Comparative multi-criteria assessment of urban renewal scenarios for existing neighbourhoods

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ABSTRACT: The growth of European cities in recent decades, mainly characterized by a decreasing density and a functional segregation, has tendentially increased mobility, soil consumption, urban sprawl, social disparities and infrastructural costs. Hence, most European countries have decided to aim for an urban sprawl limitation, in particular by increasing the density of built urban areas. To achieve this goal, new operations on unused urban areas are not sufficient, urban projects on existing neighbourhoods are also required. In a sustainability perspective, urban renewal goes beyond the issue of density. It has to integrate socio-cultural, economic and environmental aspects simultaneously. Based on a case study analysing the neighbourhood of "Fleurettes", in Lausanne, Switzerland, this paper shows how the diagnosis of the sustainability of an existing neighbourhood and a multi-criteria assessment of different scenarios, based on the use of the "SméO" methodology, can be an effective decision support tool for choosing an operational strategy. The results show that sustainability tends to increase with the level of intervention, especially in the field of energy consumption, but also by improving the quality of life, by promoting soft mobility, by offering green public spaces and by providing return on investments. Consequently, the research confirms the interest of the different protagonists (public administrations, private owners, investors, designers and users) to jointly explore possible synergies for the sustainable development of existing neighbourhoods.
Keywords: urban design, urban renewal, sustainable neighbourhoods, multi-criteria assessment

1. CHALLENGES OF SUSTAINABLE URBAN DEVELOPMENT

1.1. Trend of European cities

Urban sprawl, which typifies most European cities, is incompatible with the aim of a long-term balance reflected in the concept of sustainable development [1, 2]. Many studies have shown that widely dispersed urban development in fact represent a waste of land, places potentially damaging pressure on the landscape and requires an increase in energy consumption through the mobility of individual motor vehicles; this is accompanied by a growing environmental impact and rising infrastructure costs [3, 4, 5, 6, 7]. In a dispersed conurbation, imbalances may occur for the city centres which have to assume financial burdens that exceed their potential tax revenues, while a number of suburban localities sometimes become trapped in a slow spiral of decline [8].

Faced with these findings, many players in the built environment are working to increase territorial cohesion; this is reflected in an attempt to achieve a concerted balance both within a given territorial entity and between the different entities [9, 10]. In this context, strategies of urban densification play a central role. This reorientation of urban development towards sustainability likewise implies greater coordination between urban development and mobility [11].

The regeneration of brown field sites is a priority solution for the creation of this type of mixed and dense urban centre [12, 13]. In view of the scale of the reappraisal that must be considered for the post-industrial European city to evolve towards sustainability, regeneration of brown field sites or the construction of new projects in the remaining gaps in the urban space will not be sufficient on their own. Interventions to renew existing neighbourhoods are also necessary.

1.2. Integration of sustainability criteria into the urban renewal processes

The existing built fabric is renewed by actions to reconstruct or refurbish buildings and exterior spaces taken by their public or private owners, mainly under the influence of regulations applicable at urban, regional or supra-regional level. The scale of the neighbourhood enables a coherent and sustainable evolution of the city to be envisaged through knowledge of local potentials which forms part of an overall reflection on an urban sector regarded as a contributory factor to the functioning of the city [14].

Taking account of sustainability targets in this process of renewal implies the simultaneous integration of environmental, socio-cultural and economic objectives [15, 16]. Assessment of these different dimensions presents a major challenge, both through its complexity and through the interdependence of the issues involved.

While multiple lists of criteria or labels exist at the level of particular buildings, few tools appropriate to an assessment on neighbourhood scale are available [17].

In this study, the evaluation approach has been structured on the basis of the SméO analysis methodology, this being a decision-making tool developed for new neighbourhood projects. [18] The aim of this approach has been to highlight the strengths and weaknesses of the neighbourhood concerned and to compare different renewal scenarios, while also taking a critical look at the limits of the tool which is used. In practice, the analysis focused more specifically on 12 transverse themes evaluated using multiple criteria and aggregated by the principles of the Hermione method of multi-criteria aggregation [19].

2. DIAGNOSIS OF AN EXISTING NEIGHBOURHOOD

Diagnosis of the neighbourhood enables priorities for the urban renewal project to be defined. The choice of neighbourhood has been guided by the search for a clearly defined sector, which is liable to host a greater density of buildings located close to a public transport hub. In other words, this is a strategic site as an alternative to further urban sprawl with a location which is capable of facilitating a reduction of the environmental impacts caused by mobility.

2.1. The neighbourhood of "Fleurettes"

The neighbourhood of "Fleurettes" in Lausanne (Switzerland) covers an area of 7 hectares with a population of 1,030 persons. It is situated right next to the central railway station but has a relatively low density at present. Its coefficient of land use (CUS), i.e. the ratio between the gross floor space and the land area, is in fact equal to 0.8 against 3 in other city centre sectors.

