utilised either directly or indirectly in numerous applications that are not limited to industry purposes but also applicable on day to day usage such as, drying of agricultural and industrial products, solar powered refrigerator, water heating, solar cooking, etc. Using solar radiation for drying or removal of excess moisture from a product is a widely used method to meet the specification required for industrial processes. For instance, in the gasification process of biomass the moisture content of the feedstock should not exceed 20%, and this can be achieved by removing the moisture using solar driers . Solar energy is also widely used in cooking particularly in areas when the solar radiation intensity is high and no electricity . In solar cooking, radiation from the sun is concentrated at one point with the help of reflectors. Various type of solar cookers have already been invented such as box cooker, parabolic cooker, panel cooker and so on.[26]

B. Weakness

1) Solar Power is Available Only in Day Time: As solar radiation is available only in day time, photovoltaic panels and other collectors are able to convert solar energy into other forms of energy only when there is sunlight. For this reason solar power needs to have energy storage system to get uninterrupted power supply. The solar system is also installed with other power supplement to replace when the available solar radiation is not enough or the energy storage is not enough to supply for the rest of the day when solar radiation is not available. The backup system is also an additional cost that makes solar system more expensive . [26]

2) Solar Panels are inefficient: The conversion efficiency of solar panels are very low compared to other energy conversion system. The achievable conversation efficiency of the solar energy into usable energy by solar panels are not exceeding 20% in general. Because of the inefficiency of the panels, a large space is required to collect solar energy which is just enough for an average household . [26]

3) The Space Required for PV: Many photovoltaic cells are needed to absorb enough energy

for larger applications. The efficiency of photovoltaic panel drops dramatically due to overheating of the panel and as a result large quantities of solar panel is required . Since the space required for the solar collectors are large, identifying a space where it is not used for other purposes is frequently a challenging task. [26]

4) High Initial Cost: Although installation of solar system brings immense benefits, the initial investment cost is expensive. Quantifying the total cost is also difficult without the assistance of the manufacturing company. However, as most of the governments are concerned with the global warming that is caused by burning of fossil fuels, a subsidy and tax exemptions are provided for users of solar energy which helps to reduce the burden of overall installation cost of solar energy . [26]

C. Opportunities

1) Create New Business Opportunities: Every new innovation opens business opportunities. Currently, Tesla and Panasonic are orchestrating a huge solar panel manufacturing plant in Buffalo, New York. The powerwall produced by Tesla has increased dramatically in the recent years [16]. The demand of solar panels by real states are growing in recent years. Landowners have got opportunities to rent their unused land for new solar farms and get income. In countries like US, Germany, Italy, China, India, Japan and the UK, the market for solar products are growing very fast. Worldwide the demand for utilisation of solar energy increases by more than 9% every year. [26]

2) Increase Concerns in Using Fossil Fuels and Nuclear Energy: In many countries communities are protesting against installation of coal power plants and nuclear stations in their village. For example, in town of Kudankulam in Tamil Nadu, India, the local fisherman were protesting against the nuclear power station which was started to be built in 2002 . This condition would push governments and companies to focus on renewable energy source such as solar energy instead of other conventional fuels. [26]

3) Availability of Subsidy and Support: In most countries governmental and non-governmental organisations have subsidy and income tax exemptions schemes. The government of Malaysia has offered incentives for individuals and companies which use solar PV as energy sources instead of the conventional fuels. Since December 2011, the Government of Malaysia has implemented a Feed In Tariff scheme aiming to increase an investment in renewable energy sources. The Malaysian Feed In Tariff system permits production of electrical energy from renewable sources and sells the energy by connecting to the utility grid at a premium rate . The Malaysian government also has a tax exemption on a local manufactured solar PVs. The government of India has provided 30% capital subsidy for all solar power project under Jawaharlal Nehru Mission Scheme .[26]

4) Cost Reduction: Solar energy technologies are developing quickly and the computation in the market on the technologies are increasing. The competition in the technology leads to an improved efficiency and cost reduction.[26]

D. Threats

Although solar energy has been called as one of the clean energy sources, it still provides some sort of risk to the environment when being used in public. Some of the threat are discussed below. [26]

1) Health risks: A new investigation by Environmental Progress (EP) reported that lethal waste from the used solar panels presents a worldwide environmental danger. The disposal of solar panels, which contain unsafe components such as lead, chromium, and cadmium are running over the world, but effort to minimise the adverse effect is very minimal .According to EP research, developing nations like India and China frequently burn the e-waste to reclaim the copper wires which is profitable for resale. Since this procedure requires burning off plastic, the resulting smoke contains poisonous vapour that may cause cancer and teratogenic (birth deformity) when it's being inhaled. It is approximated that per quadrillion joules of energy produced, 11 and 21 deaths have been identified in conjunction with the solar energy health threats . [26]

2) High carbon footprint: A carbon footprint is characterised as the total amount of greenhouse gases produced either directly or indirectly in the process of realisation of a product. It is usually specified in equal tons of carbon dioxide (CO2). The fact is that even solar power plants have an environmental footprint on a lifecycle basis. For example, the Concentrated Solar Power (CSP) has an impression of 20 grams of carbon dioxide (CO2) per kilowatt-hour (kWh) of power delivered. In addition, CSP consumes a tremendous amount of water. On life cycle basis photovoltaic (PV) power plants also have carbon footprints which may reach 12g per kWh . The main components of solar PV panels are made from crystalline silicon. Manufacturing these components is an energy-intensive process that represents a high percentage of the total energy used to make solar panels. The exact carbon footprint of any solar panel relies upon numerous variables, including the materials source, the transported distance, and the energy used by the plants . [26]

3) Acquaintance with Fossil Fuels: It is crystal clear that fossil fuels are widely used all over the world since long time ago . Enormous amount of capital have been invested on power generation plants across countries that are using fossil fuels as a source of energy. These well-established existing technologies present a formidable barrier to shift the source of fuel from the conventional fuel source to solar source[26]

Biomass energy SWOT:

A. Strengths

Marginal land can increase the land availability to supply biomass production. It is estimated that the global abandoned agricultural land range from 430-580 Mha, which is part of marginal land . A nation-wide survey, organised by the China Ministry of Agriculture, on marginal land resources that may be used for energy crop production revealed an area of 34 million ha of which 7 million ha and 27 million ha are winter fallowed paddy land and wasteland marginal land, respectively. According to Yan et al. (2008)'s study, marginal land available for biomass production includes 82.3 million ha of which 24 million ha are cultivable. In consideration of economic operation of transportation, some 7 million ha can be considered available for energy crop use . According our definition of marginal land, the available marginal lands in APEC economies are about 4 million km2 or 6.5% of total land area[27]

Energy crop is a crop grown specifically for their fuel values, which include food crops such as corn and sugarcane, and non-food crops such as poplar trees and switchgrass . A number of energy crops can potentially be grown on marginal land to provide feedstocks for bioenergy, non -food products and biofuels, such as miscanthus which requires limited fertiliser, few other inputs and adds significant amounts of organic matter to the soil . According to the definition of available marginal land , available marginal land will be not used for food crops according its biophysical characteristics but some dedicated energy crop can be grown on it. Perennial lignocellulosic crops such as eucalyptus, poplar, willow or grasses require less-intensive management and fewer fossil-energy inputs and can also be grown on poor-quality land, while soil carbon and quality will also tend to increase over time .Meanwhile, the development of energy crops on marginal lands, provided that they are reasonably productive, has a major advantage over development of these crops on croplands from the standpoint of carbon impacts of direct land use change.[27]

