Alpine Industrial Landscapes in Transition.
Towards a transferable strategy for brownfield transformation in mountain regions.

Marcello Modica[1], Udo Weilacher[2]

[1]*Technical University of Munich, Faculty of Architecture, Chair of Landscape Architecture and Industrial Landscapes,* marcello.modica@tum.de
[2]*Technical University of Munich, Faculty of Architecture, Chair of Landscape Architecture and Industrial Landscapes,* weilacher@lai.ar.tum.de

Abstract: Since a few decades in many European mountain regions a process of economic restructuring is leading to the decline of traditional heavy and manufacturing industry. The issue of brownfield transformation is therefore becoming a crucial topic in the sustainable development of peripheral and rural areas too, although not yet officially recognized. The complex environmental, economic and social challenges posed by brownfield transformation in mountain areas, added to the structural limitations of marginal contexts as such, require the development of a context-specific, transferable strategy. In this perspective, the Alps, as the most developed mountain region in Europe, can play a key role as a laboratory for brownfields conversion. The first results of this research, which include a comparative analysis of the most representative industrial brownfield typologies found in mountain areas, suggest that an effective and transferable transformation strategy can be successfully developed only if a "landscape approach" based on structuralist planning principles is used. Through the development of an according strategy, the research wants to show that industrial brownfield sites can be positively and constructively interpreted, in the Alpine context and possibly in other mountain regions, as a valuable territorial infrastructure to be reactivated rather than simply a vacant land to be redeveloped.

Keywords: alpine industrial landscape, landscape transformation, brownfield recycling, mountain region

Brownfields in mountain regions – a special challenge

Due to the global structural change in industry since the late 1970s, the transformation of industrial brownfield sites represents one of the major challenges for the sustainable development of urban regions worldwide. Aiming to tackle the unprecedented land use change caused by the decline of traditional heavy industries, different planning strategies and tools have been developed and tested in the last decades (Ferber *et al.*, 2006). From the functional reconversion of vacant buildings and production spaces, also known as adaptive reuse, to the ecological-led conversion of polluted wastelands in post-industrial landscape parks, the issue of brownfield transformation has nowadays become an integral part of urban development plans and programs (Weilacher, 2008, Baum and Christiaanse, 2012, Braae, 2015). The global need to reduce the amount of landscape consumption after reaching "peak soil" (Fritz, 2010) fostered also the search for new strategies and methods.

The transformation of large scale industrial areas in densely populated urban contexts has been already thoroughly investigated (Dragotto and Gargiulo, 2003, Dettmar and Rohler, 2015). By contrast, peripheral rural regions are rarely examined as a setting for brownfield redevelopment. These landscapes are characterized by scarce urbanization, long-lasting structural development problems and in many cases by highly dynamic natural change processes, driven by high relief energy and recently reinforced by the effects of global climate change (Cherisch *et al.*, 2015). High mountain regions, for example, are very dynamic natural landscapes but so strongly tied to their stereotypical rural and recreational image that the presence of heavy industries, and thus of derelict industrial sites, are often overlooked (Nordregio, 2004). However, in many noticeable cases the cradle of a country's successful industrialization can be traced back to the early exploitation and industrial processing of natural resources in mountain areas. The Alps are an excellent model of this development, for example with regards to ironmaking and papermaking in Austria, the production of cement, textile, paper and iron in northern Italy or ironmaking, papermaking and electrochemistry in southeastern France. But the industrialisation of European mountain landscapes also took place in the Pyrenees in France (metalworking, electrochemistry) and Spain (metalworking, cement, textile); the Cantabrian Mountains in Spain (coal mining and ironmaking); the Carpathians in Slovakia (coal mining and ironmaking), Hungary (ironmaking and papermaking) and Romania (coal mining, ironmaking and electrochemistry); the Balkans in Bulgaria (coal mining, metal smelting and textile); the Caucasus Mountains in Armenia (metal smelting and electrochemistry) and Georgia (coal mining). In all of the aforementioned mountain ranges, the development of industry followed a mere functional logic, that is, to prioritize the cost-efficient use of local resources over the distribution to end-markets (Leonardi, 1998, Collantes, 2003). A first locational advantage was related to the on-site exploitation of natural resources and raw materials – such as water flows for mechanical purposes (textile and paper industry, metal forges), mineral deposits (ferrous and non ferrous metallurgy, cement and lime industry) and timber (paper industry and pre-coke ironmaking). A second one, crucial to heavy industries was the direct and costless use of independent generation of hydropower (energy-intensive heavy industries). A third locational advantage was the availability of cheap, and in some cases skilled labour force from the existing low-wage and low-profit agricultural sector. In this way, the industrialization of mountain areas assumed the character of a hetero-direct functional appropriation of existing environmental resources (Raffestin, 1989).

