Location Theory and Circular Economy. Demolition, Constructions and Spatial Organization of Firms – An Applied Model to Sardinia Region. The Case Study of the New Cagliari Stadium

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Abstract. The paper tackles a classical topic of location theory, as the Weber theory of industrial location within a modern framework of building construction and its consideration into the circular economy debate. Starting from a research project involving universities, construction and recycling enterprises and public bodies in Sardinia Island (Italy), the authors propose a model of industrial location that, starting from the assumption of the classical Weberian model, consider it both in a theoretical fashion and applying it to a real-world case study. The project of the new football stadium of Cagliari involves the demolition of the existing stadium, which will represent a source of 'secondary' raw materials for the realization of the new sport facility. The authors discuss about the 'best' locations for concrete factories, according to different scenarios, considering the insertion of a new 'material source' in the circular economy concept.

Keywords: Location theory · Industrial symbiosis · MEISAR · Circular economy · Recycled aggregates

1 Introduction

The paper starts from a set of considerations about circular economy in the field of constructions, with particular reference to the recycled aggregate concrete [1, 2]. Sardinia represents a closed market for Natural aggregate materials and Recycled

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Aggregate (RA) materials [3]. It is not possible, in fact, to interchange those materials with other Italian regions or send waste from demolitions towards these same destinations. Building constructions and demolition need proximal locations of prime (and secondary) sources as well as for waste disposal [4]. Extraction of prime materials (resources), processing, waste disposal, processing of recycled (second) materials, re-inserting them into the production process must happen within the regional territory [5]. Also, concrete batching products must reach their destination from the processing plants within a range of 30 km [6]. Over such distance the products are degraded and their quality is reduced [7]. This needs to be coupled with the analysis of characters and quality of materials, as in the framework of MEISAR project [8, 9].

The general Italian economic situation of (private in particular) building constructions [10], is stagnating [11], with mainly public local authorities - municipalities, regions, etc. - having developed construction plans of public buildings and infrastructure. The potential markets both for Natural and Recycled Aggregates are therefore related to this kind of economic decision makers [12]. We developed a model of optimal location of industrial activities related to resources extraction, manipulation of natural aggregates, treatment of waste from demolition, production of recycled aggregates and, finally, residual waste treatment and disposal, by means of the elaboration of a geographical model of industrial location and its consideration within a circular economy framework [13]. The remaining part of the paper is organized as follows. Section 2 concerns the data collection process, at Region Sardinia level to estimate the quantities of materials computed over the different territories. A map has been realized with the data described in the first section, georeferenced, visualized and shared to provide a working instrument for sharing information and an analytical tool for the location of the different actors involved. In Sect. 3 we propose the adaptation of a classical model of industrial location to consider a circular economical approach, considering putting into the market part of the waste deriving from demolition, hypothesising a set of localization scenarios for the treatment plants (batching plants). In Sect. 4 the case study is described, that of the demolition of the Sant'Elia football stadium and the construction of the new facility. We estimate its potential of waste production that - after a proper treatment - can be put into the circle of recycling and allow a network integration among the different actors - including companies belonging to the cluster MEISAR with positive consequences on the building construction sector in the Metropolitan Area of Cagliari and Southern Sardinia. Concluding remarks highlight major results and future developments of the research.

2 Data Collection and Mapping

2.1 Data Collection

The data collection phase aims to provide a framework on the production and management of construction and demolition waste (CDW), with particular attention to those CER codes actually destined for the production of RA for the packaging of concrete, the firm whose property is the subject of the MEISAR research project. Data collection but sought to extend attention to other products and sectors, directly or indirectly connected, in the production of aggregates for concrete, i.e., the natural aggregate quarries and concrete mixing centers. However, the “raw material” for the production of RA is constituted by the aggregates coming from the construction and demolition activities, the CDWs, which can be cataloged as code CER 17 of the European Waste Catalog. Table 1 shows CER 17 classification.

Table 1. CER 17 - Construction and demolition wastes (including excavated soil from contaminated sites)

CER 17	Construction and demolition wastes
17 01	Concrete, bricks, tiles and ceramics
17 02	Wood, glass and plastic
17 03	Bituminous mixtures, coal tar and tarred product
17 04	Metals (including their alloys)
17 05	Soil (including excavated soil from contaminated sites, stones and dredging spoil)
17 06	Insulation materials and asbestos-containing construction materials
17 08	Gypsum-based construction material
17 09	Other construction and demolition waste

In general, the typical CDW composition is shown in Table 2.

