Local resources and sustainable industrial production for the post earthquake reconstruction in the territory of L'Aquila. (Abruzzo, Italy)

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Summary

On April 6th 2009 the L'Aquila territory suffered the consequences of a major earthquake.
Immediately it turned out the necessity of carrying out an efficient rebuilding able to give a more sustainable dimension to the territory respect to the situation before the catastrophic event.
A first objective is a hypothesis of introduction in the studied territory (Navelli Plateau) of an industrial ecology district, in which closing the productive activities cycles already existing using their refuse.
The search moves from a territorial forest *resources* analisys that could promote the bioenergy production in order to stimulate the development of these rural zones. It's shaped a process where the development of a short chain that can mobilize resources, with an integration with other assets.
An example hypothesis is constituted from the refuse of cereals activities, the *straw*, stab in bales could be used in the production of envelope building to high insulating, using the *wood* like chassis of panels. The positive fallen back will be read in environmental and landscape terms, social and also economic (It could be approached to public incentive).
Are indicated the foundations in order to involved also private subject in public-private participation.
The used methodology will be taken advantage also of the acquired experiences in various truths for the construction of the supply chain.

Note:
* In the Faculty of architecture of Pescara, Dipartimento di Tecnologie per l'Ambiente Costruito, there is the "Laboratorio interdisciplinare territori del sisma - ricostruzione e sviluppo sostenibile" coordinated by M.C. Forlani with an articulated and complex work program, involving problems at different scale for starting a sustainable and lasting development in that territory, now earthquake-torn and felt because of the depopulation and abandon processes.

Keywords: industrial ecology, refuse-resource, low-tech, local production, carbon neutral, timber supply chain, straw bale system

1. Introduction

After Aprile 6th 2009 and the consequences of l'Aquila territory earthquake, the major difficulty is not only overcome emergency to provide shelter to the displaced, but also to rebuild an economy that has been eroded by the earthquake.
The central government has decided to resolve the issue of building emergency with housing, "temporary" as using, but in reality final as mark on territory, as they will remain forever with other use (students, tourists), once the residents have returned to their homes, making compact social

structure. This choice makes possible to postpone the reconstruction of the storic *heart* of the villages were no longer the emergency factor that pushed to the speed that would be desirable. Instead of solve the emergency by creating a local industry that could restore economy of the area, ready-made housing modules camed from other Italian regions.
The desirable hypothesis to resolve the emergency would be using a local supply chain, with temporary housings in the perspective of sustainable development, that would have to be truly reversible and "light" from the viewpoint of environmental in the whole life cycle. [1]

2. Local resources

2.1 Economical aspects

The reset of the social and economic system becomes "opportunity" to face the future with new sensitivity.
At economic level due to the reconstruction of entire villages, and the restructuring of buildings, which will be addressed in coming years, the construction sector will have a strong impulse. The starting point of research is the construction of a supply chain that allows the production of building materials through the use of unused resources or waste from local workers, to close the existing economic cycles for creating a District of industrial ecology that make possible to restart the local economy.

