UNIVERSITÀ DEGLI STUDI DI TRIESTE

Deams
Dipartimento di
Scienze Economiche, Aziendali,
Matematiche e Statistiche "Bruno de Finetti"

LOCATION THEORY IN PRACTICE: WEBER'S MODEL OF INDUSTRIAL LOCATION IN CIRCULAR ECONOMY

DOCTOR FRANCESCA SINATRA

UNIVERSITY OF TRIESTE, 27 OCTOBER 2025

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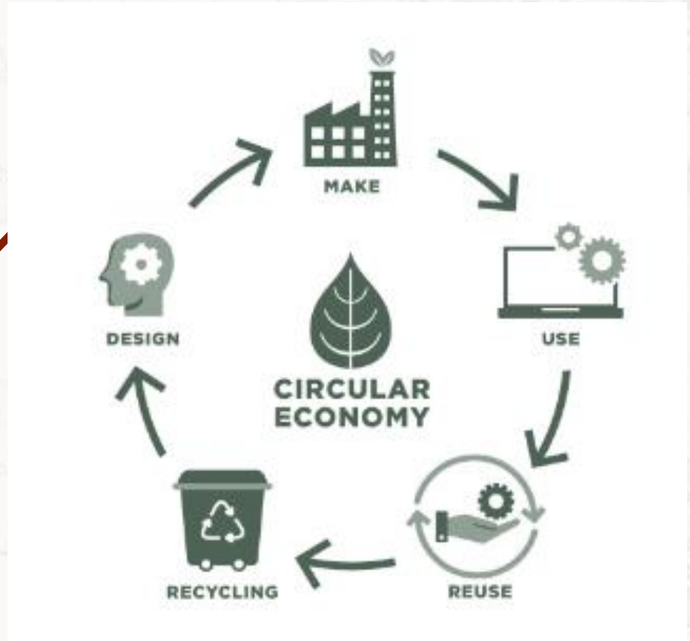
ARGUMENTS

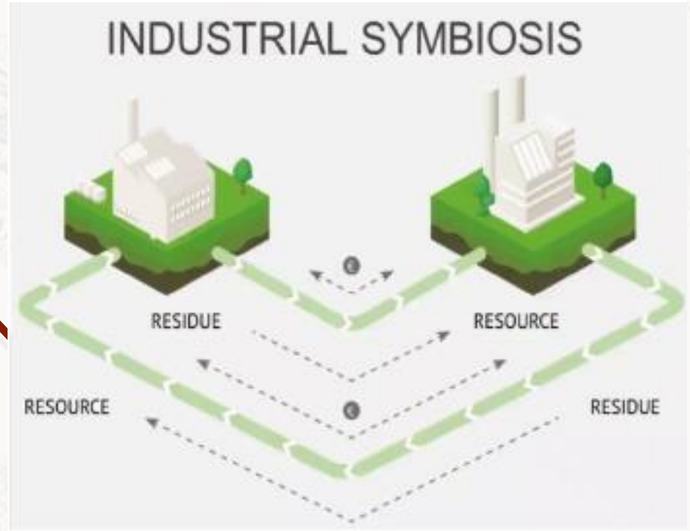
- *Circular Economy*
- *Industrial Symbiosis*
- *Localization of production activieties*
- *New trend in the fashion sector: Reshoring*

INTRODUCTION

Territorialization, Circular Economy and Industrial Symbiosis represent **key concepts** in the context of industrial areas.

Industrial settings are characterized by a **growing attention towards sustainable development**, and the **processes of territorialization** are more and more meant to address a **responsible use** of natural resources and territory planning in order to **maximize efficiency** and **reduce environmental impact.**





INDUSTRIAL SYMBIOSIS

Industrial Symbiosis (IS) aims to improve resource utilization and reduce waste by integrating and collaborating with different companies and sectors.

Its main objective is to maximize the value of waste resources through the exchange of materials, energy, services, and skills among different industries.
The basic principle of Industrial Symbiosis rests upon the cooperation among industries to leverage their waste and create a virtuous system for exchanging unique elements that define each business, forming a comprehensive network of companies.

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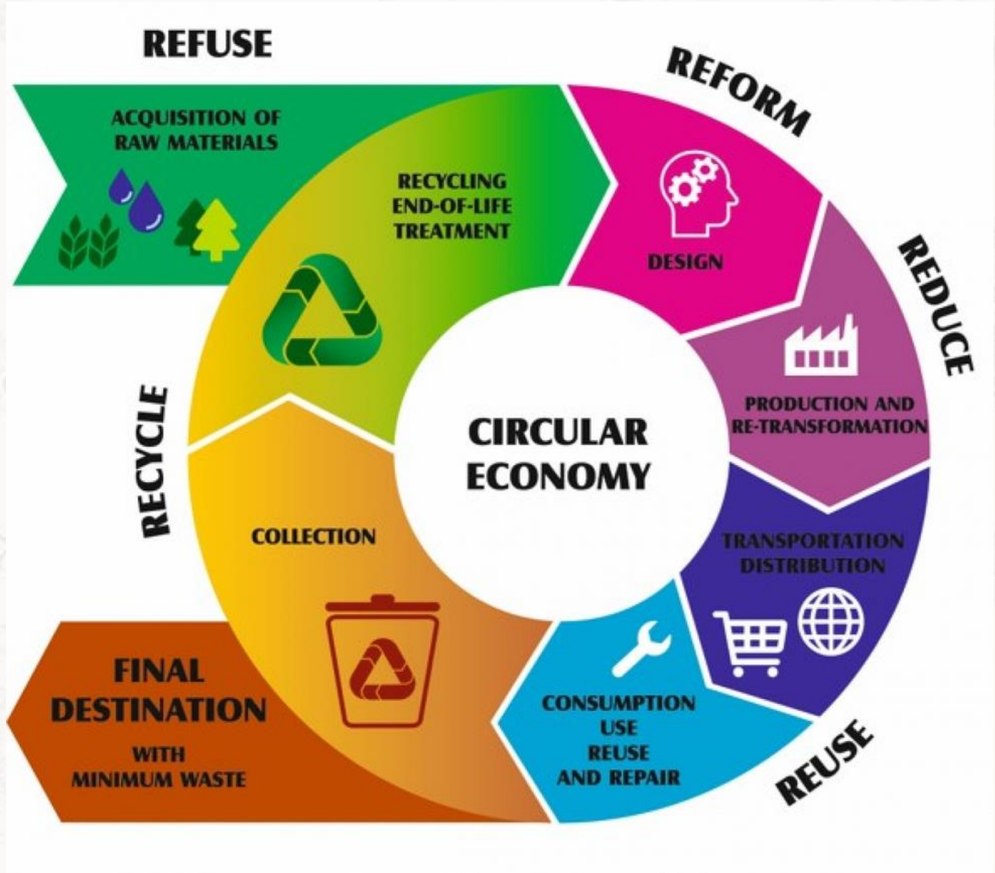
INDUSTRIAL SYMBIOSIS