Table 2. Typical CDW composition - % by weight (Fonte ARPA Regione Veneto, 2018)

Typical CDW composition	% by weight
Concrete	10%
Reinforced concrete	20%
Brick	50%
Asphalt	5%
Excavated soil	6%
Wood, paper and	2%
Plastic	5%
Steel	3%

Not all the fractions of the CDW are destined for the production of RA, but only concrete, armed and not, which constitute 30% by weight of the total of the CDW and which can be cataloged in the sub-category CER 17.01.

The CDW, like all waste, must be managed in accordance with what is defined as the Waste Hierarchy (Article 179 of Legislative Decree 152/2006 - Environmental Consolidation Act). The law establishes the hierarchy on waste management: 1. Prevention; 2. Reuse and preparation for reuse; 3. Recycle; 4. Recovery; 5. Disposal. Once the Prevention that is preparatory to the production of the waste has been removed, the other operations can be summarized in Recovery and Disposal. Typical recovery operations on CDW Management are classified in the environmental regulation (D.lgs 152/2006) with the code R5 (Inorganic substance recycling reclamation) and R13 (Storage of waste pending any of the operations numbered R1 to R12 - excluding temporary storage, pending collection, on the site where the waste is produced). Typical Disposal operation on CDW management are classified in the same environmental regulation with the code D1 (Landfill).

The data collection phase aimed to investigate what were the productions of CDWs in Sardinia with particular reference to the CER 17 code and what were the operating methods for managing them on the island. The first source for the study of production and management of CDWs in Sardinia was the Special Waste Report 2017 (ISPRA 2018) which provides data on the production of CDW at national and regional level. The first step was to find a data source that was not limited to the provision of data at the regional level but provided greater territorial detail. This data source was extrapolated from ENVIRONMENTAL AREA, portal on environmental compliance to be borne by companies, service offered by the Italian Chambers of Commerce handicraft agriculture (CCIAA) and managed by Ecocerved (https://www.ecocamere.it/), company consortium of the Italian system of Chambers of Commerce operating in the field of environmental information systems. In Sardinia there are 4 CCIAAs (Cagliari, Oristano, Nuoro and Sassari), whose territorial competences correspond to the borders of the old four provinces before the 2001 reform that brought them to eight. As of today, only the Cagliari and Sassari Chamber of Commerce have adhered to the Environment Area portal and provide annual statistical data on waste referring to MUD data (Single Environmental Declaration Model), which producers and waste managers must complete annually with reference to the year previous one.

The same data were obtained, upon request to the missing Chamber of Commerce and Ecocerved, also for the Chamber of Commerce of Nuoro and Oristano. The available data have been studied and analyzed in order to obtain the necessary information, useful for determining the productions and the management activities of the CDW that can be used for the production of RA (Fig. 1).

The Table 3 shows the type of waste management (CER 17) in Sardinia, and underlines the singularity of each area about CER 17 management.

The research focused on identifying companies operating in the field of inert construction and demolition waste, starting from the 4 companies participating in the project[1]. All the companies authorized to operate in the inert waste sector have been identified in the available and mapped databases, with the criterion expressed in the following sections. Companies adhering to the Cluster were asked for more informative detail on the MUD declarations presented, while the other companies identified are administering a form that will be integrated into the geographical data. Finally, natural aggregates, inert waste landfills - the last step in the waste hierarchy - and concrete plants were searched through specialized websites or public databases.

[1] The companies are the Recycle by Quartucciu, the SMT of Sarroch, the Ecofrantumazioni of Olbia and the Ecoinerti of Iglesias

