Representing local self-sustainability

Clementi, Matteo [1] Scudo, Gianni [1]

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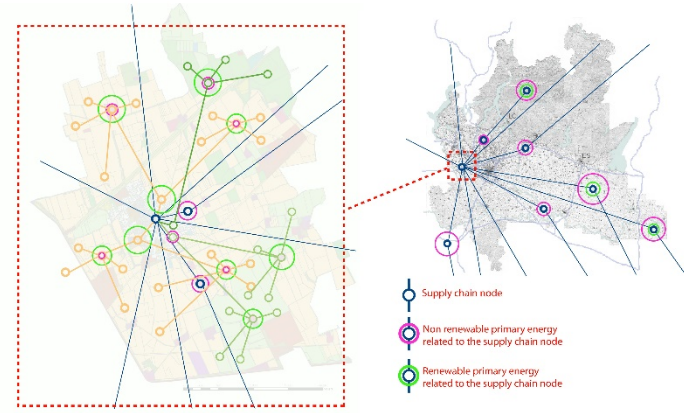
The paper shows graphical tools developed to support the quantitative assessment of local self-sufficiency scenarios. They are part of the applicative tools of ELaR, which stands for Ecodynamic Land Register, a methodology to evaluate different energy and material flows design choices to improve local sustainable development.
Flows evaluation are provided by two graphic tools: "Resources/ impacts Geographies" and "User histograms".
The "geographies" (code elements) give basic information on Local Demand of Energy and Matter (LDEM), and on Local Renewable Energy Technical Potential (RETP).
The "user histograms" (code rules) are the link structures between the changing metabolism (demand) and the locally available resources (supply), information collected in the geographies, in order to check different design choices. They report the per-capita flows - energy and matter local demand – related to the extension of per-capita productive land.

Fig. 1 Example of impact geographies concerning self-sufficiency scenarios in Albairate (Lombardy region).



1. Innovative Technologies for the quality and the sustainability of the built environment, Department of Architecture and Urban Studies (DAStU), Politecnico di Milano, Milan, Italy

Methodology

ELaR aims to highlight and rethink energy and materials flows which feed people activities through analysis carried out by Geographic Information Systems (Clementi, 2008) (Clementi & Scudo, 2009). It highlights the dynamic relations between energy and matter demand and local renewable potential which should necessarily be maintained in equilibrium in a self-sufficient system. Local demand for energy and materials and the local renewable potential supply are assessed through the information gathered and processed. The local demand for energy and materials analyzes the consumption categories of housing, food and marginally of private transport; data are expressed in terms of general amount referred to the local context or in terms of per capita data.

The information collected and processed are organized in order to enable the transferability of good practices oriented to local sustainable self-sufficiency, and to measure their effectiveness in terms of dweller environmental impacts reduction.

These elaborations are carried out through the following operations:

- Matter and energy flows analysis enabled by local inhabitant.
- Geo-referencing the nodes of the considered flows.
- Analysis of local natural capital, defined as renewable energy technical potential at the local scale.
- Developing self-sustainability scenarios rethinking local energy and matter demand and supply interactions based on good practices transfer.

Tools

The ELaR methodological approach allows to represent the evaluation of aggregate processed in graphic format easily understandable to local actors (general users, local administrations, designers, producers).

The elaboration and communication of the results are provided by two basic tools:

- "Resources / impacts geographies".
- "User histograms".

Resources/impacts geographies

Resources and impacts geographies (code elements) are obtained by collecting on the same territorial support information on Local Demand of Energy and Matter (LDEM), and on the Renewable Energy Technical Potential (RETP).

Information on Local Demand of Energy and Matter (LDEM) are collected in the form of impact geographies, while information on Renewable Energy Technical Potential (RETP) are collected as resources geographies related to local supply.

The first tool (impacts geographies), represent the supply chains of production and consumption through geo-referenced vectors which locate supply chain different nodes. Two different indicators quantify the environmental impacts associated to the different nodes of the supply chain:

- the use of primary non-renewable/renewable energy sources, expressed in MJ equivalent;
- accounting of CO_2 equivalent emissions, expressed in kg of CO_2 eq.