2.2 Territory

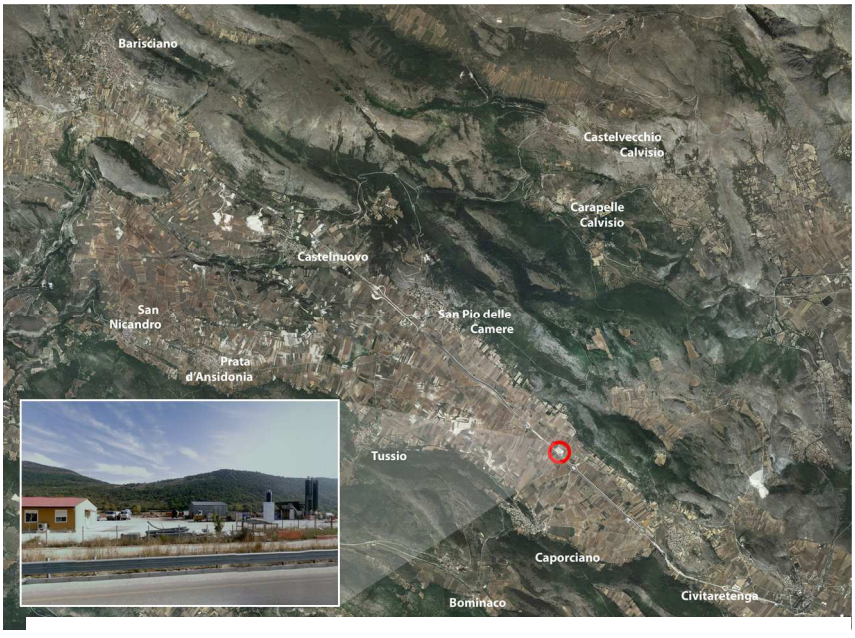

Fig. 1 Localization in Navelli's plateau territory in a already existent system.

The Navelli plateau territory is composed of five municipalities with a total population of less than 4000 people, including within 8 km: Barisciano, Caporciano, Navelli, Prata D'Ansidonia, San Pio delle Camere.
This distance allows for placement of common industrial and economic activities and tending to self-sufficiency with an energetic centre of activity through the symbiosis, creating economies of scale and trade resources. The valley with its *cereal production*, *raising sheep* which producing wool and scraps as organic waste, and the *forest resources* to develop in a system, allows to hypothesize a industrial symbiosis system that combines activities already present at the new low-tech industries, which reused wastage as raw material, and to put the unused resources in a system, first of all, the forest resource.
The industrial symbiosis will be implanted so as to interact with all neighboring municipalities, to close the cycle with the anthropic system.
In this area there are already some industrial activities that can be minimized as emissions, waste and impacts, and put in a system with new activities. The timber sector could be managed for the creation of production of cross laminated timber boards, for the production the structural frames of panels in straw bales, and also for the reuse of waste wood for energy purposes.

2.2.1 Location

The district of industrial ecology will be located so close to residential areas and thoroughfares, for

the procurement of resources. It will be located where there are already activities for creating synergies with existing plants useful to a careful use of resources and energy. The location in the figure, equidistant from the villages, lies in the presence of a temporary road construction industry, which will disposed its warehouses, after leaving the highway on which stands. The symbiosis can also be created during the transitional phase with inputs and outputs especially in terms of energy. The common location is obviously convenient for the economies of scale but not to impose.

2.3 Industrial Ecology

Welfare generated by economic activity, according to a careful approach to future generations, cannot apart from decreasing environmental costs, so must promote eco product innovations by introducing environmental technologies in production cycles: in other words must refer to the *natural ecosystems*.
Industrial ecology studies interactions between industrial systems and ecosystems, by closing cycles (as balancing of imput and output with the exchange and reuse of waste materials as raw materials of other production sectors) and through symbiosis. [2]
The idea of creating the conditions for industrial production of construction products is supported by the low impact that would have cycles of materials put in place. It is about using equipment and resources already present in part, by innovating and by intervening in the production life cycle. Moreover, the industrial processes that require a greater investment will be implemented during the course and with the help of some economic programs already implemented by the region for these areas affected by the earthquake.