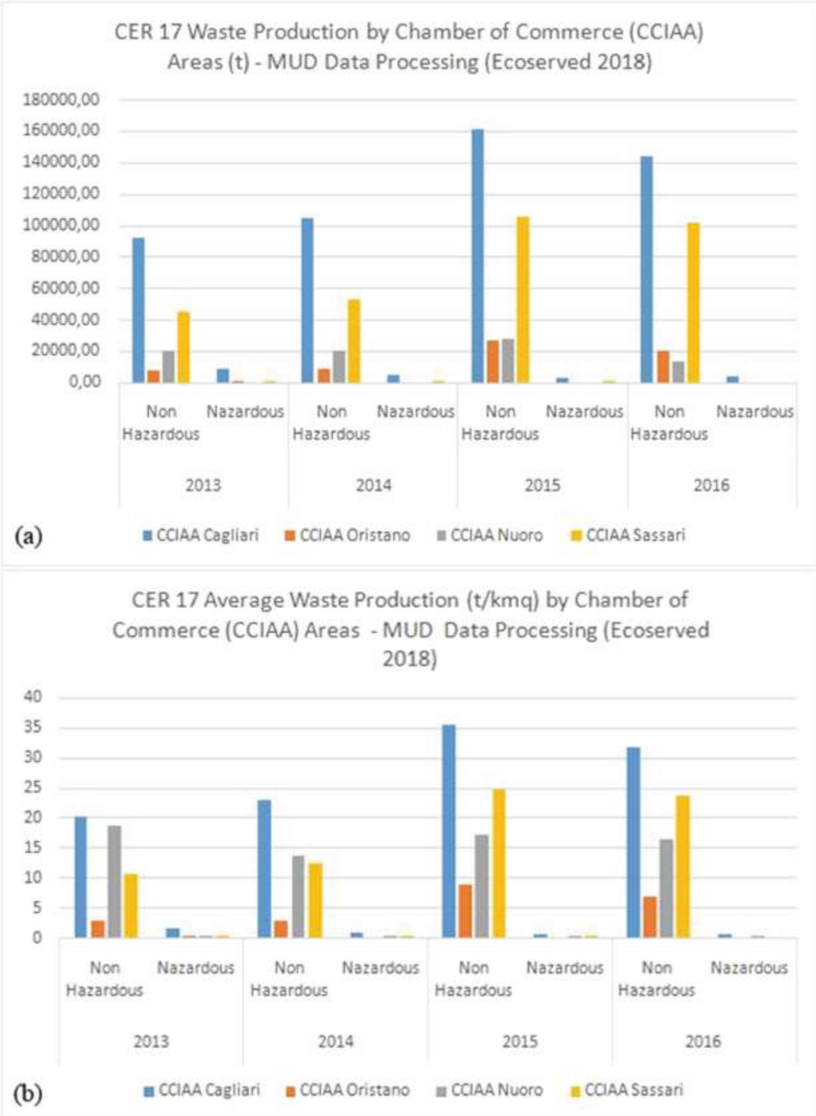

Fig. 1. Declared production of CDW - CER 17 by Chamber of Commerce (CCIAA) areas - Sardinia (a); Average declared production (t/km^2) of CDW - CER 17 by Chamber of Commerce (CCIAA) areas - Sardinia (b)

Table 3. CER 17 Management - CCIAA Cagliari, Oristano, Nuoro, Sassari

Data Origin (Chamber of Commerce)	Treatment	2013	2014	2015	2016
Cagliari	Landfill	93702	71692	90880	79817
	Incineration	50	81	103	124
	Pre-treatment	13639	5370	11200	5564
	Treatment	171	352	198	16
	Recovery	200295	184052	290122	429543
	Storage	11527	34881	32140	42378
Oristano	Landfill	30879	26267	38433	53738
	Incineration	0	0	0	0
	Pre-treatment	0	0	0	0
	Treatment	0	0	0	0
	Recovery	69603	82530	97068	79449
	Storage	577	4174	5990	1726
Nuoro	Landfill	11852	355	15806	6461
	Incineration	0	0	0	0
	Pre-treatment	0	0	0	0
	Treatment	0	0	0	0
	Recovery	56669	88550	83914	44417
	Storage	0	27634	18858	16583
Sassari	Landfill	148289	143748	191851	134186
	Incineration	0	0	0	0
	Pre-treatment	51	105	103	144
	Treatment	0	0	0	0
	Recovery	10490	23504	29065	50059
	Storage	0	9282	23980	5931

2.2 Mapping and Sharing Data: The MEISAR_Map

The data collected have been organized, visualized and shared into a project called "MEISAR_Map", based on a Google MyMaps platform in order to keep all of the authors and participants of the MEISAR project up-to-dated on the different stages of the research, obtained elaborating geographical data from multiple sources, realized by means of the QGIS platform. We georeferenced the locations of the companies belonging to the MEISAR cluster, as well as all the players at regional level involved into the different processes of production, use and disposal of natural and recycled aggregates: quarry concessions, aggregate treatment and recycling plants, batching plants, worksites, landfills, MEISAR cluster firms (Fig. 2).

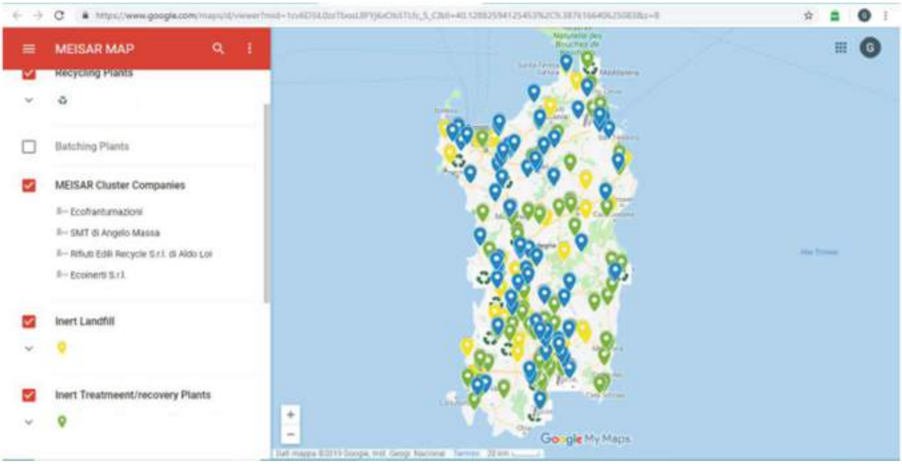

Fig. 2. The MEISAR_MAP and a sample of the data realized. http://bit.ly/MEISAR_MAP