CIRCUALAR ECONOMY

The Ellen MacArthur Foundation (2016) defines a circular economy as 'an economy designed to be regenerative and restorative, aiming to keep products, components, and materials at their highest utility and value at all times.' This definition leads to a closed-loop economic model where waste is minimized and resources are kept in use for as long as possible. By integrating IS and CE concepts, we can develop and maintain sustainable economic/productive systems that restore natural systems and regenerate materials at the end of their life cycle.



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CIRCUALAR ECONOMY

THE INDUSTRIAL LOCATION THEORY: ALFRED WEBER

The starting point is Alfred Weber's model of industrial location (Weber, 1929), originally introduced by the German scholar in 1909. This model asserts that the optimal location for production facilities is determined by transportation costs, which depend on the distance between raw material sources and markets, as well as the weight of both raw materials and finished goods. This framework was applied to analyze the locational choices in the Ruhr region during Germany's industrial revolution.

Weberian models are applicable to manufacturing firms that use physical quantities of raw materials, secondary raw materials, intermediate goods, and fuel as inputs in the production process, producing a specific quantity of output. A key feature of Weberian assumptions is the classification of resources. Weber distinguishes localized resources, which are fixed in specific locations, further dividing them into "pure" resources (fully incorporated into the final product) and "gross" resources (partially incorporated, with weight loss during processing). Other resources are classified as ubiquitous (non-localized), characterized by a relatively uniform and accessible distribution across space.

THE INDUSTRIAL LOCATION THEORY: ALFRED WEBER

The goal of Weberian models is to determine the location that minimizes transportation costs. In Weber's simplified model, which accounts for only two key points — a resource location or extraction site (for raw and secondary raw materials) and a market — this objective is achieved by minimizing the following formula:

$$T = tpr^{*}d(R) + tpm^{*}d(M)$$

T = Total transportation cost (expressed in tonne-kilometers)

t = Cost per tonne-kilometer
pr = Weight per unit of resource (input)
pm = Weight per unit of product (output)

d(R) = distance RF (resource location – production site)
d(M) = distance FM (production site – market location)

The production facility FFF will be positioned at a point between the resource location RRR and the market location MMM. The specific location will be determined by the relative weights of the raw and secondary materials compared to the finished product.

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THE INDUSTRIAL LOCATION THEORY: ALFRED WEBER

THE INDUSTRIAL LOCATION THEORY

WITHIN A CIRCULAR FRAMEWORK

An **extension of the classical Weber's model** of industrial location can be to-date adapted to host circularity.

The traditional non-circular location model needs to be **reconsidered** in order to correctly **quantify the quantity of waste produced** and its percentage of reinsertion into a circular -symbiotical - production process.

The modified model could be interesting for both considering new locations for processing waste, and also for favouring rise of new business given the proximity of the different activities. A consequence of that is the need to correctly and precisely map the potential actors involved in the process.

This requires a deep work of data organization and harmonization, also by means of geographical analytical and sharing tools (GIS software and geographical sharing packages).