B. Weakness

According to the marginal land quality, the yield of biomass on marginal land will be lower than it on agriculture land with good quality. Marginal lands in APEC economies have low productivity. The predominant NPP value is less than 6 t/ha/yr . FAO (2008) also found that switchgrass can be highly productive on fertile soils, especially when fertiliser and pesticides are applied,but that its performance on poor soils is lower . Meanwhile, the irregular shapes of marginal land increase overlap (the amount of turning required during field operations) and can result in overapplication of seed, pesticides and fertilisers, increased fuel consumption and increased work time but would not be a issue with woody biomass. Also, the marginal land usually has long distance away from the market, which will increase the bioenergy production cost. Therefore, the production investment will be higher than production on normal agriculture land. Low productivity and high production cost will restrict the economic viability. Some marginal land can be used for grazing, so the opportunity cost should also be concerned and it will also increase the production cost of planting energy crops on marginal land. [27]

Although the energy crop production on marginal land have the positive environmental impact such as restoration of degraded land and carbon sequestration. But if the marginal land is covered by permanent grassland, a carbon dept might occur when converted to energy crops. Further, if only dispersed areas of marginal land are used for energy feedstock production, the CO2 emissions associated with transport of the feedstock to the end user could negate all the potential C-mitigation. Failing in C mitigation could put a break on the development of energy crop production and full lifecycle and regional specific Life-Cycle Analysis (LCA) would be necessary to assess the GHG mitigation potentials of energy crops

.[27]

Marginal lands often provide subsistence services to the rural poor, including many agricultural activities performed by women. The emphasis on exploiting marginal lands for biofuel crop production may work against female farmers. For example, in India, these marginal lands, or so-called “wastelands”, are frequently classified as common property resources and are often of crucial importance to the poor. Evidence from India shows that gathering and use of common property resources are largely women’s and children’s work – a division of labour that is also often found in West Africa [19].However, women are rarely involved in the management of these resources. Whether the poor stand to benefit or suffer from the introduction of biofuel production on marginal lands depends critically on the nature and security of their rights to land . [27]

C. Opportunities

A lot of countries have their renewable energy planning targets in the future to reduce greenhouse gas emissions to mitigate climate change. For example, the US Energy Independence Security Act of 2007 mandated the production of 36 billion gallons of biofuels by 2022, of which 21 billion gallons must be advanced biofuels. This mandate would result in an increase in biomass production of approximately seven times the current amount—from 190 million dry tons to 1.36 billion dry tons of biomass. Biomass is a land-based renewable resource and such a significant increase is likely to result in large-scale conversion of land, from current uses to energy feedstock generation, potentially causing increases in the prices of food, land, and agricultural commodities as well as disruption of ecosystems .Therefore, to achieve the renewable energy planning target and ensure food safety, marginal land will be an attractive option for biomass production. Based on Milbrandt and Overend’s (2009) estimation, the total annual biomass resource potential on marginal lands in APEC economies was about 1.3 Gt, which converts roughly into 260 Mt of gasoline equivalent. By comparison, APEC uses about 621 Mt of gasoline and crude oil import is about 1.3 Gt annually (IEA 2006). So the gasoline potential from marginal lands could displace two-fifths of the region’s gasoline consumption and one-fifth of its crude oil imports. [27]

There already been a lot of energy policies and climate change policies to encourage bioenergy development, such as subsidies and carbon credit and tax. Although there are not policies directly related to biomass production on marginal land, the existed biofuel promoting policies will drive farmers to consider plant energy crops on marginal land. Also, the agriculture policies about marginal land will affect the use of marginal land and create the opportunities for farmers to consider plant energy crops. For example, the new Green Cover program, a $110 million national initiative, encourages landowners to convert marginal cultivated land to permanent cover . This program will make landowners to accept planting energy crops on marginal land as the economic driving. Meanwhile, as the biomass conversion technology development, the non-food energy corps conversation cost will decrease; it will make dedicated energy crop production on marginal land much more competitive. [27]

D. Threats

Marginal lands are usually far away from the market, so biomass transportation will consume much more fuel from marginal land. The high energy price will increase the transportation cost and will make biomass from marginal land less competitive than other feedstocks. Also the labour cost is higher in developed countries than it in developing countries. Therefore, bioenergy production on marginal land will have the comparable advantage in developing countries according to the lower labour cost. 4.4.2. Natural hazards and Crisis on financial market Natural hazards threaten energy crops harvest, such as poplar is usually harvested every six years. If there is a natural hazard before the harvest year, it will reduce a greater loss of energy crops from marginal land than annual crops from agricultural land. Meanwhile, the crisis on financial market will also pose a threat to bioenergy production on marginal land, because it will be in a difficult condition for new investments to improve the production and conversion technologies of dedicated energy crops from marginal land.[27]

2. Calculation and design of the system/ installation/equipment

Wood chopping machine

2.1 Input data of the project

-location

- ➢ The plot of land is situated inside the terrain owned by Agrindustria Tecco at the following coordinates: 44.45737587801233, 7.52197442146343. [fig 2.1.1]

- Numerical data

- ➢ - The dimensions of the parcel are N≈155m, S≈155m, E≈170m, W≈200m and the total amount of square metres is ≈33.000m2.

Location were we execute the project[2.1.1]

- Other information

There are ranked as the second lakes called Laghetti di Tetto Lupo and birding that are quite close to the rabbit in the company of Agrindustria, located 14.5 kilometres away.Two artificial lakes that have been made on the Tetto Lupo site serve as a wetland of passage and link to other bigger places, including the Oasi della Madonnina.

The Consortium Irriguo Valle Gesso built the two lakes—one larger and one smaller—as part of a larger initiative to streamline the use of water resources.

The two interconnected lakes have a combined area of about 7.5 hectares and a reservoir capacity that ranges from 50 to 100,000 m3. They are supplied by a hydroelectric plant's discharge, which is supplied via an outlet that begins upstream of the Spinetta village.

Torrente Gesso[fig 2.1.2], a sizable river, is also located at a smaller kilometres distance beginning at 13.8 kilometres; it has more water at some seasons of the year than others. However, it has been observed that the water is declining more and more from year to year as a result of rapid climate change.

Torrente Gesso[2.1.2]

Links:

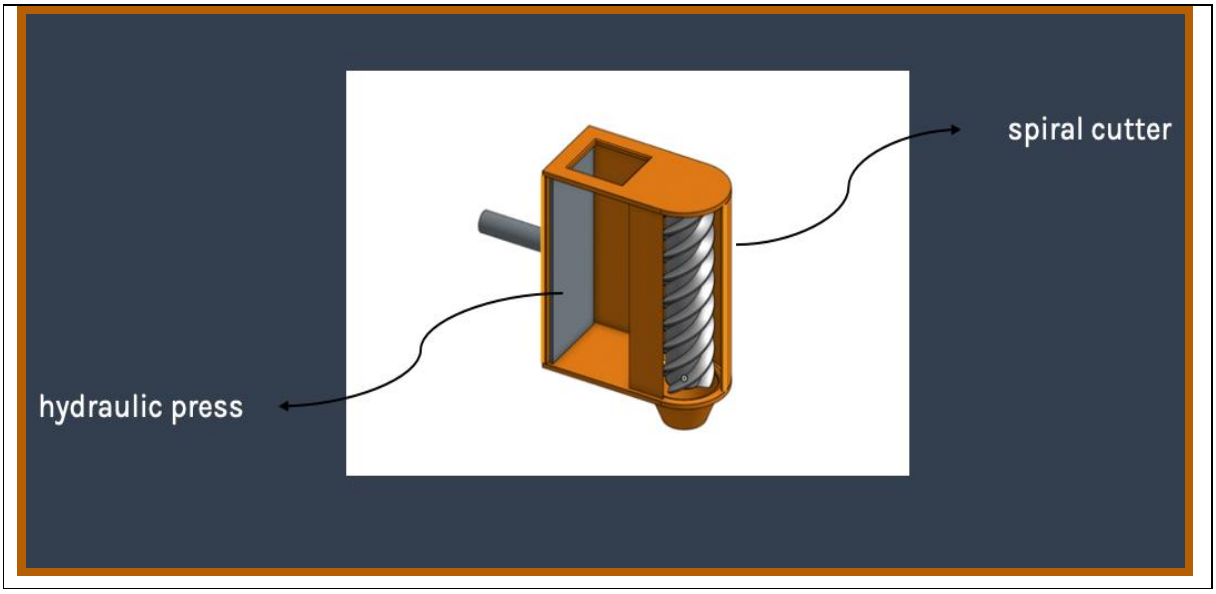
https://commons.wikimedia.org/wiki/File:Gesso_bisalta.jpg http://www.parcofluvialegessostura.it/conoscere/progetti/laghetti-di-tetto-lupo-e-birdwatching.html