The impact geographies have different configurations depending on the indicator adopted.

In the case of primary energy accounting, final energy production and consumption amount are graphically represented as colored circles of different sizes. For instance, in the case of relevant electricity consumptions, the graph representing the amount of primary energy used is located in the area where the energy is consumed and not where it is produced.

In the case of CO_2 eq. emissions accounting graphs represent the amount of the emission in the place where it takes place.

The second tool (resources geographies) are obtained by collecting in specific thematic maps quantitative data related to the locally available renewable resources. Once defined the boundaries of the local context, this phase of the methodology processes and stores in the same Geographic Information System data concerning local physical and biological/agricultural environment. This data-base provides descriptive information on the climatic conditions (solar potential mapping at different scales, pluviometric conditions, windiness, humidity and air temperature throughout the year), on actual land uses, on geo morphological aspects etc.. (Fig. 2). The main goal of such a data archive is to provide useful information to identify the current local renewable potential supply and develop possible local sustainable scenarios for good practices transferability.

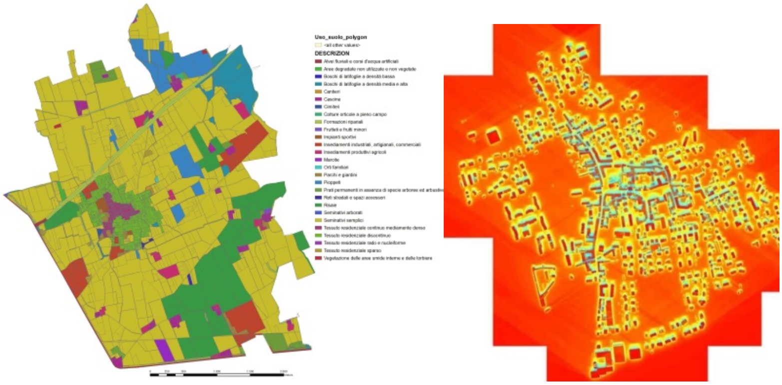


Fig. 2 Some maps that make up the resources geographies of Albairate (Lombardy region) , to the left a land use map, to the right a solar radiation map

Good practices transferability depends on the assessment of similarity between territories under analysis and good practices territories. This information, as part of one single Geographic Information System (GIS) can be associated to different portions of land, as example a cadastral land or urban parcel.

The association of such information to geometric particles using GIS, enables identifying the vocational characteristics of each portion of the local territory.

Geo-referenced information allows to use Geographic Information Systems to carry out assessments at different scales, from the whole local context, to portions of it or to individual particles (buildings or land parcel).

User histograms

The user histograms (code rules) build the connecting structure between the information collected in the geographies, in order to check different design choices. They report in terms of per-capita flows local demand of energy and matter and relate them with the extension of productive land per-capita. Histogram general structure can be easily understood looking at the following diagrams (Fig. 3 and Fig. 4).

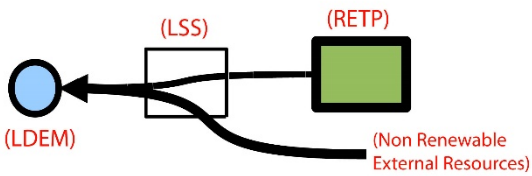


Fig. 3 General synthetic structure of a user histogram

As shown by the arrows, the histogram describes energy and matter flows direction from the right to the left. Consequently, the right side of the histogram contains information on the resources supply (RETP Renewable Technical Potential, locally available), where information on local renewable supplies are given.

The left side shows information about Local Demand of Energy and Matter (LDEM).

The central part houses strategies as possible design choices in between local renewable energy/matter supply and demand (LSS Local Self-sufficiency Scenario). They perform the main function to connect local demand and supply.

The image below shows an example of user histogram describing the main components.