The mono-structure of mountain industry, attached to specific locational factors and highly dependent on external frame conditions, is the main reason behind the continuous deindustrialisation in the last decades (Perlik, 2019). As soon as traditional heavy and manufacturing mountain industries were hit by the growing independence from raw materials and energy sources, and the global reorganization of industry – with the relocation of basic production chains in highly accessible locations or in developing countries –, their inherent lack of resilience was dramatically revealed (Raffestin and Crivelli, 1988, Gebhardt, 1990). Especially in mountain areas, the consequences of the industrial decline in the last decades were severe and far-reaching for the social, ecologic and economic conditions. Not only did many people, often coming from small local communities, loose their jobs, left the region and added to a continuous depopulation of many inner mountain valleys (Bätzing *et al.*, 1996). The closed down factories also pose an enormous problem to mountain regions from an environmental point of view. Due to the specific characteristics of the mountain environment – namely the relevant topographic constraints, the prevalence of extensive semi-natural open spaces and the scattered urbanization – the decommissioning of industrial sites often generates extensive brownfields whose structural network reaches far beyond the core productive facilities and includes the complex system of supporting infrastructures and related functional spaces. It is most remarkable, for example, that most of the typical mountain industries were tightly connected to the complex local and regional water system. In many cases the artificial water systems generated during the industrialisation phase were not only connected as artificial bypasses to the natural water systems, but the industry also changed the natural water regime substantially. From an economic point of view, a major problem of brownfield recycling in such economically marginal contexts is represented by the imbalance (real and perceived) between the amount of investments required for the entire transformation process and the uncertainty in terms of completion, achievements and returns. The high costs for the site preparation, including environmental remediation and built structures management (either demolition or preservation), are often burdening for small communities which lack of adequate financial and contractual capacities. At the same time, the lack of vision and long-term strategies, or even the conflicts between these strategies (where existing) and their feasibility, keep any potential private investor away from such operations. A further limitation is provided by the restricted range and/or scale of activities that can be really implemented in these sites, given the contextual conditions – low demand, few potential users, scarce accessibility, etc. It is not surprising, then, that the only successful reconversion projects in mountain areas are those related to the adaptive reuse of rather small sites (often less than 1 hectare) of local importance and projects related to the preservation of listed sites or buildings of historic interest (e.g. industrial heritage sites) (Lorenzetti and Valsangiacomo, 2016). Rather successful are also large-scale inner developments in major urban centres, where the pressure for land recycling is higher.

The Alps – a distinguished case study area

Located in the core of Europe, at the crossroad of strong economic regions and dynamic metropolises, the Alps were pushed through a modernization process far earlier than other mountain ranges (Bartaletti, 2011). This caused the emergence of the different forms and cycles of industrial development, leading the Alps to be today one of the few existing mountain regions worldwide characterized by a mature industrialization (Bätzing *et al.*, 2005). At least four industrial development phases since the continental spread of the First Industrial Revolution can be identified (Raffestin and Crivelli, 1988, Gebhardt, 1990). The first phase (1850-1880) was that of the industrial transition (or updated) of pre-existing activities, such as ironmaking, lime/cement production and textile manufacturing. The joint action of new technologies (coke, steam engine) and new transport modes (railway) caused an upgrade in productivity and a spatial concentration of the earlier industrial activities in valley floors and transit corridors. In the second phase (1880-1960), the discovery and spread of hydropower allowed the creation of new heavy industries in electrochemistry and electrometallurgy, which made the "industrial fortune" of many inner and remote valleys. The third phase (1960-1980) was characterized by the rapid and widespread development of light industry in low added value sectors (mechanics, electric appliances, apparels and food). This process, which affected several Alpine and pre-Alpine regions, mainly occurred through forms of decentralized industrialization, such as branch-plants and industrial districts. The last and current phase (1980-today) coincides with the functional and economic integration of the Alpine region with the surrounding metropolitan areas and global networks. In this context, advanced industries in knowledge-intensive sectors are gradually developing in major Alpine agglomerations only, thanks to the high accessibility and the concentration of research centres, business incubators and urban amenities (Perlik and Messerli, 2004).

The current phase, however, is also characterized by the progressive decline and disappearance of the historical labour and energy-intensive industry established in the earlier phases (Gebhardt, 1990). This is clearly reflected in the shift of the secondary sector employment from 50% to 36% between 1975 and 2000, and even further down to 18% by 2016, registered across the Alpine regions (sources: Alpine Convention, OECD, European Commission, FSO). Compared to the national averages of Alpine countries, these numbers show that in the Alps a slightly delayed but equally relevant deindustrialization process is occurring. At present, 289 industrial sites in traditional sectors (ferrous and nonferrous metallurgy, chemical industry, building material industry, textile industry and paper industry) have been identified across the entire Alpine arc (Modica, 2019). Of these, 142 are already closed or downsized (Figure 1). The worst performances are registered in the sectors of textile industry (26 closed sites on 35 in total) and nonferrous metallurgy (24 / 35), while the less affected sector is paper industry (12 / 47). Building material industry, ferrous metallurgy and chemical industry are in line with the Alpine average of about 50% of the sites closed or downsized.