2.2 Calculation and design of the Final solution

The main idea is the construction of a wood cutting machine that will operate in a friendly way to the environment, will produce the desired amount of wood dust and will have the packaging function.First of all, Agrindustria wants to double the amount of wood dust it has. They are currently comparing about 10 over 15 tons of wood dust. They want to double this quantity to 30 tons, so that means they need a powerful and fast machine, which is low cost labor and will produce a large quantity in a short period of time.For this reason , we have researched two standard wood cutting and chipping machines, of which their point of intersection is their common result.As we are going to see later, the main function of the first machine is to push the pieces of wood with a special component and with the pressure they are driven to a cylindrical cutter that will turn them into much smaller pieces so that later the powder manufacturing process can continue.specifically This machine We manufacture main components and technology which consists of a hydraulic press which is built to send the pieces of wood to be cut and the spiral cutter which has the property of further chipping the pieces of wood. The image below shows the first and main part of the process.

The fist solution of cutting and chopping machine

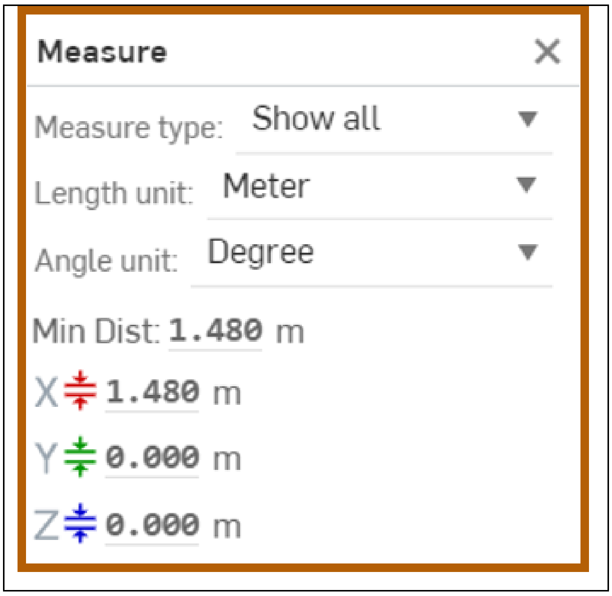
Here we see the illustration of the first design machine for cutting and compressing wood, which was to pass later on to the next stage of powder.[fig2.2.1]



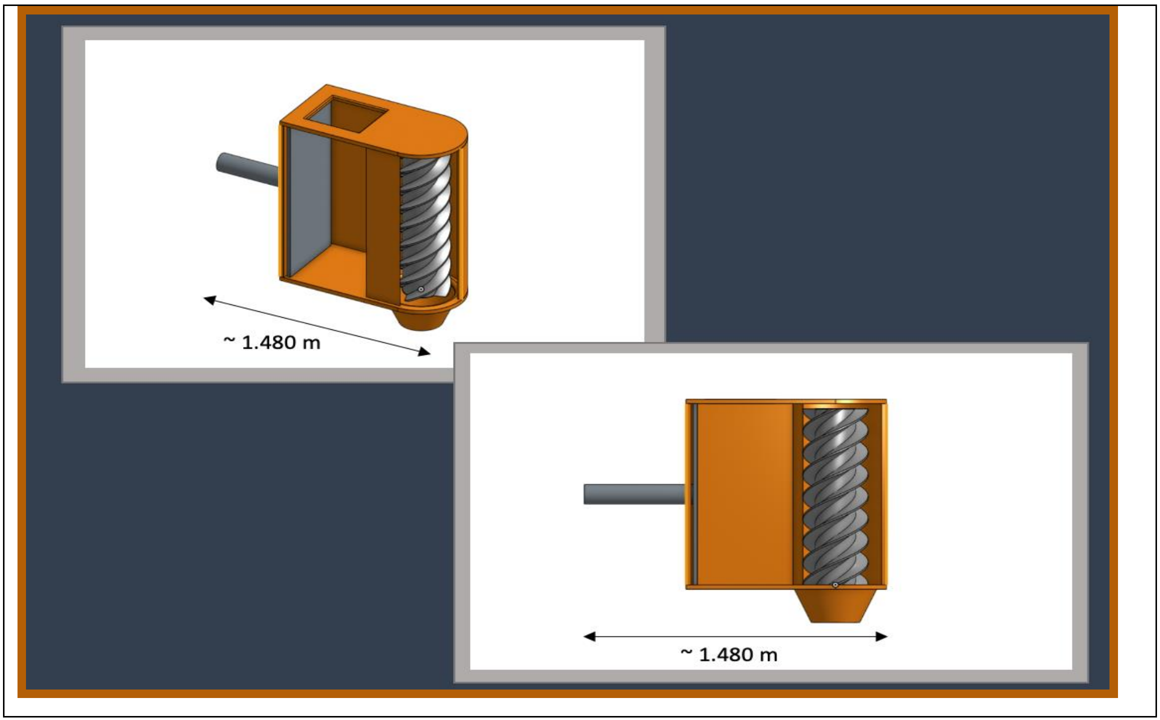
First concept of wood chopping machine[2.2.1]

-Follow the exact dimensions of the above component

In length

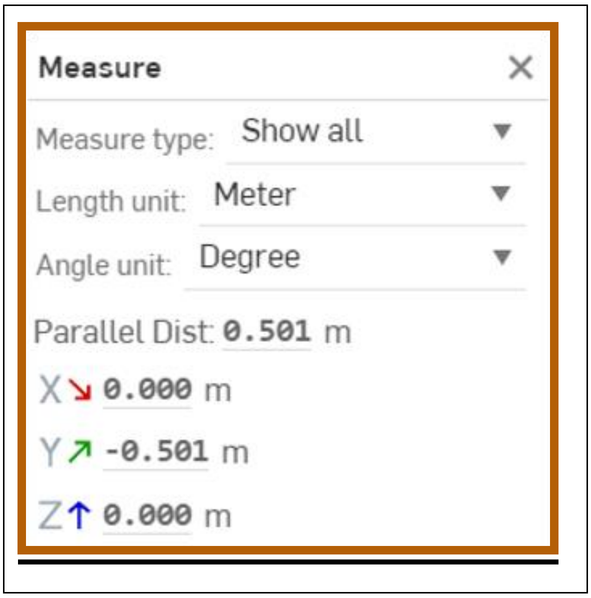


Measure of first concept.[fig2.2.2]