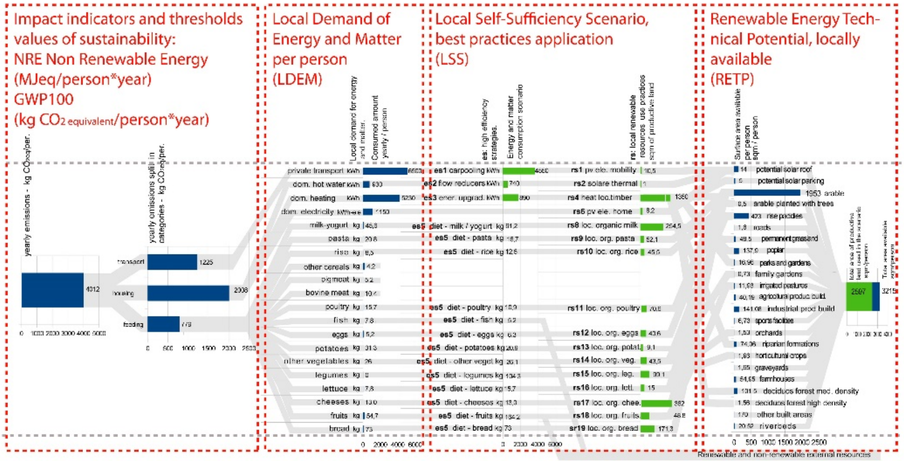


Fig. 4 Example of user histogram describing the main components

The extreme left of the graph shows data of energy and matter demand expressed in terms of the indicators adopted, in this case the CO_2 equivalent emissions. The quantities of energy and materials are aggregated into the consumption categories of housing, food and, marginally, of private transport, to compose the total amount of energy and impact (NRE, GWP 100) per person (on the extreme left) (Fig. 5). Such option gives the possibility to compare the data with reference threshold values per person (15800MJ of primary non-renewable energy - NRE per year as sustainability goal suggested by the 2000W Society program (Semadeni et al., 2002), and between 1000 and 2000 kg of CO_2 per year - GWP100) .

The right part of the graph represents the local renewable supply, it shows the extension of the productive surfaces in the local context, expressed in square meters per person (Fig. 7). The productive surfaces are intended to be the productive portions of land for agriculture and forestry, as well as the built-up portions that shows relevant features such as high solar vocation surfaces.

The far right part of the histogram brings together the extensions of productive land per capita identifying the amount of productive land available. The different colors of blue and green refer to the extension of productive land available per person (in blue) and the extension of the available productive land interested by the application of good practices assumed in the scenario (in green) (Fig. 7).

The structure of information allows in the design phase to operate a useful and immediate comparison between productive land necessary to local self-sufficiency and land actually available. Such condition of immediate comparison drives the design choices among the good practices, in order to find out the ones more suitable to the real conditions of the territory.

The central part of the histogram is representative of best practices application, and identifies two specific application steps. The first, in the column to the right, refers to strategies to improve efficiency, both in terms of energy use and matter consumption. The main function of this phase is to reduce the amount of energy and matter shown in the part related to the current demand (on the left). The second application step to the right refers to the application of good practices on renewable energy use, with the purpose to mediate between the energy and matter reduced demand and the potential renewable supply. It starts from the data on decreased energy and matter demands following the implementation of high efficiency best practices (es) in order to verify the application of local renewable resources use practices (rs). The data shown in the histograms translate the amount of energy expressed by the demand in the amount of productive land required in order to compare the result with the quantity of locally available productive surface per person (Fig. 7).

In summary the user histograms allows to:

- Interrelate local energy and matter demand in direct relation to the local renewable resources supply. They give immediate information on future strategies on the basis of the principles which structure the paradigm of self-sustainable local development.
- Provide a framework of information useful to compare different strategies in different geographic areas and to verify the transferability of good practices.
- Assess the sustainability of the design decisions, using quantitative indicators and quantitative thresholds. The indicators used are GWP100 (accounting CO_2-equivalent emissions, threshold value 1000/2000 kg CO_2/person*year) and NRE (accounting non-renewable primary energy, threshold value 500W of non-renewable resources 15800MJ/person * year according to the 2000W-Society program) (Semadeni et al., 2002).