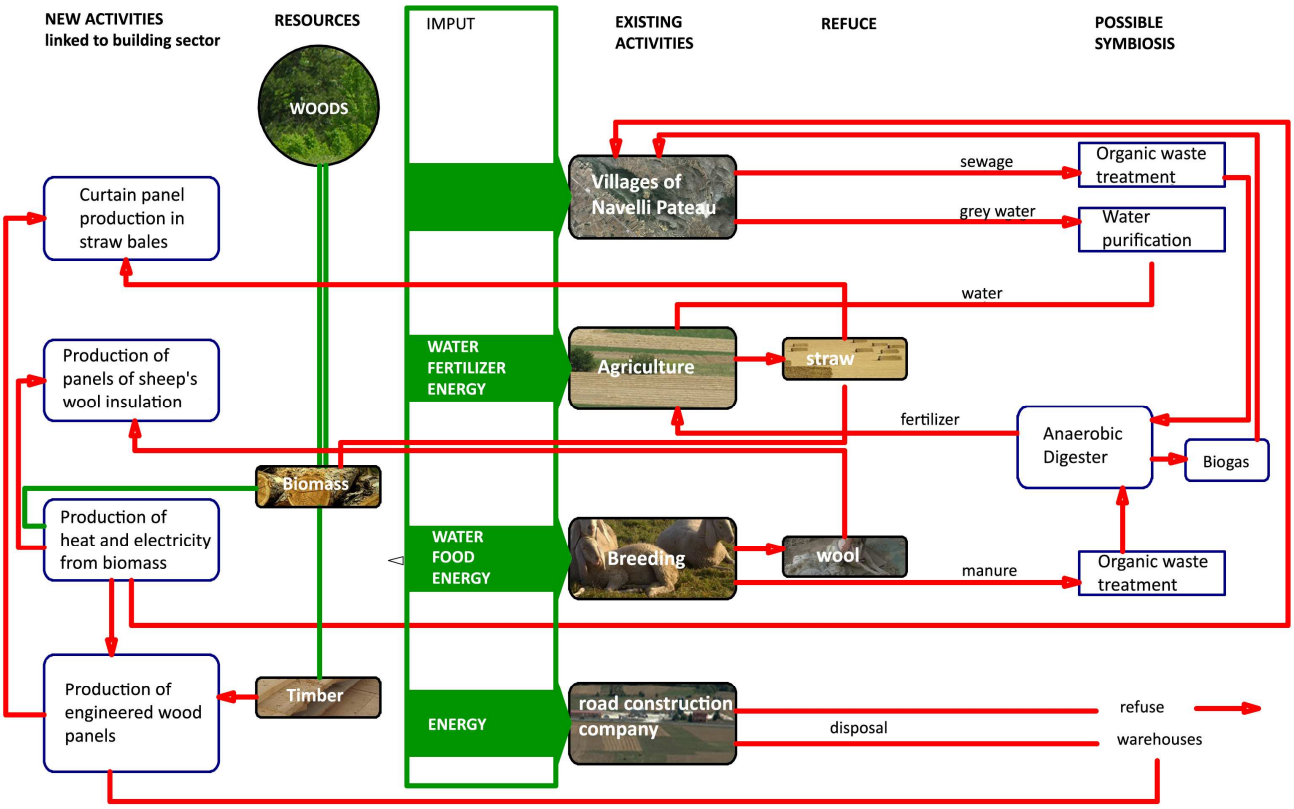

Fig. 2 Industrial Symbiosis.

2.3.1 Symbiosis

The industrial cycle assumed in the area is that in the figure. We want to introduce low-tech working in the main economies of the area: *breeding* and *agriculture*. The scraps from the wool will be sheared from sheep is used as feedstock in the production of insulating wool, the scrap as livestock waste is used to create biogas.

The straw that remains after harvesting the grain with the harvester, in square bales, is stored for being framed with wood panels and used as padding, but also as bearing walls in the reconstruction. The timber resource, unused because of diseconomies, but present in large quantities in the neighboring forests, it is managed to produce various building components, particularly those which are defined as engineered wood: laminated wood for the frames of the panels and cross laminated timber frame. Its residue is used as biomass, creating a cycle of exploitation of territory and green jobs . Moreover, even the residue linked to the individual municipalities for gray water and trash, will be put to the system.

3. Forest land management

3.1 Forest resources

The five municipalities are characterized by a good forest cover: there are about 2700 hectares of hardwood's forest, mostly formed by copse woods, and about 2500 hectares of coniferous forest.
Despite of these resources we have to register the reluctance in these territories to manage the forests. The ownership of forests is largely private and it is very fragmented. Moreover, for the most part, the woods have not a big economic value as deciduous beech and black pine plantations never managed.