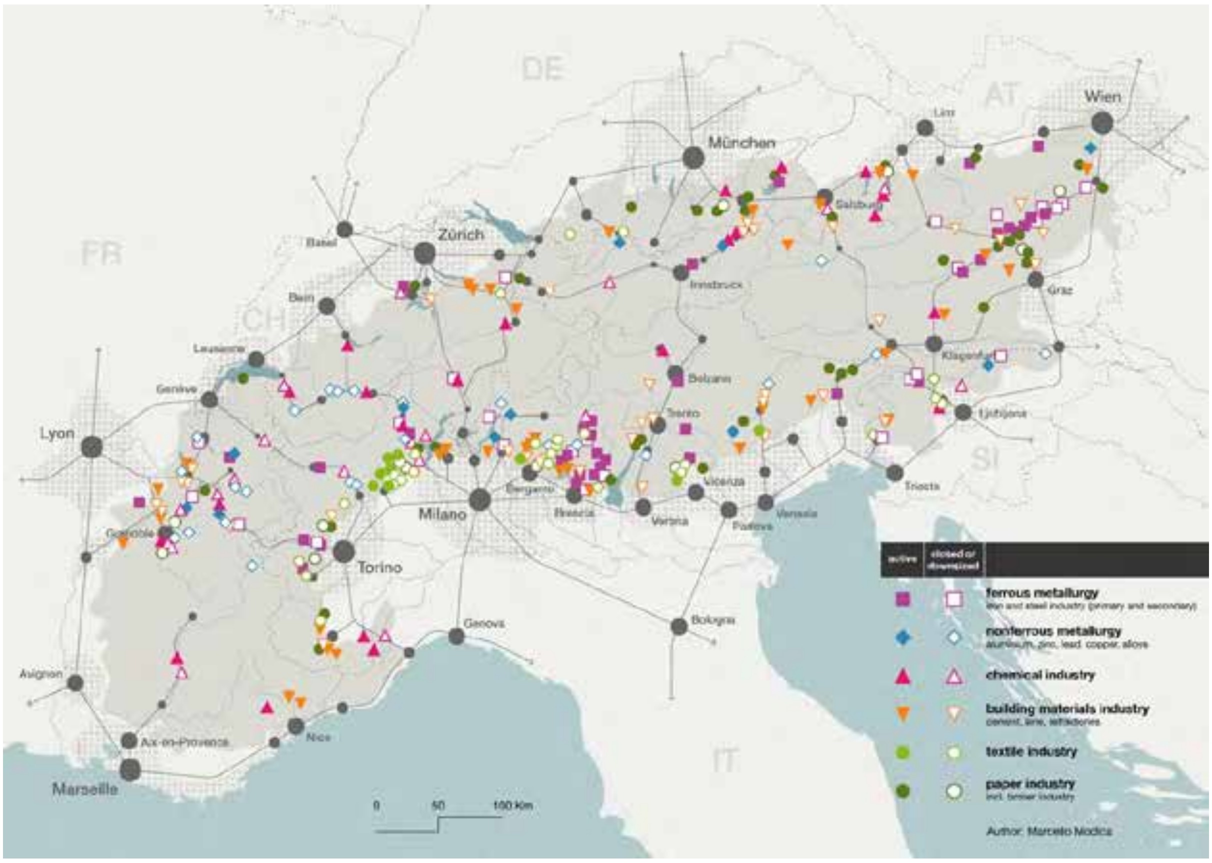

Figure 1 – Survey of large industrial sites in the Alps (elaborated by Marcello Modica)

Given this scenario, it is reasonable to expect that in many Alpine areas the already significant amount of disused or underused industrial sites will tend to increase in the near future. Although not yet officially recognized at the regional planning policy levels and by the scientific community, the management of brownfield sites is currently becoming a crucial issue in the sustainable development of the Alpine region. Three main challenges can be identified in this context:

- environmental regeneration: soil de-contamination from potentially hazardous waste (with expected positive effects beyond the site itself, e.g. in connection to rivers and groundwater), prevention of natural disasters (e.g. flood prevention and landslide protection), ecological compensation (e.g. soil de-sealing and improvement of disrupted ecological corridors);
- economic development: sustainable re-industrialization (e.g. making or reactivating space for small-scale business activities in green economy sectors linked to local nature-based production chains, innovation and research activities and business support centres) and multi-seasonal tourism (e.g. in connection to cultural heritage valorization, artistic events, etc.);
- socio-cultural development: prevention of rural depopulation and social desertification, improvement/sustain of local public services, protection of cultural identities

The Alps are a distinguished case study area not only because of its key position in the middle of Europe and its crucial importance to all six Alpine countries and their neighbours. This central European mountain region is, in fact, a unique socio-cultural complex integrated into a dynamic natural setting that currently transforms dramatically under the influence of the global climate change (Grabherr *et al.*, 2010). Many of the brownfield sites are located at strategic key positions in the region with regard to the future development of sustainable living environments on a local and regional scale. By carefully combining the solutions to the above mentioned three major challenges at different administrative levels, the recycling of industrial brownfield sites will prove to be essential for the economic, ecological and social consolidation of the Alpine region. In this perspective, the Alps can be considered as a real laboratory (test-field) for brownfields conversion in mountain regions. The INTERREG Alpine Space project *trAILs – Alpine Industrial Landscapes Transformation*, initiated and coordinated by the Technical University of Munich, builds exactly on this vision.