Application

The results show the current level of development of the tools, by the application of ELaR to the local context of the Albairate municipality (Lombardy region), going through the following stages of the methodology:

- Assessment of the local demand for energy and matter (LDEM) (Fig. 4) and drafting the related geographies of impacts (Fig. 6) .
- Quantitative impacts assessment, through the application of the impact indicators (GWP100) to the user histograms (Fig. 5).
- Assessment of the renewable energy technical potential (RETP) (Fig. 6) and elaboration of the specific thematic maps (geographies of resources) (Fig. 2).
- Assessment of self-sufficiency scenarios through transferability processes of good practices to increase energy efficiency and the use of locally available renewable energy potential (Fig. 7) (Fig. 8).

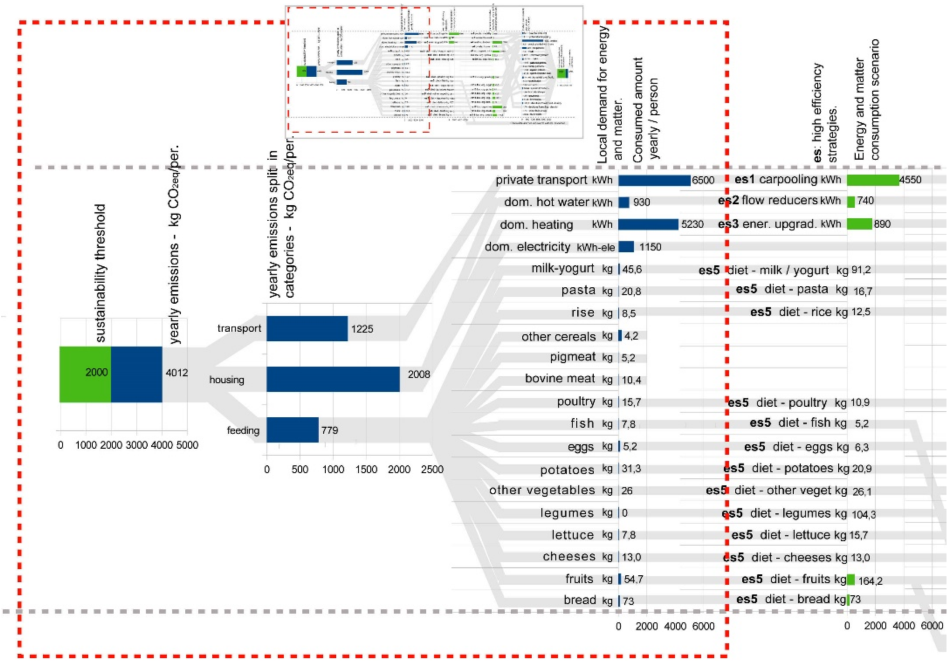


Fig. 5 Part of the user histogram concerning Local Demand of Energy and Matter (LDEM), Albairate (Lombardy region)

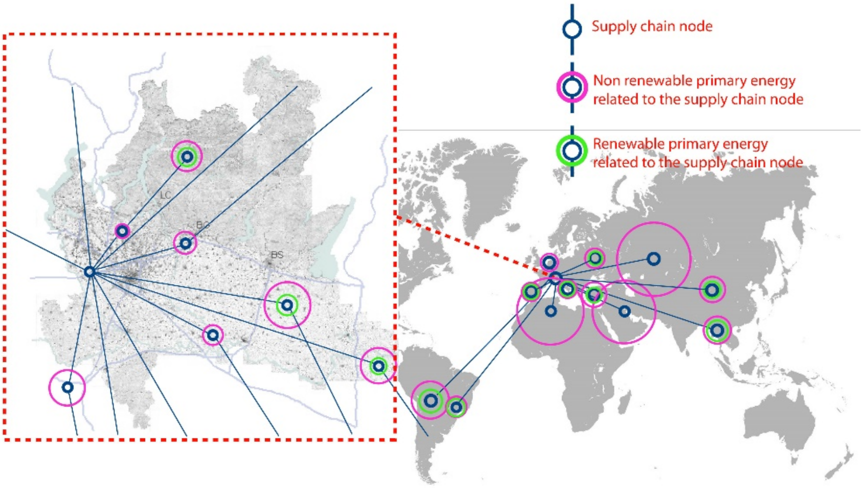


Fig. 6 Geographies of the impacts associated with the consumption of primary energy, concerning the Local Demand of Energy and Matter (LDEM) in Albairate