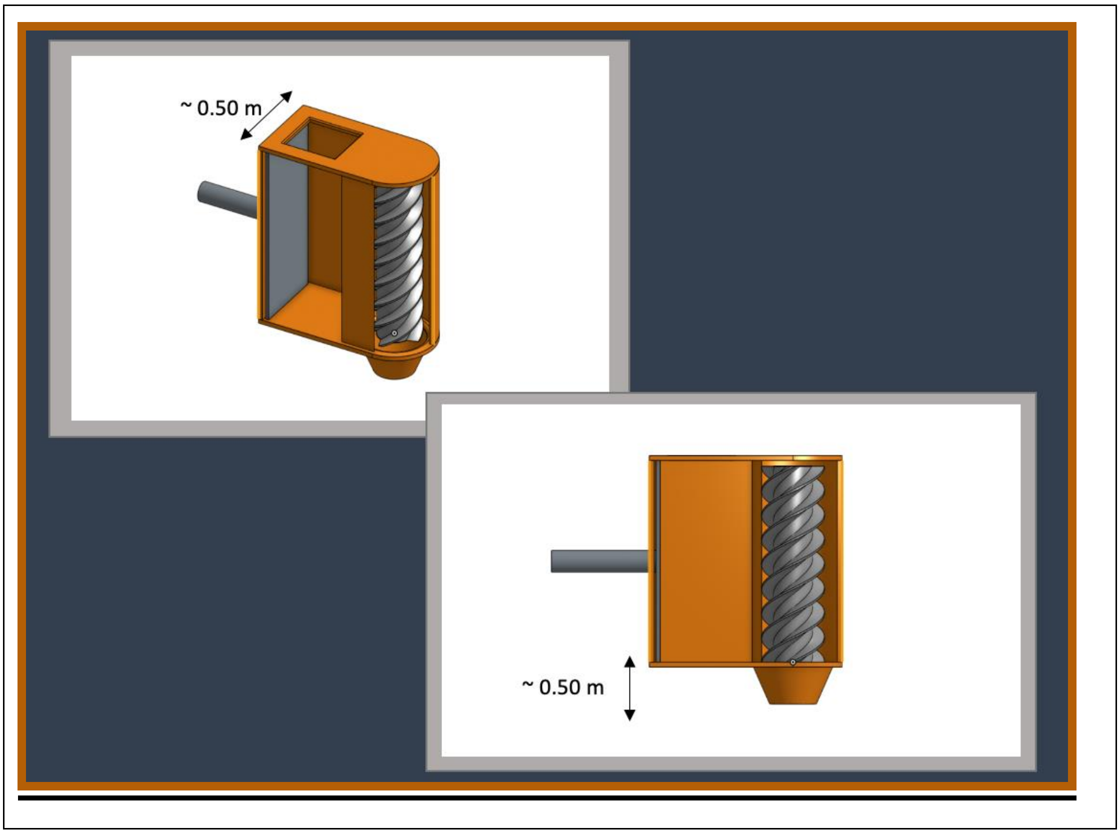


Ilustration with measures[fig2.2.3]

In width

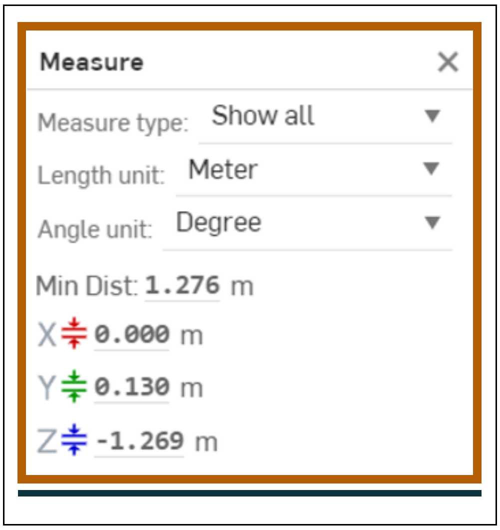


Measures in width [fig2.2.4]

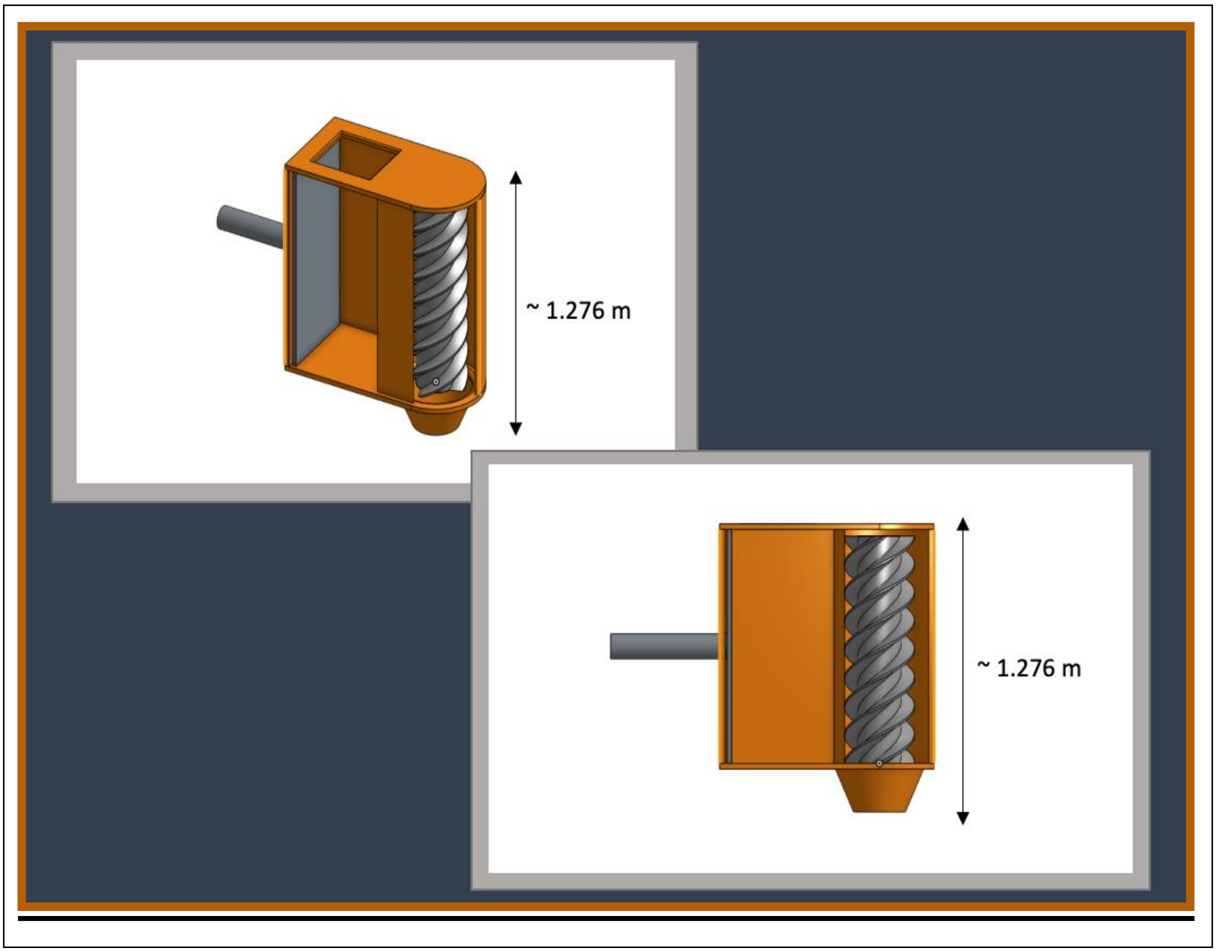


Ilustration with measures in width[fig2.2.5]