Landscape typologies as result of industry-environment interactions

In order to identify and test potential strategies for the recycling of mountain brownfield sites, an in-depth analysis of the most representative site typologies has been developed as a preliminary cognitive step in the framework of the present research. The selection and analysis of site typologies has been managed in a two-step process. At first, three "groups" of industrial activities have been identified on the basis of the most relevant physical interactions between industry and the mountain environment, i.e. minerals, water and energy. Accordingly, four key production sectors have been selected: building material industry (mineral extraction), ferrous metallurgy (mineral extraction and large-scale hydropower), textile industry (water flow exploitation and small-scale hydropower) and nonferrous metallurgy (large-scale hydropower). A second step consisted in the identification of a specific productive site typology within the selected sector, connected to a basic productive process (function). The assumption is, that similar industrial activities generate similar spatial interactions, footprints and thus landscapes (form). As result, the following typologies of industrial landscape have been identified: cement plants (building material industry), EAF steelworks (ferrous metallurgy), spinning mills (textile industry) and aluminium smelters (nonferrous metallurgy). For each typology, six sites differing by location, status and size have been at first compared morphologically, based on a figure-ground analysis. As soon as the results were available, an on-site detailed analysis of one specific site per sector has been performed. This site analysis consisted in a prolonged site visit (one week) during which the site and the surroundings have been intensively and continuously explored and photographically documented, focussing especially on the spatial characteristics. The following paragraphs describe a brief descriptive synthesis of the four landscape typologies, supported by three representative images from the site visits.

Cement factories

The selected sites for the typological analysis are (Figure 2): Italcementi, Albino/IT – Wietersdorfer & Peggauer Zementwerke, Peggau/AT– Ciment Vicat, Montagnole/FR – Salonit Anhovo, Deskle/SLO – Zementwerk Eiberg, Schwoich/AT – Colacem - Gemonio/IT. The in-depth analysis has been conducted on: Zementwerk Eiberg - Schwoich/AT.

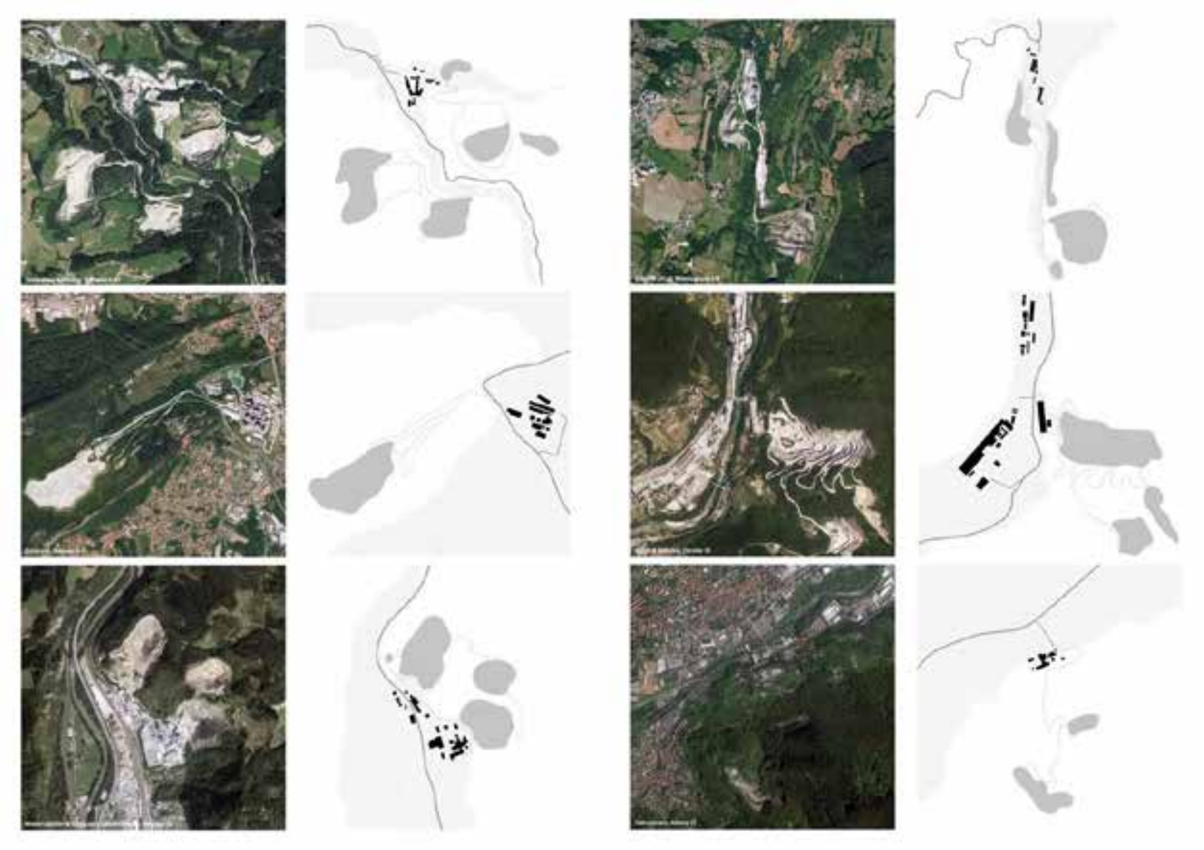

Figure 2 – Cement factories, typological study (elaborated by the author)