Geo-referencing was performed using the geocoding service provided by the Google platform was used, while data coming from official sources as RAS - Sardinia Region authority held plane coordinates in national geodetic systems and were loaded without further corrections. The data have been integrated and controlled by means of the direct observation and check on different sources[2].

3 The Model – Circular Economy and Industrial Location à la Weber Revised

3.1 Circular Economy and Industrial Symbiosis

The research carried is interesting within a theoretical framework of a circular economy of recycled aggregates [14, 15], revising a classical model of industrial location adapted to the current situation. That has been done both analysing the theoretical foundations but also trying to hypothesize practical effects and evidences, to benefit the MEISAR clusters both in terms of the academics and of the industries involved (n 5 companies of aggregate recovery).

The circular economy concept within the classical industrial localization models is consistent with the industrial symbiosis, in considering to-date challenges of re-using par of waste of a production - or demolition - process again into the production process [16].

Such concept is associated with the theories carried on by authors like Georgescu-Roegen, Ayres, Kuznets, et al. [17–19], in which the economical process must not be

[2] I.e. in the case of data on quarries and their licenses the ‘Quarries Cadaster’, although quite outdated, dating back to 2007, has been checked and data crossed with existing licenses, verifying their locations by observing the regional orthoimages and satellites maps in Google Maps.

considered only as a linear one and based on a continuous growth, but inserted into a circular process of reduction and re-use of waste. Industrial symbiosis appears as the ‘operational arm’ from the industrial and localization point of view of the circular economy [20, 21]. Geographical proximity is necessary but not the only condition to exploit this kind of symbiosis. However, it appears important as in many cases – and this is very likely the case of the case study presented here – the presence of bulky products and waste need to minimize the costs and mileage before their processing and re-processing [22]. The idea is such that separate industries can be put into a collective approach towards the reach of a competitive advantage based on the exchange of physical products, energy sources, and by-products of production processes [23].

3.2 Weber Revised

The starting point is the Weber’s model of industrial location in 1909 [24]. The model was a typical product of that linear scheme of the classical economic theory: extraction of resources - manufacturing - distribution to the market. In such a scheme, enters space: namely as an origin of resources and as place of disposal of waste, without caring about their destiny. In the present case, the production is characterized by the presence of two different kinds of materials, as raw materials - extracted from quarries - and ‘second’ raw materials - as those coming from recycling. In doing this, the model become a ‘circular one’, as waste - or part of waste - is reused. A spatial consequence is that destinations of final products become also locations of origin of new materials.

Going to the roots of the model, Alfred Weber in his essay on the “Theory of Industrial Location” set some simplifying assumptions, as the fixed locations of all inputs and market, and the fact that the manufacturing firm chooses the best location where the sum of the total transport costs, incoming and outgoing, is minimized. In the most basic version of the model, the industry uses only one input material localized at a given location of a homogeneous plane and sells its output in a unique market localized in the same plane. Technology is allowing constant returns of scale and not allowing input substitution.

In Weber’s hypotheses it is important the classification of resources. Weber talks about localized materials (inputs), as those having a fixed location in space, furtherly organized in “pure” - they are completely used into the production process and therefore in the final product - and “gross” - the lose some weight during the production process, and therefore having only a part into the final product. Other resources are defined as ubiquitous or non-localized, being fairly uniformly distributed and accessible in space.

The target is a localization leading to minimizing transport costs, with transport considered as relying on a unique mode. That happens, in Weber’s simplified model, where there is only one site for materials and one for the market, by means of minimizing the following formula:

$$T = t\,w_r * d(R) + t\,w_m * d(M)$$

With:

T = Total Transport Cost (in ton-km)
w_r = weight per unit of input
t = Transport Cost in € per ton-km
w_m = weight per unit of output
d(R) = Distance RF (resource site - production site)
d(M) = Distance FM (production site – market)

The manufacturing firm F will locate in a point between the resource site R and the market place M. Such location will depend on the weight of the materials compared to the final product. Weber introduced an indicator called MI = Material index: MI = weight of the localized resources/weight of the final product; Pure Resources: MI = 1; Gross Resources: MI > 1

In the case of pure resources entering completely into the final product, no waste will be available, and therefore the location will happen at an intermediate point between R and M (first case, Fig. 4). In the case in which gross resources prevail, (IM > 1), localization will occur at a close proximity of the resources site R, to minimize transport costs of waste (third case, Fig. 3).