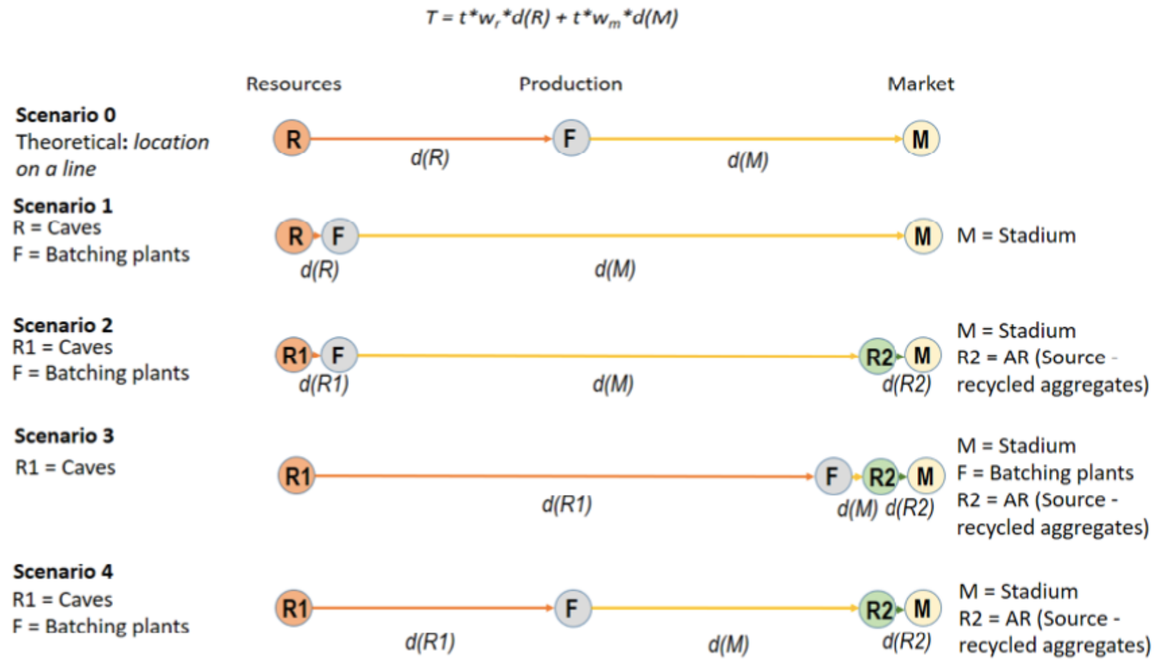

Fig. 2. The Weberian localization model of batching plants in a circular economy: case study of a stadium demolition and demolition. Source: Balletto et al. (2019) [13]

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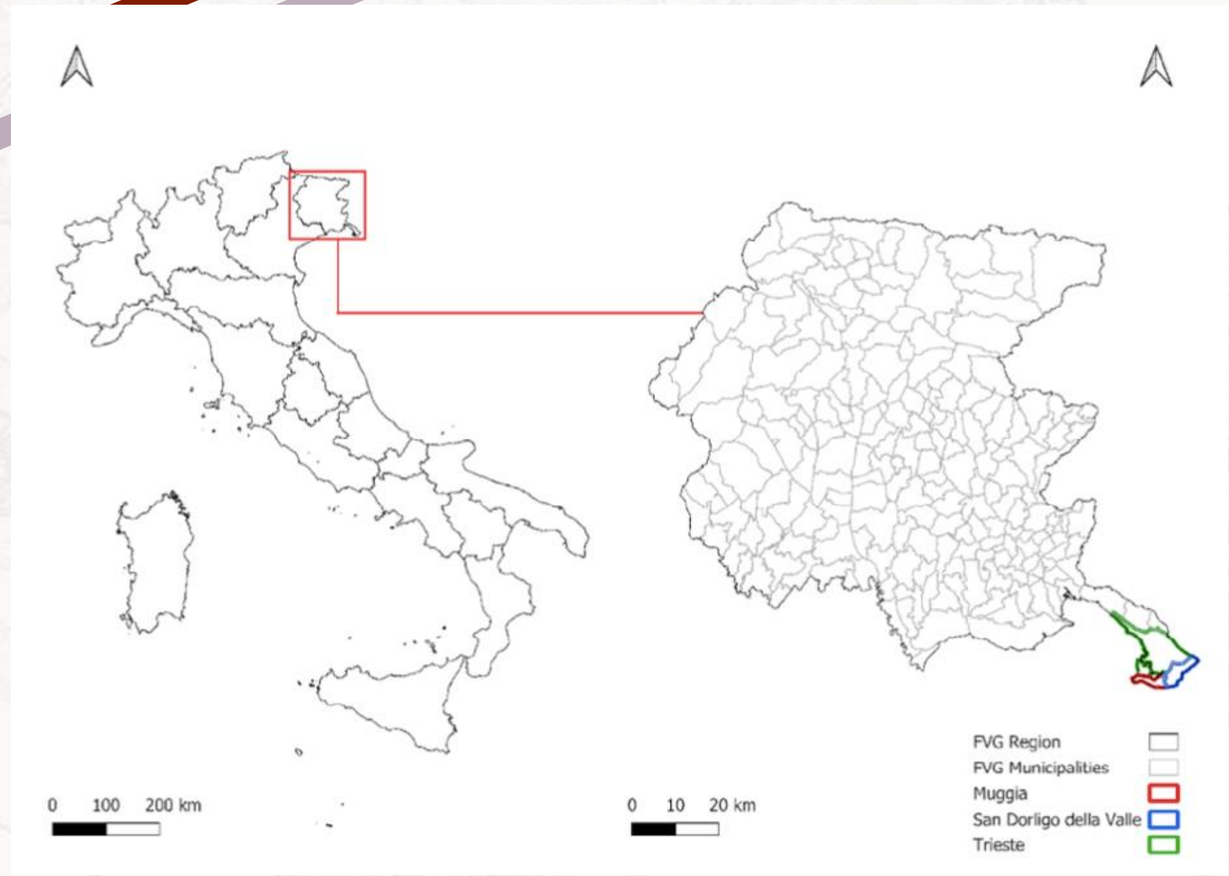
CASE STUDY : THE INDUSTRIAL ZONE OF TRIESTE

The area under study corresponds to the **Industrial Zone of Trieste**, specifically the area of competence of Co.SELAG that includes portions of the municipalities of **Trieste, Muggia and San Dorligo della Valle.**



RESEARCH

The goal of the **Consortium** is to contribute to economic growth and the creation of jobs within its territory, trying to **promote the technological development and competitiveness of local businesses.**

IMPACT

The **strategic position** of this industrial area, crossed by important road, highway and railway connections, allows joining the port of Trieste with the European net, making it a fundamental node.

PRODUCTIVE

Co.SELAG focuses on the adoption of **CE and IS** to address the problems related to **environmental sustainability**. it develops several projects in collaboration with both the FVG Region and the European Union, respectively **APEA and ECOLE.**

METHODOLOGY

A geographical database process implementation has been started, in order to prepare a cognitive tool regarding the real company assets. Localization can provide a **"spatial" idea of their location and spatial distribution.**

The data provided concerns the companies that are part of the study area, which have been provided in the form of an excel file containing the following information: **name, address, contacts, sector type and ATECO code**, **type of activity established , the size of the company and finally the number of employees.**

The companies which could potentially be involved in the creation and/or implementation of circular strategies and industrial symbiosis were **146 companies.**

SECTORS	
RETAIL TRADE	MANUFACTURING/INDUSTRIAL
WHOLESALE TRADE	MANUFACTURING/SERVICES
WHOLESALE AND RETAIL TRADE	SERVICES
CONSTRUCTION	SERVICES/INDUSTRIAL
ECOLOGY/WASTE	TRANSPORT AND LOGISTICS
MANUFACTURING	EMPTY CELLS
MANUFACTURING/ARTESANAL	

Fig. 3. : Included sectors in the analysis. Author: Sinatra F. (2024)

CIRCULAR ECONOMY

The map provided gives a **clear overview** of the **locations of the companies** and their surroundings, allowing a better understanding of the arrangement of industrial activities.