The driving force behind cement production landscapes is mineral extraction. The activities are usually organized around a cement production site (the cement plant) and one or more quarries for the extraction of raw materials (limestone, marlstone, clay). The topography is often complex and uneven (Figure 3): due to the location and nature of cement production, cement plants have a strong relationship with both natural topographic features (mountain slopes, depressions/canyons, etc.) and artificial ones (quarrying-related surface alteration). Although the average spatial footprint of cement plants is rather limited and compact (but highly fragmented in many buildings and standalone structures), the inclusion of quarries and quarry-to-factory connections makes the overall extension of cement production landscapes quite remarkable. The ratio between open spaces and built spaces largely favors the firsts, as the only buildings are concentrated in the cement plant site. More than the buildings themselves, which often stand out massive and prominent (Figure 4), are the open spaces the characterizing feature of cement production landscapes. Mineral "used" surfaces – such as paved areas on the premises of the plant, white roads connecting the plant to the quarries and the active quarrying sites – are often integrated with extensive natural/green "unused" spaces – abandoned quarrying sites and interstitial leftover spaces. The complexity of the cement industry landscape typology is at the same time a major challenge and opportunity with regards to transformation. It is a challenge in relation to its large footprint, whose management often requires a multi-scalar and multi-sectoral planning approach. But it is also an opportunity due to the already existing high level of integration of the (former) productive landscape into a wider environmental context. The site recycling potential lies here mostly in the extensive landscape alteration caused by mining activities (Figure 5), which can be turned, through selective renaturation and increased fruition, into new and valuable ecosystem services.

Figure 3 – Overview of the Eiberg cement plant from the Pölven foothills (copyright: Marcello Modica)

Figure 4 – The Eiberg cement plant along the rectified Weißache (copyright: Marcello Modica)

Figure 5 – The abandoned and partially renatured Neuschwent quarry (copyright: Marcello Modica)

EAF (Elelctric Arc Furnace) steelworks

The selected sites for the typological analysis are (Figure 6): Ugitech-Trimet, Ugine/FR – Monteforno Acciaierie e Laminatoi, Bodio/CH – Ascometal-Winoa, Le Cheylas/FR – Voestalpine Böhler, Kapfenberg/AT – Breitenfeld Edelstahl, St. Barbara im Mürztal/AT – SIJ Acroni, Jesenice/SLO. The in-depth analysis has been conducted on: Ascometal-Winoa, Le Cheylas/FR.

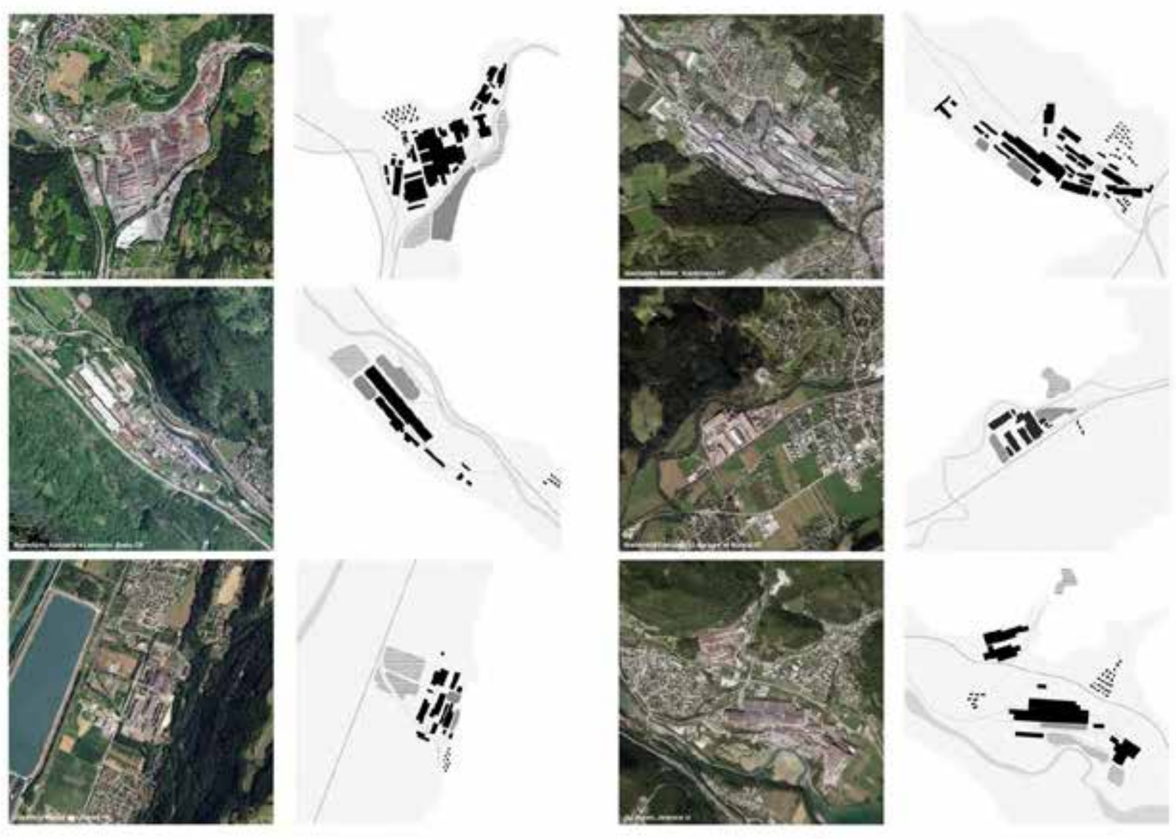

Figure 6 – EAF steelworks, typological study (elaborated by the author)