3.1.1 Diseconomies of wood resource

Therefore the woods in this territory has seen like a problem: the public owned forest is not managed as the municipalities do not have many economic resources and management costs would exceed revenues. Instead, individuals have a small use of the wood cutting for personal use for heat production.
This means a loss in many terms. In fact the forest is a multifunctional system: in addition to the loss of wood production, it fails the social function (the forest management brings jobs), the tourist/landscape function; the soil defense function (hydrological function) may be less as well when devastating fires occur for a lack in forest management. [3]

3.2 Setting up the short wood energy chain

Therefore the first step is to enable a continuous and organic land management, planning decisions respecting forest's multifunctionality and the sustainability's principles. This also means that management cannot and should not cover only the areas of public property, but it must establish a participatory process involving the privates. Therefore it needs to make economically attractive forest management that so far has meant only a cost. [4]
A good way could be the creation of a short chain of "wood energy". This term refers to all factors of production, processing, transportation and use of wood for energy purposes. The wood energy chain must be short to save on wood transport costs: supply distances must remain within 30-40 km [5]. Planning of timber utilization on large surfaces is essential for a short chain development: as already mentioned, the fragmented state of ownership of the forests is a big problem and it would be hoped a meeting of owners in associations, or cooperatives, or forestry community.
Last prerequisite for the creation of a short chain wood energy is the demand for wood as fuel. This can take another chance constructing teleheating centrals at medium and small scale, producing a local reliable demand of firewood creating a positive feedback on the whole chain. In this way the creation of new arboriculture plantations, activity promoted by government, in abandoned or marginal agricultural areas, where other activities are not convenient, could follow the increased wood demand.

3.2.1 Economic Impacts

There are many recent Italian and foreign experiences on the use of modern wood energy by individuals and communities [5]. In fact, the wood has recently acquired increasing importance as a source of renewable energy, becoming one of the sources more used because its widespread presence in the territory. This also for the rising of fossil fuel prices (not to mention the excessive

dependence on energy from foreign countries) and for the positive impacts in the territory in economic, social and environmental terms.
Indeed, the wood does not produce new CO^2, it does not produce specific emissions of polluting gases and dust (especially in the new devices that also increase much energy efficiency of wood) and also biodiversity protection take advantages of forest management for energy production [4].
Moreover, when the industry can be structured, job opportunities may increase in some work units per 500-1000 population: these numbers are modest, but nevertheless can contribute actively to curb the abandoning phenomenon of the upland or marginal areas.
In broader terms, we must not overlook the fact that the capital invested in the sector remain entirely within. The same savings resulting from the use of this local source compared to other energy sources more expensive is definitely an asset that remains *in loco*; heating costs represent a major item in households and public administrations budgets [5].
The initial investment must be based on funds that help to trigger the process, including possibly also the participation of government in the development and supply chain management. The times of economic return are not too long and once fully operational the system produces many benefits not only economic, sustaining itself .

3.2.2 Power Generation for the Eco industrial District.

Fig.4 Cogeneration process

The use of lignocellulosic biomass to produce thermal energy is a response that can be given in certain industrial processes where high temperatures are used (round timber).
Biomass can also be used in a cogeneration plant, enabling the combined heat and power. That situation must be assessed but not imposed on the territory, through a careful feasibility analysis.
This technology enables the most efficient use of primary energy because it allows a reduction in energy costs. The cellulosic biomass is well suited to cogeneration plants in gas. This plant configuration allows the combination of a traditional boiler fueled biomass plant with a small wind turbine driven by hot gases of the same turbine. The assessment whether there are the conditions inside the complex of industrial ecology, for the use of thermal energy in terms of temperatures and time of availability can be reversed considering expanding the use of heat to the territory adjacent of Commons with an district heating network. The electricity Instead, being of the most valuable quality, if in excess can also be transferred to the network. In fact, the maximum economic benefits are realized with increasing hours of engine operation and when you reach the economic value of both the quality of energy produced [6].

4. Sustainable industrial production of building material

4.1 Wood as building material

4.1.1 Activation of the timber sector as construction material.

The only way to really preserve the forests of the Abruzzo region is to use wood in construction. Even the timber sector as construction material is all to build and is calculated more time for economic return and the initial use of regional resources. The black pine forests amounted to 2500 hectares, only in the towns of Navelli Plateau, and is aim well to create cross laminated timber. The 2700 hectares of hardwood forests can be a resource used for the panel frames made of straw bales.