In height



Measures in height [fig2.2.6]



Ilustration with measures in hight[fig2.2.7]

Mass , Volume and Surface area

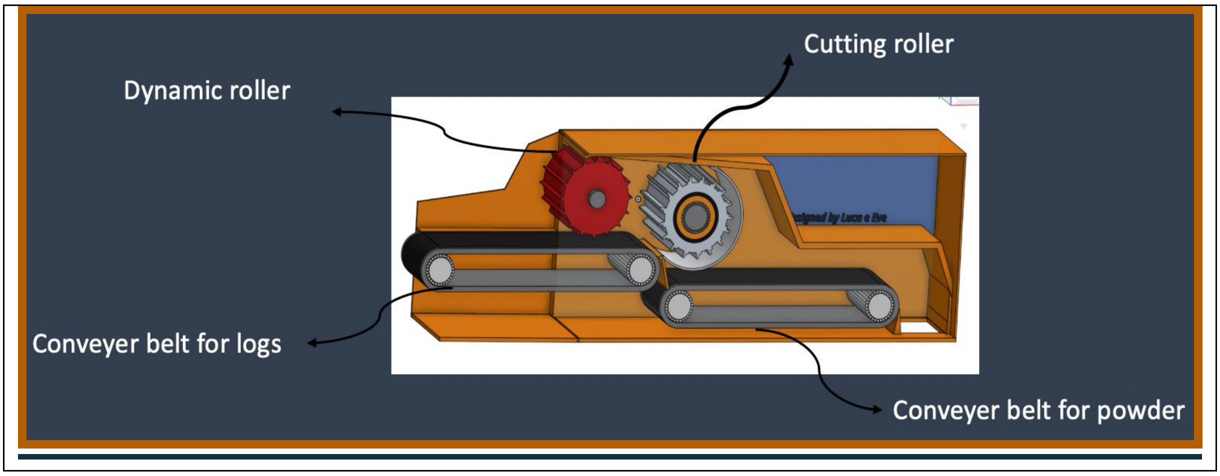
Mass Override	1332.977 kg
Volume	2.140e+8 mm^3
Surface area	1.016e+7 mm^2

Mass, volume and surface area[fig2.2.8]

Continuing, the second solution of a wood cutting and chipping machine

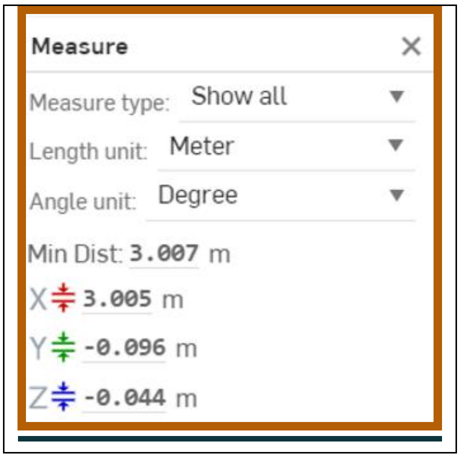
follows.

This device The following are its primary elements and primary technologies: A dynamic roller that rises in accordance with the size of the wood so you can also catch it still to enter the next process, the cutting process, and another roller that has blades attached to it to be able to perform the cutting; these have an easy maintenance, being easy to take down and change. Two conveyor belts, one for transporting wood and one for transporting powder that returns from the process through which the wood passes. [fig2.2.8]

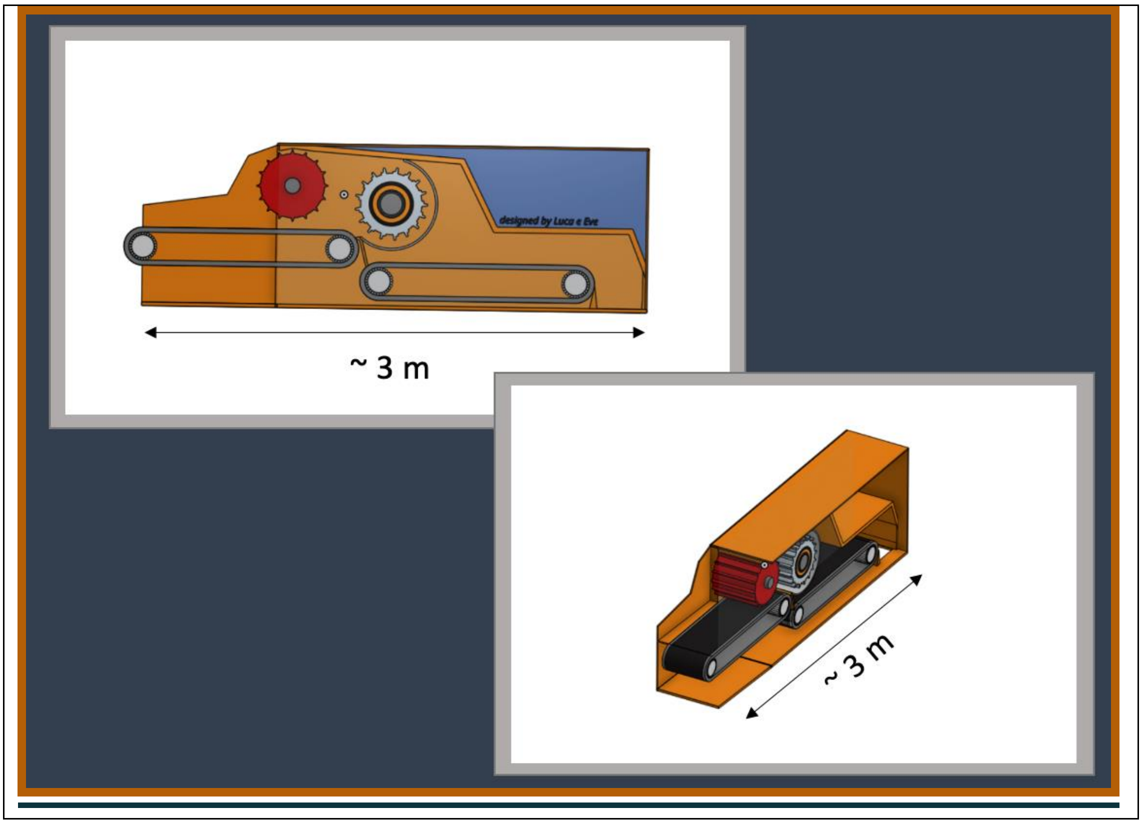


Second model of wood chopping machine [fig2.2.9]

In length

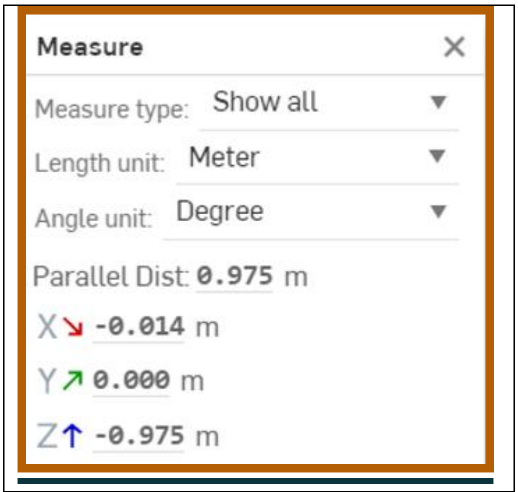


Measures in length for second model [fig2.2.10]