An extreme case is given by the localization in the market-place M, (second case, Fig. 4) in the case in which the final product is mainly realized using perishable resources available at the same market location - as water, for instance, considered as ubiquitous.

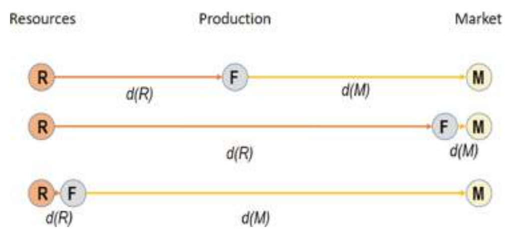

Fig. 3. Location à la Weber in the simplified model (along a line)

4 The Case Study

The opportunity to insert the proposed model into a real case is given by the Sant'Elia Stadium, which is scheduled to be demolished together with the realization of a new facility for the Cagliari Football Team. The following actions - and related sections - have been performed: Sect. 4.1 Quantification of concrete in present Stadium and quantification of the extractable concrete (main material) of the current stadium (Sant'Elia); Sect. 4.2 Policy considerations.

4.1 Recycled Aggregates (RA) from Sant'Elia Stadium

The characterization of the concrete of the Sant'Elia Stadium refers to the beams of the second ring and the foundation blocks. Before performing the demolition of part of these structures, tests were carried out to evaluate the mechanical performance of concrete. The obtained debris, divided by source, were crushed to obtain two types of coarse RA, both with grain size 4–16 mm. The demolition materials of the beam and foundation have been kept separate for the subsequent characterization tests according to the tests foreseen in the UNI EN 12620: 2008 standard for CE marking level 2+ [25]. Six concrete mixes, with 30%, 50% and 80% of total mass of coarse RA, were produced in order to obtain a description of physical and mechanical properties. An additional mix of ordinary concrete with only natural aggregates was produced for comparison. Tests on recycled concrete (workability values at 14 and 28 days, compression) gave the following encouraging results:

– Recycled concrete produced with coarse recycled aggregates, even when the natural aggregates replacement percentages reaches 80%, as shown equivalent mechanical performances then those of ordinary concrete.
– The performance of recycled concrete is not related to the parent concrete mechanical characteristics.
– The results showed that the care in the study of the design of the mixture is fundamental for competitive recycled concretes.
– The durability tests on recycled concrete are in progress, the first results obtained show optimal performance of concretes even in the long term.
– The selective demolition of the structures is fundamental to obtain concrete recycled aggregates immediately marketable, with size distribution similar to those required by the concrete plants.
– Following the results presented and the extensive international literature on the topic, Public Administrations must produce specifications that provide the use of recycled concretes.

After these interesting results, volumetric quantification was carried out instead of the concrete of the Sant'Elia stadium.

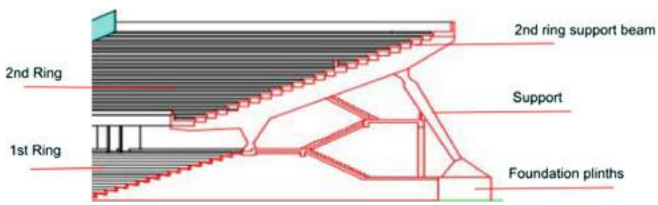

Fig. 4. Section and detail of the Sant'Elia stadium - Cagliari

From the design drawings (Fig. 4) and site inspections, together with the characterization of the materials, it was possible to make a preliminary estimate of the potential reusable material. The total volume of recoverable concrete is therefore equal to approximately 8.880 m^3. These 8,800 m^3 in place are destined to grow if in pile; the literature confirmed also by the information received from the cluster companies has faced a growth coefficient of 2.5–3, or m^3 of RA in a heap equal to 22,000–26,400 m^3

4.2 Policy Considerations

The case is an interesting one as the new facility will be realized in close proximity to the existing one and the process of demolition/construction will occur in a condition of spatial and temporal closeness. This is interesting in terms of production of waste, their treatment and reuse in recycled aggregates, as they have important implications from the urbanistic and planning point of view, given the effects generated by such activities in the area of Cagliari and South Sardinia.

With reference the volumes of materials estimated in the previous section, that for the considerations described above must be packaged and placed in the concrete packaging process within a distance not exceeding 30 km from the stadium. Therefore all the companies potentially interested in the circular economy process - recycling plants and concrete mixing centers - will be those included within this range in response to the demand for concrete for the new stadium, using the ARs from the current stadium.