4.1.2 Industrial development : cross laminated timber panels.

The black pine while presenting some interest from the standpoint of forestry, currently produces mostly the low-value timber and is therefore not suitable for fine destinations. Starting from the consideration that the only practical way forward to increase the value of this resource is that of *"industrial development"* was first made a choice among the alternatives to industrial use for a production of high added value. Between these, the use in systems such as engineered wood panels in cross laminate timber seemed the best and already successfully tested in other regions of Italy (Tuscany for example).
The *black pine* has significant results for the values of shear strength of glue and wood. This proves that gluing the slats almost fully restored the resistance of solid wood.

4.1.3 Industrial development : glue laminated timber

As for the majority coppice hardwood forest, timber production in question is also characterized by pieces of small size. The coppice is characterized by the frequency of cuts, with cycles of regrowth and maintenance, as well as being aimed at the production of raw and semifinished products for the market, are necessary for the preservation of the forest. This resource can be used to manufacture glued laminated timber panel, characterized by a technological process of bonding pressure[7].
These structures, made of size 40 x 300 cm, will be used for the casing panels straw bale panels.

4.2 Construction products of straw and wool sheep

4.2.1 Straw bale panels

The straw bale panels that we want to introduce in a commercial production can not be used in self-construction, but will be activated the production of prefabricated components with wooden frames and the internal structure of the frame in straw bale.

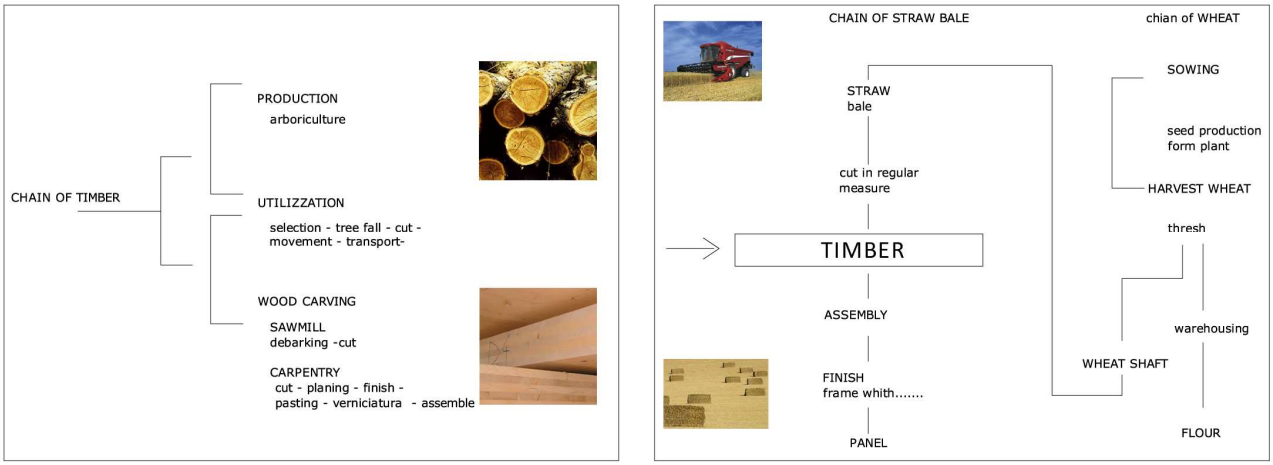

Fig.4 Production Life Cycle of timber and of straw bale.

Life cycle of *"straw heart"* of cladding panel starts up from end of life of working cycle with harvester of cereal, in the Navelli territory. The cereal stems are roll up in square bale from harvester. This product is carried in a shed where it will be finish cutting the lateral sides. In this way, more resistant and dense part of panel will be preserved, ready for position in timber frame. Such reinforced straw bale will be staking together, held by iron clamps.
The panel, after assembling, will be plastered with lime for becoming a breathable sheathing board. The finish panel will be ready for carrying until construction site where it will be assembled. The environmental impact of straw bale is carbon neutral, and the end of life of this material will be considered both for recycling and combustion or gasification as biomass for producing heat and energy.