The present study has therefore tried to develop a **mapping of the area through the use of QGIS t**hat emerges as a fundamental geographic informative tool for the analysis of the distribution of the activities carried out within the boundaries of the Consortium.

Fig. 4. District of the Industrial Zone's companies (Personal Elaboration, 2024)

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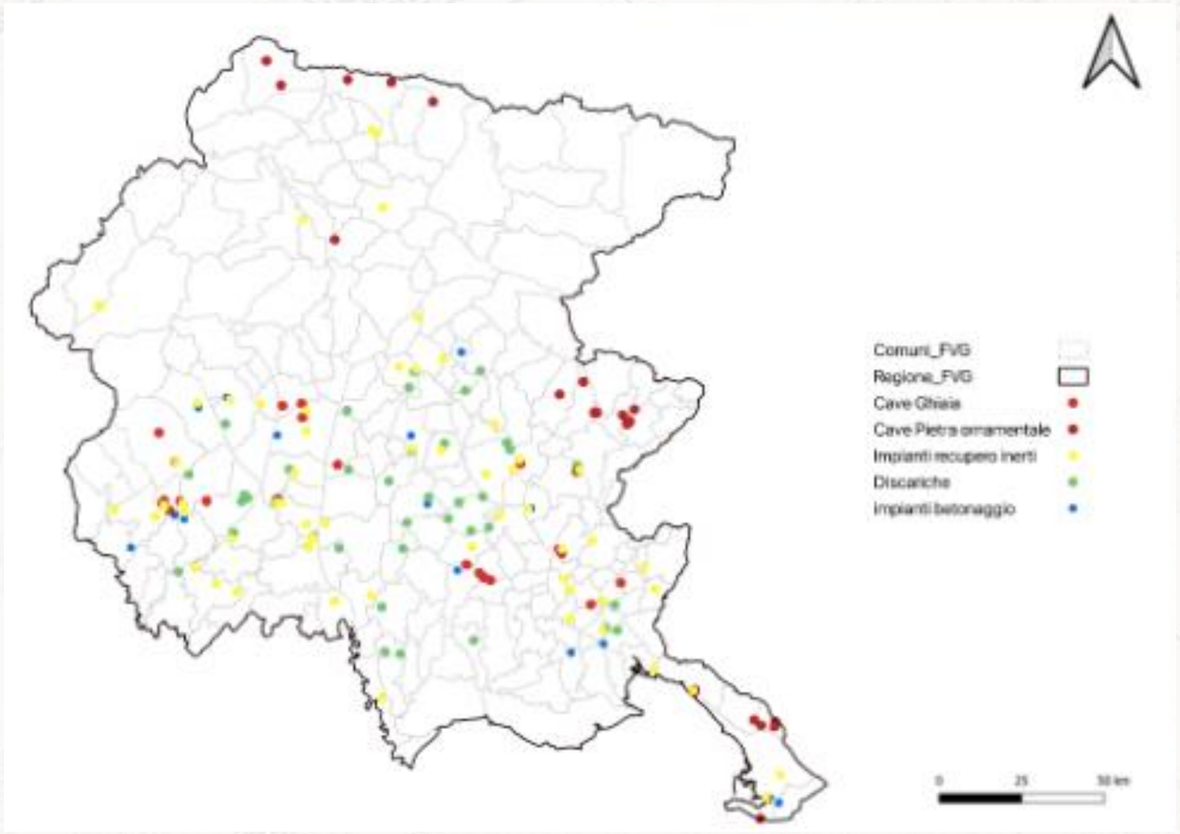


MEISAR MAP FVG

The methodological approach used is therefore similar to the one developed in the **MEISAR "Materials for Sustainable Construction and Infrastructure: the Recycled Aggregates"- projec**t, based on the core principles of the circular economy.

One aspect of this project was the introduction of **cluster analysis** in which it is essential to take into account the spatial constraint, where the distance between the plants and the place where secondary raw materials are used must **not exceed 30 km.**

The MEISAR FVG Map allows the construction of a map that binds to Weber's theory in circular view.