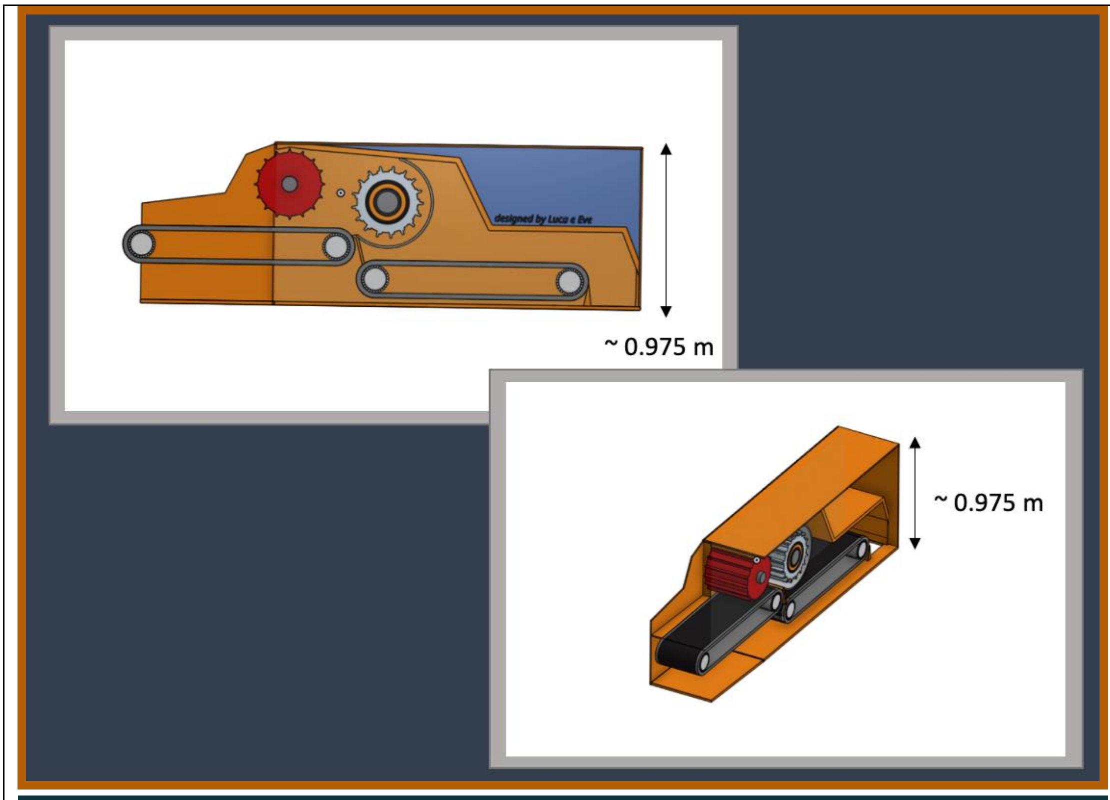


Ilustration with measures in lenght[fig2.2.11]

In height



Measures in height for second model [fig2.2.12]



Ilustration with measures in lenght[fig2.2.13]

Mass , Volume and Surface area

Mass	Override	622.524 kg
Volume		0.354 m^3
Surface area		34.057 m^2

Mass, volume and surface area for second model[fig2.2.14]

2.3. Benefit of the proposed solution

As this machine will operate energetically, the unique solution and investment are significant, profitable, and undoubtedly advantageous to the environment.

Our objective is to use renewable energy sources that can be recycled and used again while still producing energy.

In this specific instance, only one machine needs to be built or purchased because the Agrindustria company already has a modern, effective equipment that improves the final form of the powder and packing.

In conclusion, this means that the cost will be lower.

3. Investment cost and profitability analysis

3.1 Cost of the proposed solution

We are planning the implementation of this new process, which will bring to our company the production of wood scraps that we buy, the production of wood powder to replace the one that Agrindustria Tecco SRL buys from other producers in quantity of 10/15 tons to be produced by them in the amount desired to be doubled. For this process we need the purchase of a machine that can chop the wood in such a way that it can produce powder.

This new implementation consists of certain acquisition and maintenance costs, more precisely direct costs and indirect costs:

- **Direct costs**

Any cost that is directly associated with producing a product is considered a direct cost. The majority of direct costs include direct labor, direct materials costs, and manufacturing supplies.

To easily identify direct costs, think of the components that go into the finished product that you're selling. If you're manufacturing baseball bats, your direct costs would include the wood, composite, or metal needed to make each bat, as well as the salaries of the line workers making the bats.

While most direct costs are variable, there can be instances when direct costs are fixed costs, such as rent or property taxes specifically for a manufacturing plant.

In the case of the Agrindustria company, the following are necessary as direct costs for the implementation of this new production:

- Wood cutting machine
- Wood scraps
- The location/hall where it will be implemented and located
- Labor force for hiring a machine operator
- The packaging process
- The filtering process

- **Indirect costs**

Indirect costs, often referred to as overhead costs, focus less on product production and more on day-to-day business expenses.

For instance, costs such as administrative staff, facility rental, and office supplies are needed to properly manage the business, but they are only indirectly related to the production process and are considered an indirect cost.

In the case of the Agrindustria company, the following are necessary as indirect costs for the implementation of this new production:

- Administrative staff
- Office supplies
- Utilities

3.2 Benefit of the proposed solution

The benefits of implementing this new process are numerous because, first of all, it reduces the cost of purchasing this powder, producing it in larger quantities by themselves, buying a large amount of wood scraps and passing it through this process definitely brings a larger amount , or equal to the one they were buying but at a categorically lower price.

Thus, our proposal was to do this process which, as its implementation costs, represents only the direct cost of ordering the wood-cutting machine and the direct purchase of wood scraps.

3.3 Net present value

As far as the direct costs are concerned, they are represented by the purchase of this new wood cutting machine, the price of which is included between **77,500.00 - 147,100.00 Euro**, the cost of purchasing wood, wood scraps is 60 euros per ton, which includes the its location is already owned by Agrindustria and does not involve the construction of a new building, so it is reduced to around 0 euros. As far as the labor force is concerned, it is necessary to hire or train a maximum of two people who will take care of the process. And the packaging and the filtering process, because they are already present inside the company, they do not have to be purchased that way and this cost is reduced to 0.

All that consists of indirect costs are managed by the Agrindustria company, these are some costs that differ and we cannot provide exact data and amounts about them.

Name	Cost	Period
Wood chopping machine	**77,500.00 - 147,100.00 Euro**	1 time purchased
Wood scraps supplies	60 € per ton	depends
Location/ hall	0 €	1 time purchased
Machine operators	1 / 2 * 1,624 / 2,475 €	1 time / per month
Packaging process	0 €	1 time purchased
Filtering process	0 €	1 time purchased

3.4 Payback period

So the payback period can be divided into 3 cases, the most unfavorable case, favorable case and the very most favorable case.

The unfavorable case is the one in which certain troubles can happen, for example:

- the power source drops, the production drops and thus the quantity will no longer be produced as we expected

-defective parts, the parts can fail, so the repair cost depends on the type of failure, which can go from €2 to the worst case in which the company may be forced to buy a new car.

- the purchase price of the raw material would increase significantly and the price of the product for sale would remain unchanged or decrease.

The occurrence of this unfavorable case increases the period in which the payback will be returned to us completely, thus making a profit.

The favorable case is represented by the production that goes smoothly as we expected, nothing changes, nothing breaks down, the production, purchase and sale prices remain equivalent, so the payback is made in the period we expected.

The very most favorable

This case is represented as the best scenario that can happen, for example:

- the price of the raw material drops significantly, and the selling price increases or remains the same.