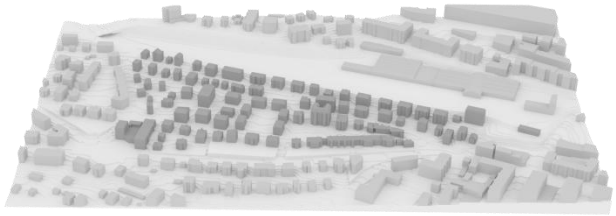

Figure 1: Image of the Fleurettes neighbourhood in Lausanne (Switzerland).

2.2. Evaluation by domain

Evaluation of the neighbourhood enabled us to arrive at the results which are summarised in Table 1. In relation to the targets of sustainability, some headings show a negative situation (-), others a neutral trend (0), while one alone is already favourable (+).

Table 1: Summary evaluation of the sustainability dimensions of the neighbourhood as it is today using the SméO method

Heading	Existing	Nature of the data
Resources	-	Findings
Site and architecture	0	Assumptions
Health and comfort	-	Assumptions
Land and landscape	0	Assumptions
Infrastructures	-	Estimates
Construction concept	+	Estimates
Communal life	-	Assumptions
Identity	0	Findings
Viability	0	Findings
Security	0	Assumptions
Energies	-	Assumptions
Water and waste	-	Estimates

2.3. Priority potentials

The headings which were the subject of an unfavourable evaluation are those which present greater potential for evolution towards improved sustainability and, in that sense, are areas which merit priority development in the renewal scenarios:

- *Resources:* Improved water management by separation of the waste water discharge network and water recycling systems at building level.
- *Health and comfort:* Improvement of air quality and noise level (these two aspects cannot, however, be resolved at neighbourhood level because the sources which generate noise and pollution are located beyond the boundaries of the neighbourhood).
- *Infrastructures:* To avoid occasional pollution of the adjoining lake, a storm water retention facility might be built. More spaces to park cycles and the availability of car sharing schemes could favour soft mobility.
- *Communal life:* Prevention of a possible "ghettoization" of the neighbourhood by introducing low rental housing, so slowing the process of gentrification.
- *Energies:* Reduction of energy consumption and environmental impact by energy-efficient building renovation and introducing new sources of more renewable energy.
- *Water and waste:* Facilities to recover rain water at building level.

3. THREE SCENARIOS OF URBAN RENEWAL

To achieve greater sustainability of the neighbourhood, three separate scenarios were considered. They differ primarily through a growing degree of intervention, interventions being cumulative between the three scenarios.

3.1. First scenario (S1): Renewal by restructuring existing buildings

In this scenario the morphology of the neighbourhood remains unchanged, no building is reconstructed but all are renovated for energy purposes to comply with a high energy standard known as Minergie-P standard

corresponding to the target of a "2000 watts society", [20] having regard to the constraints relating to the heritage value of certain buildings. The heating and domestic hot water system is modified by transition from fuel oil to the Lausanne municipal neighbourhood heating system with the production of 67% renewable energy (incineration of household refuse, mud from wastewater treatment, wood and gas on high demands). Photo-voltaic solar panels meeting 10% of total electricity needs will be installed. Passages for fauna and flora between the gardens are laid out and vegetation planted on the garage roofs. At the scale of the building, rain water recuperation systems are proposed. Measures are taken to facilitate communal life, including the creation of a mutual assistance network and financial support for neighbourhood activities.

Figure 2: Situation plan Scenario 1

3.2. Second scenario (S2): Densification in compliance with current legislation

The neighbourhood retains its existing structure but reconstruction is effected on all plots of land on which greater density is permitted by the building regulations and laws on air protection, noise abatement and prevention of non-ionising radiation and serious accident risks. 42 of the 98 buildings will therefore be reconstructed (Fig. 3). The new constructions respect Minergie-P energy standard, green surfaces are laid out on the roofs and grey water is recycled. Parking spaces have been reduced to the statutory minimum, a public car park is provided on the periphery of the neighbourhood and car sharing zones established. The network of cycle tracks is supplemented near the neighbourhood to improve soft mobility access. Surfaces on the ground floor of buildings in the south west of the neighbourhood are reserved for business activities to create a commercial zone. Anti-noise barriers are installed along the railway lines and the road in the far south of the neighbourhood. The amount of vegetation is increased in the street which becomes a public space with priority for pedestrians and cyclists.

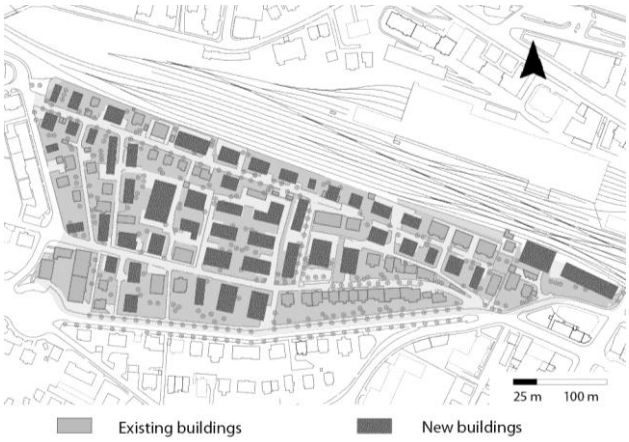

Figure 3: Situation plan Scenario 2

3.3. Third scenario (S3): Densification breaking with the regulatory limits

This scenario corresponds to a greater margin for manoeuvre in relation to the existing regulatory provisions and plots of land. Properties considered to be of national importance and local interest are retained to preserve the historical and heritage value of the site. The distribution of space incorporates the existing situation and proposes optimum density while maintaining high quality public spaces which facilitate exchanges and soft mobility. The aims linked to management of water and energy, protection against noise, non-ionising radiation and major accidents are upheld and integrated in particular by setting up activities in screen buildings erected along the railway tracks.