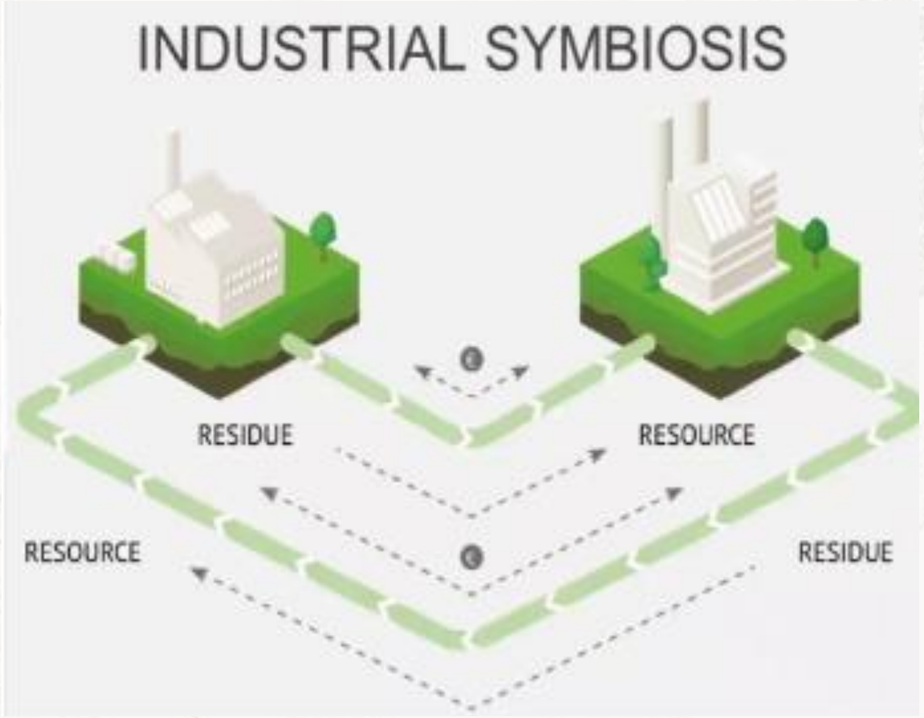
INDUSTRIAL SYMBIOSIS IN THE INDUSTRIAL ZONE

During discussions with one of the local companies, a need emerged for the utilization of **by-products** from **lemon processing**, which are generated during the production o**f liqueurs**."

Until then, the lemons were used **exclusively for the outermost part of the skin**, while the rest of the product, despite being intact, was no longer used, thus **becoming a waste** of production for the company.

Consequently, the Consortium has explored the production system of the Industrial Area of Trieste through ad hoc interviews with companies involved in the food sector and which were interested in the waste production of the liquor factory.

Then, thanks to the development of this **IS strategy**, unused parts were categorized as by-products, stored, and in most cases, given as a gift to individuals for food use, to farmers for agricultural purposes, or, at worst, disposed of as waste.



CIRCULAR ECONOMY IN THE INDUSTRIAL ZONE

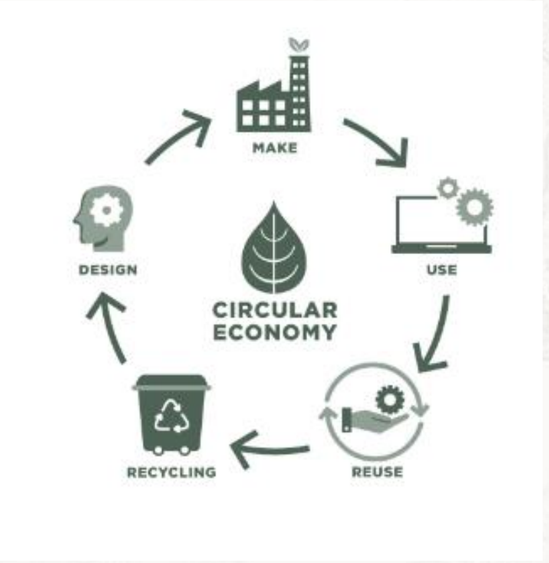
A meeting was organized with the entrepreneur of a company located within the consortium's district.

The interview was carried out due to the fact that the c**ompany began the demolition works** of one of their buildings which occupies approximately **26,000 m2.**

From the waste generated by this demolition, the company will try to **recover most of the reusable material,** for the construction of their new plant that will rise a few kilometers from the old.

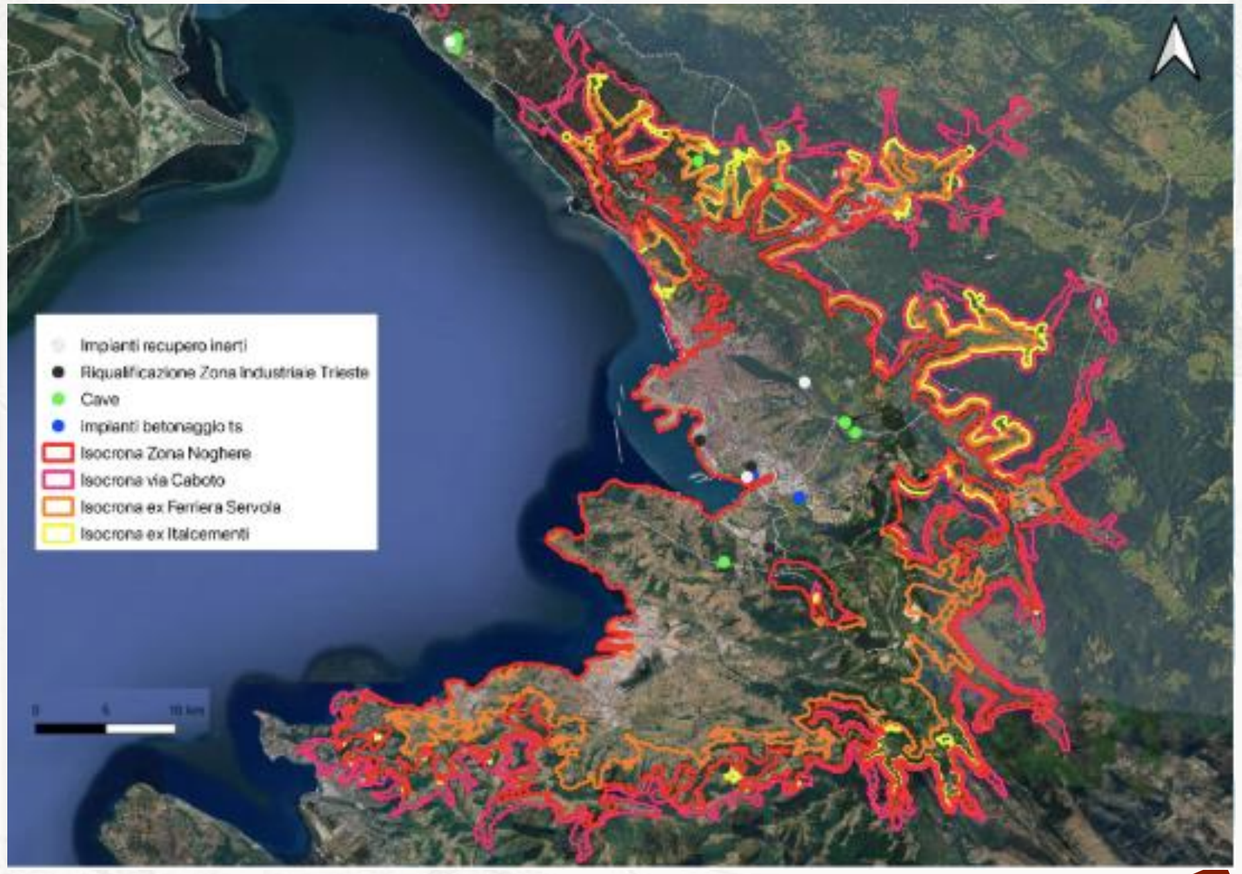
Different steps to implement the circular economy practice, as:

- The **analysis** of all the materials present as iron, asbestos etc.
- **Strip-out** operations,
- **Remediation of asbestos** in other areas and then the cement analysis in order to establish their typology.



ISOCHRONES

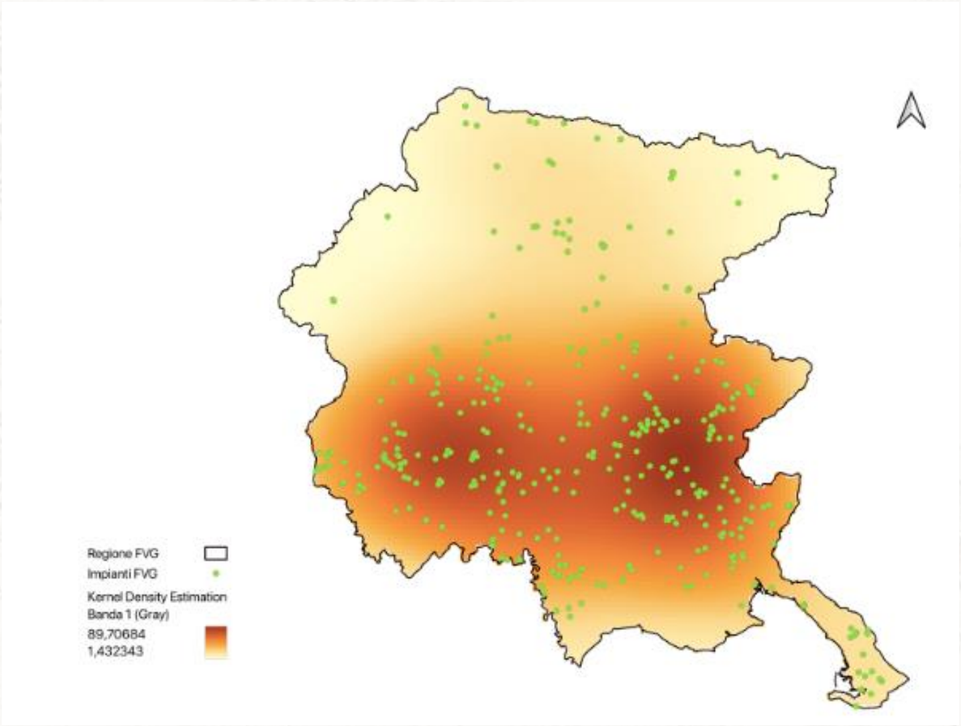
- Furthermore, by constructing an isochrone map, it was possible to represent the road accessibility within 30 km of inert waste recovery facilities from redevelopment projects currently and in the coming years involving the industrial area of Trieste, particularly in relation to demolition and reconstruction projects.
- Using the Travel Time tool in QGIS, isochrones were mapped within a 30 km radius around the industrial area of Trieste, enabling the identification of recovery plants, concrete batching facilities, and quarries.
- The confirmation is that the industrial area of Trieste is an environment where industrial symbiosis exists, and consequently, the conditions are in place to activate a circular economy in the context of construction activities.



KERNEL DENSITY

- Through the application of the MEISAR methodology, a territorial mapping was carried out to identify potential synergies and opportunities for the circular economy throughout the Friuli Venezia Giulia region
- Using Kernel Density Estimation in QGIS, a map was created to analyze the spatial concentration of concrete plants, quarries, recovery plants, and landfills in Friuli Venezia Giulia.

- This analysis highlighted areas with high and low densities of these facilities, revealing strategic zones with strong infrastructure presence. The close proximity of plants fosters industrial synergies, optimizes material flows, and supports sustainable resource management and circular economy practices.



- The analysis showed that proximity and cooperation between urban and port industries encourages the development of innovative strategies, with positive environmental and economic impacts.
- The results are discussed in detail to highlight the strengths and weaknesses of this territorial model.
- The industrial area of Trieste and the Friuli Venezia Giulia region demonstrate how location and logistical, structural, and economic factors can drive territorial development.
- The research clearly mapped plant locations and territorial organization, aiding the identification of synergies and sustainable planning, especially in Trieste.
- The area shows strong potential for industrial symbiosis and circular economy practices in demolition and construction. However, further detailed analysis of material flows is needed for deeper insights.

RESHORING

- The fashion industry, known for its dynamism and trend-driven nature, plays a pivotal role in the global economic system. Over time, this sector has experienced significant changes in production strategies, notably a shift toward offshoring to capitalize on cost efficiencies driven by globalization. This trend led to fashion manufacturing being dispersed across various global locations.
- In recent years, however, there has been a notable shift in production strategies, with growing attention to reshoring—the process of bringing manufacturing activities back to domestic or nearby markets. This shift reflects a strategic response to the complex challenges facing the fashion industry today. Reshoring is increasingly driven by the need to strengthen supply chain resilience, improve agility in responding to market demands, and address critical issues such as environmental sustainability and ethical production practices.