- the price of energy decreases

In this case, the payback will be made much faster, so the profit will be made much faster.

Machine capacity per hour: 1 TPH

Pieces of wood for one day: 8 T/day

Pieces of wood per month: 8T * 30 days = 240 T/month

Pieces of wood per year: 24 T * 12 months = 2880 T/year

Price per year for pieces of wood: 2880T * €60 = €172,800/year

Powder from a ton of wood waste: 1T wood waste -> 0.6 T powder 600 kg of powder

Monthly amount of powder: 600 kg830 = 144,000 kg/ month = 144T powder/month

Annual amount of powder: 600 kg830*12 = 1,728,000 kg powder/year = 1,728T powder/year

The price of a bag of powder: €10 / 25 kg

Powder bags per month: 144,000 kg : 25 kg/bag = 5,760 bags

Packaging cost: €1 – bag

The unfavorable case

Price of wood scraps = 60 €/Ton

Packing cost = 1.0 €/ bag

Machine operator wage = 2.475 €/month

Sale price per bag = 10€/bag

The favorable case per month

Month	Price of wood scraps	Maintenance cost	Packing cost	Personnel price	Sale price	Profit
1 month	14,400 €	25,000 €	5,760 €	4,950 €	57,600 €	7,490 €

The favorable case per year

Year	Price of wood scraps	Maintenance cost	Packing cost	Personnel price	Sale price	Profit
1 year	172,800 €	300,000 €	69,120 €	59,400 €	691,200 €	89,880 €

The unfavorable case

Price of wood scraps = 70 €/Ton

Packing cost = 1.1 €/ bag

Machine operator wage = 2.600 €/month

Sale price per bag = 9.8€/bag

The unfavorable case per month

Month	Price of wood scraps	Maintenance cost	Packing cost	Personnel price	Sale price	Profit
1 month	16,800 €	25,000 €	6,336 €	5,200 €	56,448 €	3,112 €

The unfavorable case per year

Month	Price of wood scraps	Maintenance cost	Packing cost	Personnel price	Sale price	Profit
1 month	201,600 €	300,000 €	76,032 €	62,400 €	691,200 €	37,344 €

The very most favorable case

Price of wood scraps = 55 €/Ton

Packing cost = 0.9 €/ bag

Machine operator wage = 2.500 €/month

Sale price per bag = 14€/bag

The very most favorable case per month

Month	Price of wood scraps	Maintenance cost	Packing cost	Personnel price	Sale price	Profit
1 month	13,200 €	25,000 €	5,184 €	5,000 €	80,640 €	32,256 €

The very most favorable case per year

Month	Price of wood scraps	Maintenance cost	Packing cost	Personnel price	Sale price	Profit

1 month	158,400 €	300,000 €	62,208 €	60,000 €	967,680 €	387,072 €

3.5 Pay back period

If we consider the 3 scenarios, Agrinfustria Tecco SRL will recover its investment in the following way

In the most unfavorable case, Agrinfustria Tecco SRL will obtain an annual profit of €37,344 and will cover its initial investment of €147,100 in 3 years and 9 months (147,100/37,344).

In the favorable case, Agrinfustria Tecco SRL will obtain an annual profit of €89,880 and will cover its initial investment of €147,100 in 1 year and 7 months (147,100/89,880).

In the most favorable case, Agrinfustria Tecco SRL will obtain an annual profit of €387,072 and will cover its initial investment of €147,100 in just 3 months (147,100/387,072).

We must specify that these calculations are valid only when the production hall is already owned by the company (it must not be purchased or rented).

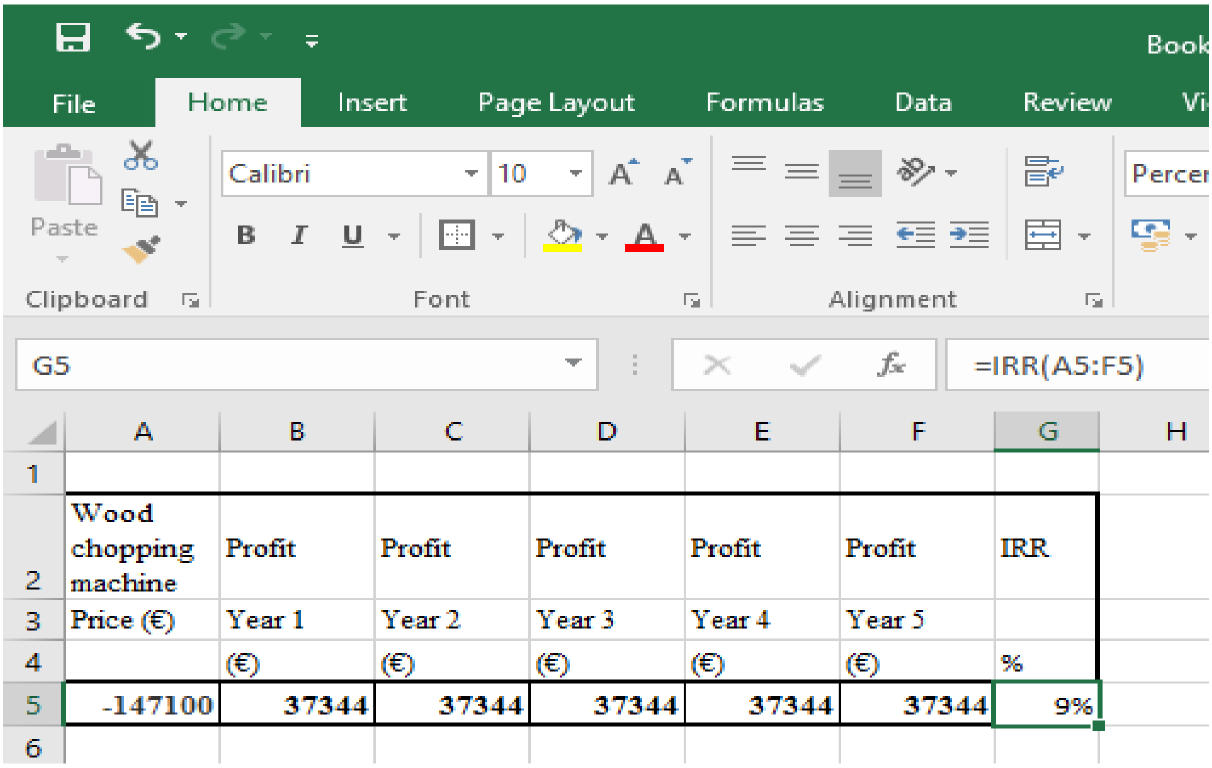
3.5 Internal Return Rate

For the calculation of the internal rate of return, we will also start from the 3 scenarios proposed previously, considering that the operating time of the machine is 5 years (after this period, the machine can be considered physically and morally worn out).