The driving force of mountain steelmaking landscapes shifted through the time from mineral extraction (iron ore) to the large-scale exploitation of hydropower. This technological upgrade, occurred at the thresholds of the 20th century, caused a major physical transformation of the productive sites, as well as their moving to favorable locations with plain topography and good railway accessibility. The activities are organized around a core production area (EAF site and rolling mills) and several additional "service" spaces for pre and post production activities. Due to the size of heavy production activities here carried on, the average spatial footprint of EAF steelworks is rather big, although the functional proximity between the production phases makes it also quite compact (Figure 7). Built spaces, which are often consisting of huge steel-framed halls with impressive footprints, give structure to the whole landscape, leaving to open spaces a marginal role as mere "extension" of buildings (Figure 8). However, while in the core area the form of open spaces is mainly related to roads and aprons, as physical separation between the buildings, on the edges of the site they increase by size and relevance. In fact, a system of functional wide open surfaces can be usually found in the proximity to the production site, such as large aprons for goods storage and by-product waste dumps (often with severe contamination problems). The stop of production activities and the closure of the site causes the progressive abandonment of these spaces, which are slowly camouflaged within the surroundings through spontaneous renaturation. The recycling potential of EAF steelworks, however, does not belong either to open spaces and built spaces, but more on the existing infrastructural system represented by the in-out railway network (Figure 9). Although originally designed for production purposes, the complex railway system supporting EAF steelworks can be easily reused and adapted for other activities requiring the same infrastructure, such as logistic platforms or industrial parks.

Figure 7 – The Ascometal-Winoa site in the wide Gresivaudan valley, seen from the Brame-Farine. (copyright: Marcello Modica)

Figure 8 – The former rolling mill halls surrounded by leftover open spaces (copyright: Marcello Modica)

Figure 9 – One of the railway links between the site and the Grenoble-Chambery regional railway (copyright: Marcello Modica)

Textile spinning mills

The selected sites for the typological analysis are (Figure 10): Cantoni ITC, Ponte Nossa/IT – Zegna Baruffa Lane Borgosesia, Borgosesia/IT – Seilerwarenfabrik, Füssen/DE – Linificio Canapificio Nazionale, Villa d'Almè/IT – BPT, Tržič/SLO – Spinnerei Hämmerle, Feldkirchen/AT. The in-depth analysis has been conducted on: Cantoni ITC, Ponte Nossa/IT.