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RESHORING

This trend has been intensified by the rise of fast fashion, which not only accelerates the premature disposal of textile products but also significantly increases waste generation. Central to the problem is the inherently unsustainable nature of the entire textile value chain, encompassing raw material extraction, production, distribution, consumption, and end-of-life management. In addition to environmental concerns, the issue also raises critical social and economic challenges that require thoughtful attention

DIFFERENT STRATEGIES

- Reshoring, or "relocalization," refers to the decision of companies to bring back production that was previously outsourced to foreign countries. This strategy is often driven by factors such as rising labor costs in foreign countries, risks in the global supply chain, the need for quality control, and environmental concerns. Similar strategies include:
- Nearshoring: Moving production to nearby or neighboring countries to reduce logistical distances and geopolitical risks.
- Onshoring: Localizing production within the home market.
- Insourcing: Bringing back previously outsourced production activities to be handled internally.

RESHORING

Connection to the Circular Economy

These strategies are increasingly linked to the principles of the circular economy, which aims to reduce environmental impact, minimize waste, and maximize resource use. Key points of connection include:

- **Reduction of transportation emissions:** Bringing production closer to the consumer market reduces transportation distances, thereby decreasing CO_2 emissions associated with international logistics.
- **Optimization of resource use:** Reshoring often promotes **greater transparency** in resource management, enabling practices such as recycling and material reuse.
- Promotion of **energy efficiency:** Companies that **reshore production can adopt more advanced and sustainable technologies**, reducing energy consumption and improving environmental performance.
- **Development of local economies:** By reshoring, companies c**ontribute to economic growth and material reuse within a local context,** reducing reliance on linear global supply chains.
- **Integration of circular production models:** Localized production facilitates the implementation of circular models, such as repair, regeneration, and recycling, as materials and products are closer to consumption and recovery centers.

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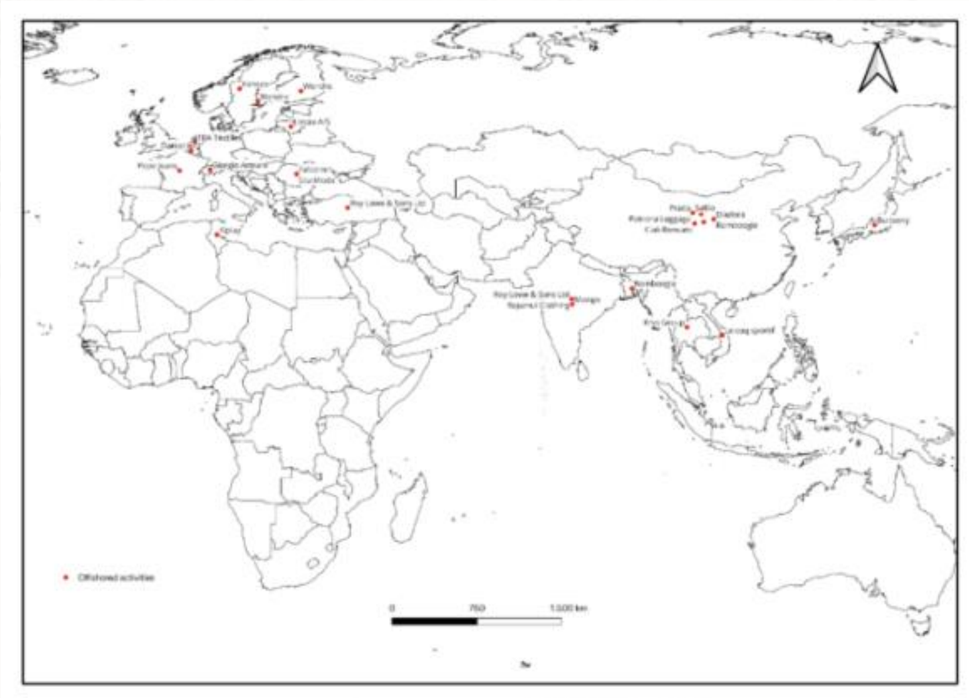
CASE STUDY

- The Data for this study were taken from the European Reshoring Monitor, a database tracking reshoring events reported by EU national media from 2014 to 2018. The research focused on reshoring cases in the fashion-related sectors: textiles, wearing apparel, and leather products. Out of 32 identified cases, 29 were analyzed using QGIS to map the original offshored locations and the reshored destinations. A network analysis was then performed to comprehensively examine the repatriation of production activities.