To activate this process, which is moreover desirable, it is necessary in the tender to provide for the use of the RAs at least in the percentage of 30% to be sent in the packaging of the concrete on the aggregates, thus falling under the ordinary regime envisaged by the legislation in line with the guidelines of the Plan for Ecological Public Procurement in Sardinia Region [26].

4.3 Contextualization of Weber Model

The case study presented here can be inserted into the Weberian localization theory in a linear context, with two fixed locations, one of extraction of resources and one of market (M), together with a production site in site between them (F).

With reference to the original model - represented by Scenario 0 in Fig. 5 - the proposal here foresees a set of basic hypotheses.

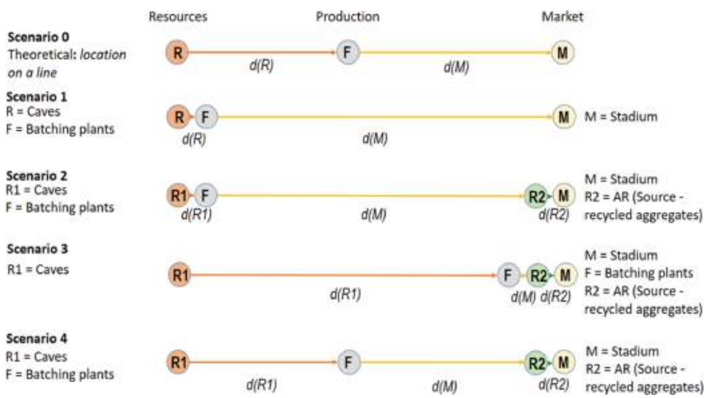

Fig. 5. The Weberian localization model of batching plants in a circular economy

The point R indicates to a generic extraction site - a quarry - from where Natural aggregates are taken as raw materials. M is the market site, or the area of Sant'Elia Stadium where the new facility will be realized. F indicates the place of production of aggregates, the batching plants.

In its more simplified version the model foresees four scenarios (Fig. 7), although in more realistic simulations considering also real quantities of materials and products, waste and capacity of production and processing plants, it will be possible to evaluate further scenarios with multiple locations - of extraction and production - as well as to hypothesize more efficient allocations.

- Scenario 1 is the classical case. The batching plant, F is localized in close proximity of resources. Waste recycling from demolition is not considered.
- From Scenario 2 on, the market site M is considered as a second site of resources (R2), together with quarries (R1). The localization of the batching plant F remains in proximity of raw materials but R2 becomes important for extracting 'second' raw materials. In this case, however, as these latter need a further processing, a transport of second raw materials from the extraction site to processing site (F), still localized in R1, and again to the market M.
- In Scenario 3, the production plant F is localized in close proximity of the market (M) and second raw materials (R2). Such scenario is an optimal one when the share of second raw materials (Recycled Aggregates) is prevalent and the recourse to standard raw materials is scarce. In any case the cost of transport of raw materials to the processing plant and location is considered.
  Scenarios 2 and 3 are extreme cases as they are based on the hypotheses that foresee, respectively that standard raw materials (NA - Natural Aggregates) are dominant - in the first case - and second raw materials (RA - Recycled Aggregates) are - in the second one.
- Scenario 4 identifies cases à la Weber where a batching plant could be localized in a point F in an intermediate position in which the cost function of transport of raw materials - first or second; NA or RA - is minimized, not necessarily therefore foreseen a location of a batching plant is in proximity of a resources' site.

A part from the theoretical aspects, such scenarios are linked by operational considerations, among theme, the percentage of demolition materials that can be transformed into RA, that in the specific case could reach the 100% of structural concrete of the stadium.

4.4 Some Empirical Observations

We considered the data collected and organized referring them particularly to the Cagliari area – Municipality – Metropolitan area. We created a set of isolines from the Sant'Elia Stadium location, spaced by 5 km distance up to 30 km, being this distance the maximum one drivable from a batching plant to a destination. The data used are those above described, plus the graphical road network of the Sardegna Region, where the service areas/shortest path algorithms in QGIS were run.

In Table 4 some summary statistics concerning the presence of dedicated plants in the Cagliari Region are presented. A first general observation we can do is that a wide percentage of plants and disposal sites are actually located very close to the urban area of Cagliari, in an area of intermediate dimension between the Municipality of Cagliari and its Metropolitan area.