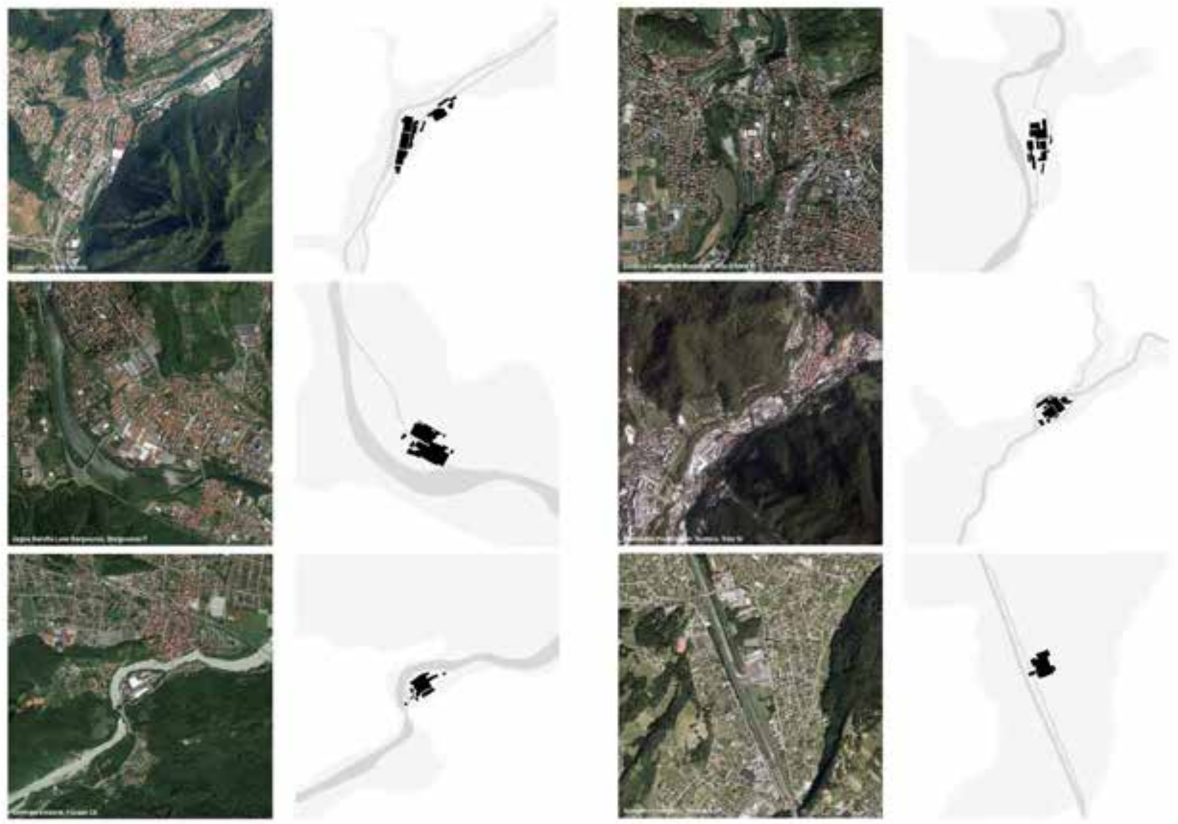

Figure 10 – Textile spinning mills, typological study (elaborated by the author)

The driving force behind textile industry landscapes is water, originally exploited for mechanical energy production and later for electrical energy too (though in small scale). The activities of textile mills, and in particular of spinning mills, are organized in highly compact production sites, usually located in narrow valley floors in direct contact with rivers and minor water courses (Figure 11). In particular, spinning mills are often positioned strategically within meanders or at the entrance of gorges, as the particular topography of such locations (height difference) allows faster water flows. Within the core productive site, built structures are largely predominant over open spaces – often consisting in narrow lanes for small-scale product handlings and pedestrian mobility. The two most recurring building typologies, extensive shed halls and massive multistory buildings, are usually combined in complex and hyper-dense ensembles which literally stands out from the surroundings (Figture 12). However, if the system of artificial water-catchment infrastructures (canals, dams, basins, etc.) is also considered, as it should be, the spatial footprint of spinning mill changes completely. Due to the existing functional and physical linkages between the factory site and the river course, the first can be considered at all effects as an integral part of the river system, and so of the valley floor landscape. The recycling potential of textile mills lies indeed in their waterscapes, a symbiotic combination of built and natural heritage whose transformation might easily be connected to cultural landscape valorization (Figure 13).

Figure 11 – The Cantoni ITC cotton mill in the narrow Seriana valley. (copyright: Marcello Modica)

Figure 12 – Overview of the compact shed halls towards the centre of Ponte Nossa. (copyright: Marcello Modica)

Figure 13 – A section of the artificial canal running through the factory site. (copyright: Marcello Modica)

Aluminium smelters

The selected sites for the typological analysis are (Figure 14): Trimet, St. Jean de Maurienne/FR – Novelis, Borgofranco d'Ivrea/IT – Montecatini-Alumetal, Mori/IT – Constellium, Steg-Hohtenn/CH – Pechiney, L'Argentière-la-Bessée/FR – Salzburger Aluminium, Lend/AT. The in-depth analysis has been conducted on: Constellium, Steg-Hohtenn/CH.