RESHORING MONITOR FASHION INDUSTRY

Company Name	Company Country	Announcement Date	Offshored to	Reshored to	Sector	Source
Lexon A/S	Denmark	09/06/2017	Lithuania	Denmark	C13 - Manufacture of textiles	European Reshoring Monitor
Aigle	France	03/05/2016	Tunisia	France	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Roy Lowe & Sons Ltd	United Kingdom	07/05/2017	Turkey	United Kingdom	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Roy Lowe & Sons Ltd	United Kingdom	07/05/2017	India	United Kingdom	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Roy Lowe & Sons Ltd	United Kingdom	07/05/2017	China	United Kingdom	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Komax	Denmark	19/01/2016	Sweden	Denmark	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Le Coq sportif	France	09/02/2017	Vietnam	France	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Bombardier	Italy	12/05/2015	Bangladesh	Italy	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Bombardier	Italy	12/05/2015	China	Italy	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Nordtex	Estonia	27/06/2017	Sweden	Estonia	C13 - Manufacture of textiles	European Reshoring Monitor
Inspelia	Estonia	27/06/2017	Finland	Estonia	C13 - Manufacture of textiles	European Reshoring Monitor
Diadora	Italy	18/06/2017	China	Italy	C15 - Manufacture of leather and related products	European Reshoring Monitor
Pepe Jeans	Spain	03/11/2016	France	Spain	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Kiko Group	France	09/11/2016	Thailand	France	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Benetton	Italy	11/10/2016	NA	Italy	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Elle Textiles	United Kingdom	08/06/2018	Netherlands	United Kingdom	C13 - Manufacture of textiles	European Reshoring Monitor
Burberry	United Kingdom	14/06/2015	Japan	United Kingdom	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Mango	Spain	26/07/2016	India	Spain	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Mango	Spain	26/07/2016	China	Spain	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Regatta Clothing	United Kingdom	18/05/2016	India	United Kingdom	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Pedro Luggage	United Kingdom	12/11/2014	China	United Kingdom	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Dunart	France	19/05/2016	Belgium	France	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Yoox	Italy	19/11/2015	China	Italy	C14 - Manufacture of wearing apparel	European Reshoring Monitor
OVS	Italy	26/04/2013	NA	Italy	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Falconeri	Italy	15/05/2015	Romania	Italy	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Burberry	United Kingdom	19/11/2015	China	United Kingdom	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Paul Smith	United Kingdom	05/06/2014	NA	United Kingdom	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Safilo	Italy	15/07/2015	China	Italy	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Elio Mioto	Italy	03/11/2014	Romania	Italy	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Dan Romano	Italy	15/07/2015	China	Italy	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Prada	Italy	13/04/2014	China	Italy	C14 - Manufacture of wearing apparel	European Reshoring Monitor
Giorgio Armani	Italy	26/05/2014	Switzerland	Italy	C14 - Manufacture of wearing apparel	European Reshoring Monitor

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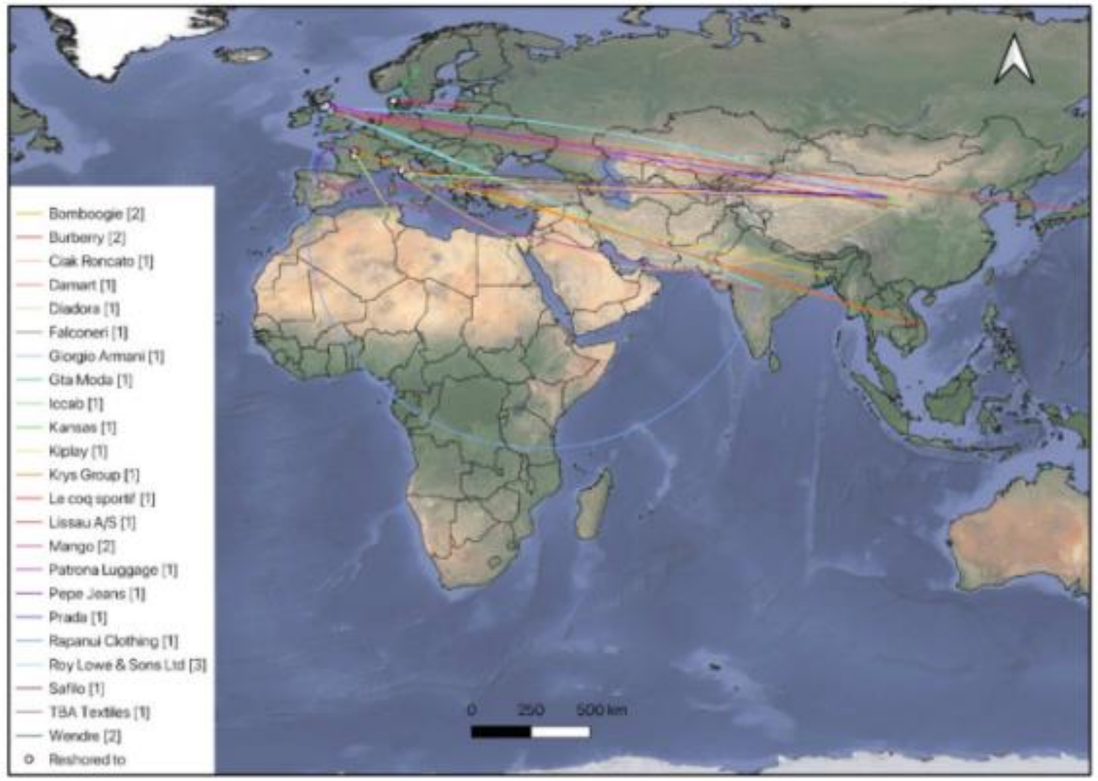
CASE STUDY

- This phenomenon is interpreted as an example of a global circular economy, which can have a positive impact on the environment and the local area. The QGIS network analysis shows that reshoring in the textile and apparel (T&A) sector is still limited globally, primarily driven by European firms that had offshored to Southeast Asia and China. Italy and the UK have the highest reshoring cases. Reshoring enhances brand identity, especially in Italy where "Made in" quality is valued, and offers social and environmental benefits like reduced transportation emissions and local community support.



RESHORING

Benefits and Challenges

- Increased supply chain resilience, lower environmental costs, and better control over quality and environmental compliance.
- Reshoring emerges as a strategic tool with the potential to align financial objectives with social and environmental responsibilities.
- Reshoring companies can enhance their brand identity, particularly in the Italian market, where the "Made in" label is seen as a key indicator of product and service quality.

- Initial reshoring costs, the need for local infrastructure, and supportive policies.
- While reshoring offers opportunities, it also presents challenges and risks, such as higher costs, an increased tax burden, and the need for adaptation, which may discourage some firms from adopting this strategy.

RESHORING

Conclusion

Strategies like reshoring can be powerful tools to align businesses with circular economy principles, promoting a more sustainable and resilient production model. To maximize benefits, an integrated approach is essential, combining industrial policies, fiscal incentives, and technological innovation.

Research in the fashion sector on reshoring and sustainability highlights how local production reconversion is not only a response to global crises, but also a lever for cultural and strategic change. Overall, the studies converge on the importance of collaboration between public and private actors to develop circular models that are resilient, inclusive, and capable of regenerating territories.

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