Table 4. Summary statistics of plants in the area

Plants	Plants within 30 km from Sant'Elia stadium	Total Plants in Sardinia	% Plants 30 km from Sant'Elia over total
Batching plants	9	61	14.75
MEISAR cluster	1	4	25.00
Quarries	15	91	16.48
Waste disposal	12	61	19.67
Treatment plants	20	101	19.80
Total	57	318	17.92

A further visual analysis (Fig. 6) can help also in deriving some extra information on the spatial distribution and concentration of the plants. We can notice how batching plants are furtherly concentrated and in close proximity of the Cagliari urban area, with 7 plants within 15 km of the Sant'Elia area. Another consideration is that all the other three categories considered (quarries, waste disposal and treatment plants) are generally located at close proximity to each other, forming in many cases some real clusters in

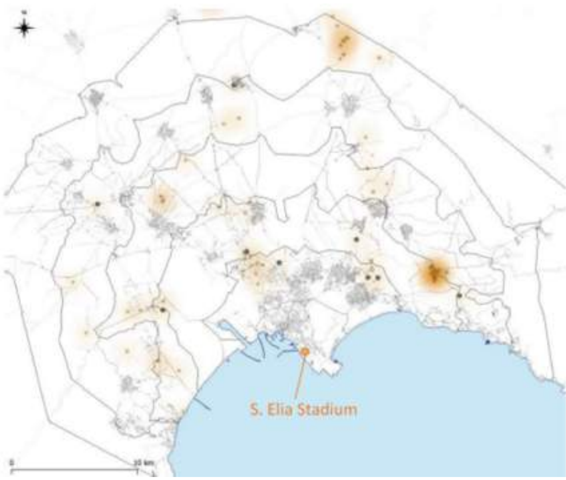

Fig. 6. The spatial distribution and concentration (heat map) of batching plants (grey dots), quarries, waste disposal, treatment plants (lighter dots) within 30 km from the Sant'Elia Stadium (orange and red area). Highlighted: The Donori Cluster (North) and the Quartu Sant'Elena (East) Cluster. (Color figure online)

the area. We can particularly notice two clusters in the Eastern part of the area considered (Eastern part of Quartu Municipality) and North-eastern of the urban area (Donori).

These clusters confirm the co-existence in space of plants whose activity is strictly related and follow principle of geographical industrial location theory. Also, batching plants tend to be ‘attracted’ by the areas of extraction/processing – here also confirming partly the theory and the Scenario 1 case.

As a general remark, we can notice that batching plants are located at intermediate locations between the built-up urban area and the extraction/disposal sites, and very rarely located in proximity to them. The presence of the two clusters confirm that the metropolitan city of Cagliari is the most suitable territorial dimension for developing governance policies for the re-use of RA [12].

5 Conclusions

The present research represents an intermediate point within a wider research project that is mainly based on the analysis of concrete and natural aggregates used in the construction sector and its usability in a circular economy system. What we carried on so far represents both a conceptual and an operational framework for modeling the circular economical concept among an industrial localization model and to understand what could be the real and actual implications of implementing, in Sardinia, a system of reusing waste from construction into the production process as recycled aggregates.

The case study appeared interesting as Sardinia appears as a closed market for both natural and recycled aggregates, being it quite difficult - if not impossible - to set flows with the continents of this kind of products and by-products.

In particular what we have been focused on is the real case study of the Sant’Elia old football stadium as an important source for recycled aggregates, particularly in line with the project of realization of a new football facility in close proximity to the, now dismissed, existing one. The operations of demolition and construction of the new facility will represent an interesting case study for putting in action a plan for a local circular economy: the volumes considered, in terms of materials, are such that their optimal use can transform into a positive opportunity for the construction system of the entire sub-region of Cagliari Metro and South Sardinia. That could also represent an interesting test-bed for a broader set of policies to be implemented at regional and - possibly - national level.

The present paper ended up with the set-up of a modified model of industrial localization capable of considering the circular economic - and industrial symbiosis - principles within a classic economic framework to develop operational governance policies, in line with the international trend of Itaca, BREAM and Leed agreements.