The unfavorable case

Wood chopping machine Price (€)	Profit Year 1 (€)	Profit Year 2 (€)	Profit Year 3 (€)	Profit Year 4 (€)	Profit Year 5 (€)	IRR (%)
147,100	**37,344**	**37,344**	**37,344**	**37,344**	**37,344**	**9**

Pentru calculul IRR vom utiliza functia financiara IRR a programului Microsoft Excel:

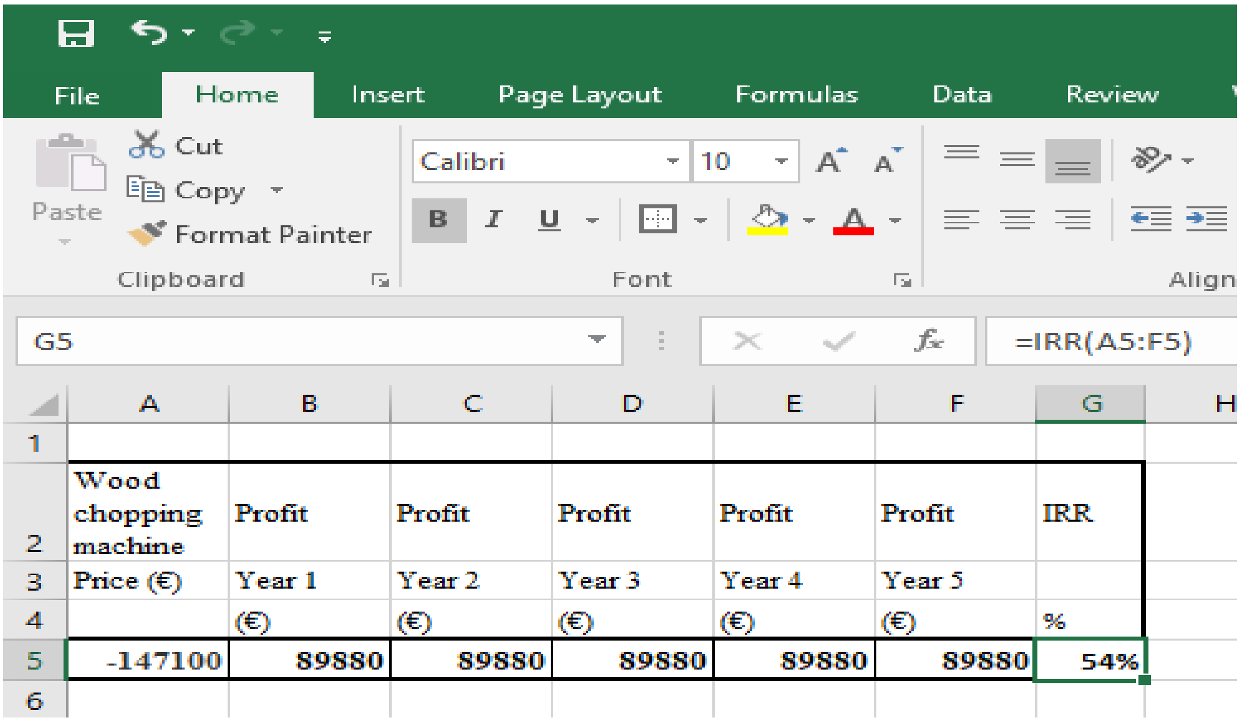

G5 =IRR(A5:F5)

	A	B	C	D	E	F	G
1							
2	Wood chopping machine	Profit	Profit	Profit	Profit	Profit	IRR
3	Price (€)	Year 1	Year 2	Year 3	Year 4	Year 5	
4		(€)	(€)	(€)	(€)	(€)	%
5	-147100	37344	37344	37344	37344	37344	9%
6							

The favorable case

Wood chopping machine Price (€)	Profit Year 1 (€)	Profit Year 2 (€)	Profit Year 3 (€)	Profit Year 4 (€)	Profit Year 5 (€)	IRR (%)
147,100	**89,880**	**89,880**	**89,880**	**89,880**	**89,880**	**54**

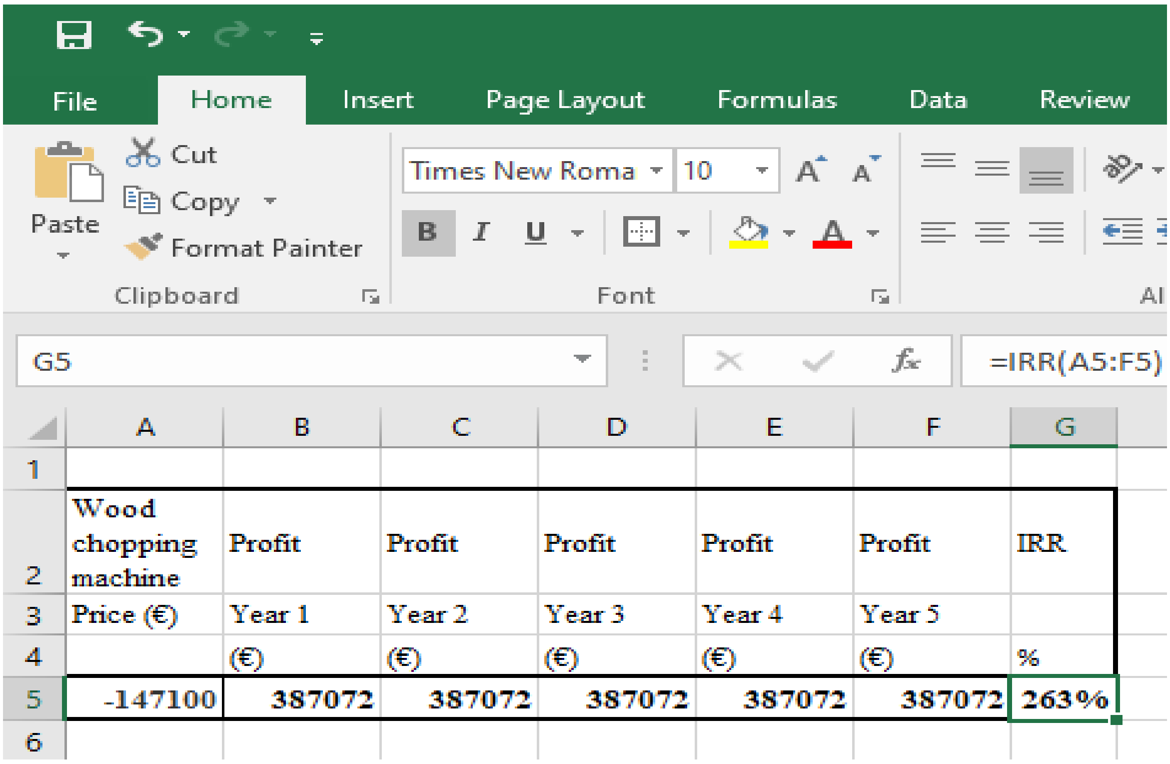
Pentru calculul IRR vom utiliza tot functia financiara IRR a programului Microsoft Excel:



The very most favorable case

Wood chopping machine Price (€)	Profit Year 1 (€)	Profit Year 2 (€)	Profit Year 3 (€)	Profit Year 4 (€)	Profit Year 5 (€)	IRR (%)
147,100	387,072	387,072	387,072	387,072	387072	**263**

For the IRR calculation we will also use the IRR financial function of the Microsoft Excel program:



	A	B	C	D	E	F	G
1							
2	Wood chopping machine	Profit	Profit	Profit	Profit	Profit	IRR
3	Price (€)	Year 1	Year 2	Year 3	Year 4	Year 5	
4		(€)	(€)	(€)	(€)	(€)	%
5	-147100	387072	387072	387072	387072	387072	263%
6							

It can be seen that in all 3 scenarios we obtain a good internal rate of return, between 9 and 263%. Of course, for the most favorable scenario we get the highest value for IRR.

1.5 Conclusion

The conclusion is that following all the requests and conditions imposed by the agribusiness and the conditions imposed by the medium climate zone, after all the analyses we made a final decision considered to be the best and this decision was to choose to procure wood scraps that let's insert them into the wood cutting machine to produce powder, the concept that has as its main technology a hydraulic press and a spiral with knives, and as an energy supply method we are going to use photovoltaic panels because it is the most advantageous in the agribusiness environment and is also already a technology known to them.[27]

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