4.2.2 Timber frames

The chassis of panel is made of glue laminated timber structural if the wall is also supporting, or in simple panels if the masonry is not supporting.
Created the timber supply chain, and sustainable management (Sustainable Forest Management) of the product will create the conditions for the industrial production of wooden frames. The process for the creation of the curtain panels in straw bales, will be divided into two phases: the first phase starts with the creation of the sector and the definition of management policies, but the second phase will see the production of panels local wood.
To start the cycle of wood, we will use the forest resources. The sawmills in the area will be a first point of reference for the early stages of processing, then will start new industries for the processing of the product in stages. The industrial cost of start-up can be mitigated through partnerships with industry leaders in the production.

4.2.3 Panel straw bale: finished product characteristic

The final panel will be modular, both in thickness (39 to 49 cm), respond to requests for climate zone in which will be used, both in width (modulated by a 2 or 3 meters of the base, with the height of an interp), to be flexible in their design requirements, but also meet the needs of production and transport.
It will be possible to use it, without other workings on, in building covering, walls and floors but also in a structural system with timber.
Building with straw bales offers high levels of thermal insulation and construction speed. The insulation value is better than current building regulations demand and also sound reduction is more than 50db.

4.2.4 Cross laminated timber frames

The cross laminated timber boards are formed by individual layers each consist of tables of the same thickness that are pasted on each other in a right angle. The number of layers is odd to having a symmetrical structure that ensures the dimensional stability of the panel.
The raw material for cross laminated timber boards, consists of rough planks of sawn timber obtained mainly from external sections of the trunk. (PICTURE cut the trunk) This product, generally considered in the world of sawmills as product of low value, however, has the best properties in terms of strength and stiffness.
The width of individual boards of the panels is between 80 mm and 240 mm, the thickness between 10 and 35 mm. The typical structure of the panel is made up of layers of plates or panels stacked monolayer, oriented alternately at 90 ° almost rigid binding of individual panels is obtained by gluing the entire surface smooth and through a proper system of applying the glue. It is also necessary to maintain the pressing request from the glue throughout the pressing cycle.
The panels are produced for industrial purposes and not visible. Used wood with resistance class S10 DIN 4074 and 10% to strength class S7. In the presence of nodes, the boards are truncated and jointed to the desired length. The panels are used in service classes 1 and 2 (moisture content in structures that correspond to internal temperature of 20 ° and a relative humidity of the surrounding air only for a few weeks a year exceeds a value of 65% and 85% respectively).[7]

4.2.5 Insulation Abruzzo Lamb's wool

The wool is obtained from the annual sheep shearing. Each year is produced a large quantity of sheep wool that is because unused underground and not easily usable. Wool, rather than thrown, could be stored before being used in insulation panels.
Once cut, it will be washed with sodium hydroxide to remove fat and impurities. To protect it from moths and parasites will use the same treatments used in textiles for clothing, already tested for 50 years. The wool is then carded (combed and reduced thin coats) and subjected to needling (needle machine through mechanical process) to create felt rolls and panels of desired thickness.
Sheep's wool has excellent thermal and acoustic insulation properties, is breathable and highly hygroscopic. Can absorb large quantities of water without losing its insulating power. In case of fire retardant and does not emit toxic substances. Unlike the fiber can be attacked by moths or vermin and should be treated.

5. Discussion and final Conclusions.

Therefore it can be possible think for the reconstruction of the province of Aquila to use of light and sustainable materials with a life span of Km zero.
We can imagine a conscious reconstruction using local sheep's wool panels for energy efficiency measures and *restructuration*, as well as panels of straw and wooden floors for local *reconstruction* of buildings that are irreversibly damaged.
The necessary growth of the construction sector within the next few years, fuelled by funds allocated to the first houses by the central Italian government, will allow the growth of the whole territory having the courage to invest in this sector and in sustainable development in general, facing the building with low tech, low-impact systems.
At the same time we will have the ability to grow the territory in environmental terms as well as economic, and to reverse the depopulation, ongoing even before the earthquake, with the creation of welfare.

5.1 References

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