References

1. de Larrard, F., Colina, H. (eds.): Concrete Recycling: Research and Practice. CRC Press, Boca Raton (2019)
2. Rodríguez-Robles, D., Van den Heede, P., De Belie, N.: Life cycle assessment applied to recycled aggregate concrete. In: de Brito, J., Agrelo, F. (eds.) New Trends in Eco-efficient and Recycled Concrete, pp. 207–256. Woodhead Publishing (2019)
3. Delvoie, S., Zhao, Z., Michel, F., Courard, L.: Market analysis of recycled sands and aggregates in NorthWest Europe: drivers and barriers. In: IOP Conference Series: Earth and Environmental Science, vol. 225, no. 1, p. 012055. IOP Publishing, January 2019
4. Balletto, G., Pani, L., Mei, G., Borruso, G.: Approcci economia circolare applicati agli stadi: dalle antiche campagne di spoglio alla demolizione con recupero di frazioni. Il caso dello stadio di Cagliari. In: Cuboni, F., Desogus, G., Quaquero, E. (eds.) Edilizia Circolare, pp. 1161–1180. Edicom Edizioni, Monfalcone (Gorizia) (2018)
5. Balletto, G. et al.: La pianificazione sostenibile delle risorse. Analisi e proposte per il dimensionamento del fabbisogno minerario di seconda categoria ad uso civile. La Sardegna come caso di studio. Franco Angeli, Milano (2005)
6. Renner, G.T.: Geography of industrial localization. Econ. Geogr. **23**(3), 167–189 (1947)
7. Pasini, C.S.: Economia industriale. Economia dei mercati imperfetti. LUISS University Press-Po, Roma (2013)
8. Materiali per l'Edilizia e le Infrastrutture Sostenibili: gli Aggregati Riciclati (MEISAR) cluster Top-Down finanziato dalla Regione Autonoma della Sardegna attraverso: POR Sardegna FESR 2014/2020 - Asse Prioritario I "Ricerca Scientifica, Sviluppo Tecnologico e Innovazione" Azione 1.1.4
9. Pani, L., Francesconi, L., Lopez Gayarre, F.: Properties of precast hollow concrete blocks using recycled concrete aggregates. In: Sardinia 2015 15th International waste management and Landfill Symposium, pp. 1–10. CISA, Coop. Libraria Editrice (2015)
10. De Angelis, G.: Il Mercato del Lavoro in Italia: una lettura a partire dal caso dell'Edilizia. Argomenti **10**, 65–82 (2018)
11. Il Mercato Delle Costruzioni in Sardegna Rapporto annuale 2016 e stime previsionali 2017. http://www.cnasarda.it/media/Estratto%20Rapporto%20Costruzioni%20marzo%202017.pdf
12. Balletto, G., Garau, C., Desogus, G., Mei, G.: Urban redevelopment and energy saving. The case of the incentives in Italy, between risks and opportunities. In: Third International Conference on Advances in Information Processing and Communication Technology-IPCT, pp. 110–114. Institute of Research Engineers and Doctors, USA (2015)
13. Lloyd, P.E., Dicken, P.: Location in Space: A Theoretical Approach to Economic Geography. Harper & Row, New York (1972)
14. Sferra, A.S.: I rifiuti in edilizia: Riuso e riciclo nell'industria 4.0. FrancoAngeli (2019)
15. Kamino, G., Gomes, S., Bragança, L.: Improving the sustainability assessment method SBTool Urban–a critical review of construction and demolition waste (CDW) indicator. In: IOP Conference Series: Earth and Environmental Science, vol. 225, no. 1, p. 012004. IOP Publishing, January 2019
16. Baldassarre, B., Schepers, M., Bocken, N., Cuppen, E., Korevaar, G., Calabretta, G.: Industrial symbiosis: towards a design process for eco-industrial clusters by integrating circular economy and industrial ecology perspectives. J. Clean. Prod. **216**, 446–460 (2019)
17. Arrow, K.J.: The economic implications of learning by doing. Rev. Econ. Stud. **29**(3), 155–173 (1962)

18. Ayres, R.U.: Industrial metabolism: theory and policy. In: Ayres, R.U., Simonis, U.E. (eds.) Industrial Metabolism: Restructuring for Sustainable Development, pp. 23–37. United Nations University Press, Tokyo (1994)
19. Kuznets, S.: Modern Economic Growth. Rate, Structure and Spread. Yale University Press, New Haven (1966)
20. Domenech, T., Bleischwitz, R., Doranova, A., Panayotopoulos, D., Roman, L.: Mapping industrial symbiosis development in europe_ typologies of networks, characteristics, performance and contribution to the circular economy. Resour. Conserv. Recycl. **141**, 76–98 (2019)
21. Lamonica, B., Lacy, P.: Circular Economy: Dallo spreco al valore. EGEA, Milano (2016)
22. Oliveira Neto, G.C., Correia, J.M.: Environmental and economic advantages of adopting reverse logistics for recycling construction and demolition waste: a case study of Brazilian construction and recycling companies. Waste Manag. Res. **37**, 176–185 (2019)
23. Lucia, M.G., Duglio, S., Lazzarini, P. (eds.): Verso un'economia della sostenibilità: Lo scenario e le sfide. FrancoAngeli, Milan (2018)
24. Weber, A.: Über des Standort der Industrien. Part. I. Reine Theorie des Standorts, Tübingen (English Trans. by C.J. Friedrich (1929) Alfred Weber's Theory of Location of industries). The University of Chicago Press (1909)
25. Tam, V.W., Soomro, M., Evangelista, A.C.J.: A review of recycled aggregate in concrete applications (2000–2017). Constr. Build. Mater. **172**, 272–292 (2018)
26. Official website. https://www.gppbest.eu/?page_id=41&lang=en