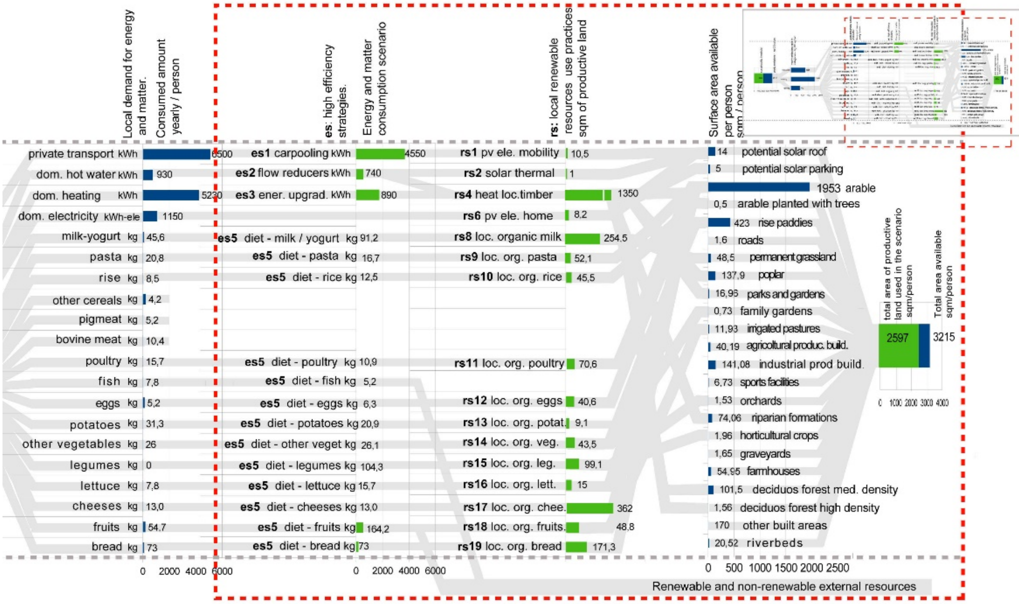


Fig. 7 Part of the user histogram concerning the strategies adopted in the proposed Local Self-sufficiency Scenario (LSS), Albairate

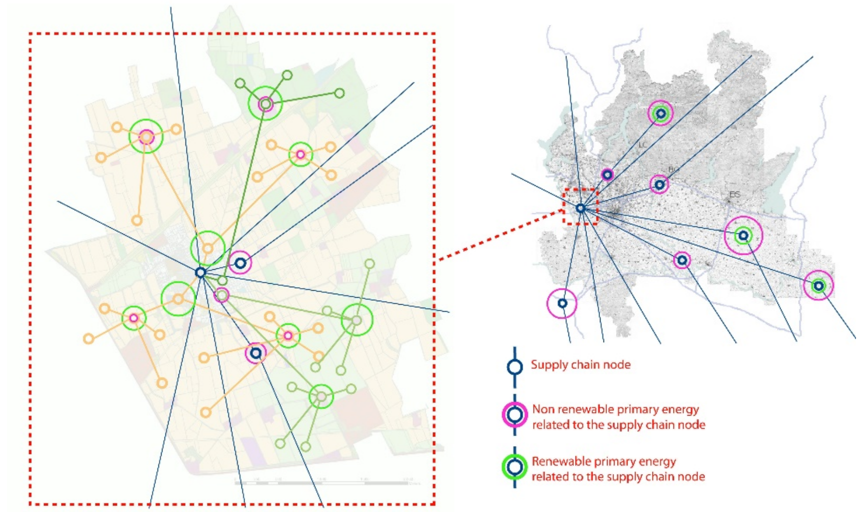


Fig. 8. Extract from the impact geographies concerning the adoption of good practice on local supply chain of bread (sr19) inside di LSS, Albairate

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