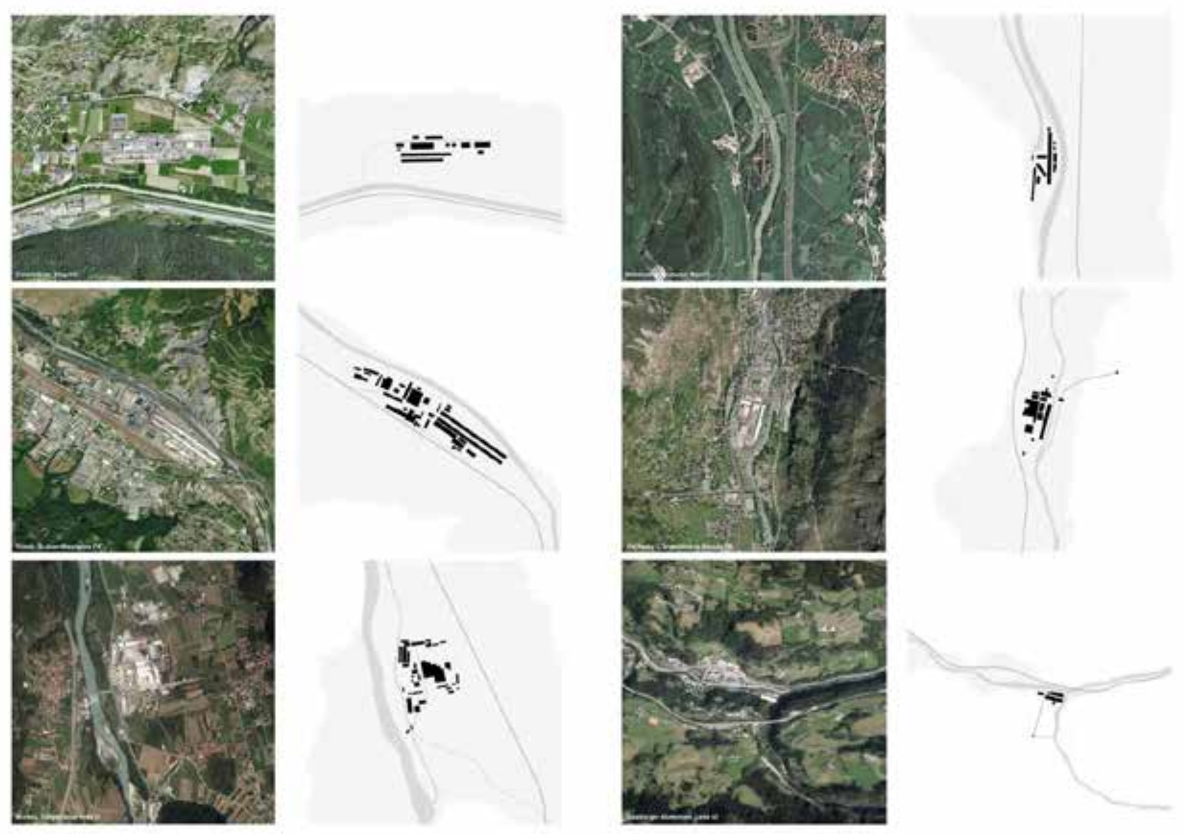

Figure 14 – Aluminium smelters, typological study (elaborated by the author)

Aluminium smelters are industrial facilities in which the electrolysis process is used to extract aluminium from its oxide (alumina). The driving force behind aluminium industry is therefore energy, and in the case of mountain regions, hydroelectric energy. For this purpose, aluminium smelters are often located in inner valleys where the higher elevation of reliefs ensure the necessary supply of water (Figure 15). In the first generation of smelters, the necessary hydropower was generated directly into the factory site, while in latest and larger facilities the same was transferred from massive power stations located in the vicinity. The spatial organization of the activities within the productive site is largely dependent from the size of the site itself. Older and smaller smelters have a rather compact footprint, which somehow recalls those of textile mills (with which they also partially share waterscapes), while bigger ones are more similar to EAF steelworks and heavy industrial sites in general. The relationship between open and built spaces is not univocal, being mostly influenced by the location, size and age of the facilities. On average, the open spaces are extensive paved surfaces functionally organized for internal transport and storage purposes, often integrating a basic railway network for in-out goods transfer. A particular feature of large smelters are the long-shaped electrolysis halls, massive buildings with a relative cheap, but highly flexible, architecture, which can be easily reconverted for new production purposes (Figure

16). Compared to the previous typologies, the high heterogeneity of sites makes difficult to identify, for aluminium smelters, a common recycling potential. In most of the cases, however, if the existing buildings are not suitable for an adaptive reuse (e.g. due to their conditions or size), the internal transportation grid (roads, railway) can be used as a "platform" for the implementation of new built structures (Figure 17). Redundant paved surfaces along the perimeter, for example, can be de-sealed, eventually decontaminated and renaturalized as ecological compensation zones.

Figure 15 – The Constellium site and the Rhone (background) seen from the Bietschhorn foothills. (copyright: Marcello Modica)

Figure 16 – The former electrolysis halls. (copyright: Marcello Modica)

Figure 17 – The site internal railway yard and the two alumina silos in the background. (copyright: Marcello Modica)

Towards a common transformation strategy?

The survey revealed that many alpine countries and regions are dealing with the same kind of problems while trying hard to get brownfield transformation projects started and implemented efficiently. Especially the communities affected by deindustrialisation, often rather small and overstrained with planning tasks of high complexity, could solve their brownfield issues more efficiently if a useable and transferable transformation strategy existed. Although the transformation of each single site to a certain extent depends on the specific local context, the typological analysis allowed to identify a specific recycling potential across different sites, sharing the same productive background and landscape structure. If the regional context provides the frame conditions for the economic, environmental and social regeneration of brownfields, their typological specificity already includes the elements for their physical transformation. First test-design experiments (research by design) recently conducted on the selected representative sites, including different transformation intensity from radical to conservative scenario, are proving the validity of this approach.

A transferable recycling strategy for brownfields in mountain areas needs to help activating the full range of potential benefits connected to each single brownfield typology, while considering also the existing contextual limitations. This strategy should be based on at least three key principles:

- gradualness: to ensure a temporal "affordability" of the recycling process, a gradual and incremental development, organized around macro and micro phases with clear objectives, boundaries and actors, has to be considered;
- flexibility: to ensure an equilibrium between long-term goals and concrete, immediate achievements, a functional "adaptability" of transformation has to be also considered by assigning to specific categories of spaces the same macro-functions (production, leisure, environmental compensation, etc.);
- inclusiveness: the strong inter-dependance between the brownfield site and its context (local and regional) requires any potential recycling process to follow a spatial "coherence", by considering the site and its context as a unique environmental, economic and social system.

To foster the operationalization of such principles, a "landscape approach" based on structuralist planning components is essential. By considering the existing landscape structure of mountain industrial sites as the result of the functional interactions between industry and the mountain environment, a sequence of different but complementary systems of built and open spaces can be easily identified. The integrated and gradual reactivation of these systems, driven by specific contextual economic, ecologic and socio-cultural needs, can help to set concrete and realistic planning milestones in the complex transformation process of mountain brownfields, thus easing its successful completion. Through the development of an according strategy, the research wants to show that industrial brownfield sites can be positively and constructively interpreted, in the Alpine context and possibly in other mountain regions, as a valuable territorial infrastructure to be reactivated rather than simply a vacant land to be redeveloped.

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