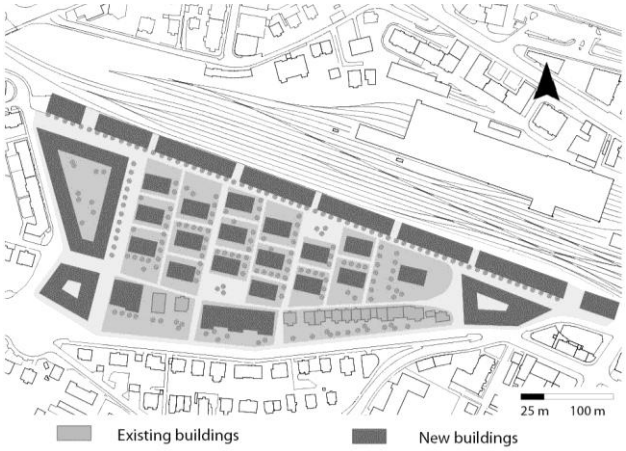

Figure 4: Situation plan Scenario 3

4. COMPARATIVE ANALYSIS OF THE SCENARIOS

4.1. Density

Table 2 shows how densification in compliance with the regulations allows a maximum achievable CUS of 1.3 with a human density of 247 persons + jobs per

hectare (pers+jobs/ha). It is therefore not possible to increase the density of the neighbourhood significantly while still respecting the legal texts and land regulations.

Table 2: Summary of aspects linked to the density (CUS = ratio between gross floor space and land area / COS = ratio between built space and land area)

	Existing	S1	S2	S3
CUS	0.84	0.84	1.3	2.0
COS	0.22	0.22	0.25	0.35
Human density [pers + jobs/ha]	151	151	247	377

The human density in Scenario S3 remains lower than that observed in various existing neighbourhoods of the city which reaches 484 pers+jobs/ha. It is therefore realistic in the Lausanne context and remains compatible with the integration of other sustainability criteria. The densification which maximises the potential according to the legal bases (S2) tends on the other hand to make for non-optimum use of the land and penalises the quality of the neighbourhood in town planning terms.

4.2. Mobility

The existing roads and pedestrian paths are retained in Scenarios S1 and S2. Respect for the layout of the plots of land does not allow them to be changed. On the other hand, in Scenario S3 restructuring within the neighbourhood is proposed. This new pedestrian network makes for soft mobility through the neighbourhood in every direction. In all three scenarios the routes are meeting zones and one-way only.

4.3. Green spaces and vegetation

The proportion of green spaces remains very high in all the scenarios (Table 3), partly because of the layout of vegetation on the roofs. In Scenario S2, maximisation of the density implies consumption of green areas, which are therefore largely present on the roofs. This explains the lower permeability of the neighbourhood. Although Scenario S3 is denser it shows a higher percentage of green spaces because vegetation is laid out on all of the roofs.

Table 3: Summary of green spaces and planted vegetation

	Existing	S1	S2	S3
Green spaces [% of m^2]	50%	51%	52%	56%
Permeability [% of m^2]	49%	50%	46%	44%
Number of trees	158	158	200	200

The trees which were felled to make way for the new buildings have been replaced. Scenario S3 enabled a green space to be laid out within the neighbourhood with squares along the access routes to the north and south of the neighbourhood, allowing diversification of the spaces. Some existing trees have been retained.

4.4. Investment costs

Evaluation of the economic viability of the different projects was then compared, working with anticipated assumptions of construction prices, maintenance costs and rentals.

Table 4: Estimated yield of the different scenarios (GFA = gross floor area)

	S1	S2	S3
GFA renovated buildings [m^2]	57'100	22'589	4'596
GFA new buildings [m^2]	0	64'351	135'404
GFA low rentals [m^2]	0	17'388	28'000
Investment [CHF]	137,038,800	279,443,500	484,944,400
Income[CHF]	14,845,870	23,891,532	39,108,080
Income [CHF] (with low rentals)	14,845,870	23,286,365	38,006,464
Charges [CHF]	5,709,950	8,694,040	11,200,000
Net yield	6.7%	5.4%	5.8%
Net yield (with low rentals)	6.7%	5.2%	5.5%

The results show the lower profitability of Scenario S2 despite the maximised permitted densification in compliance with the regulations (Table 4). The results of Scenarios S2 and S3 show the need for a range of different investment models. When low rental accommodation units are introduced, the average yield is in fact distinctly lower; this implies the involvement of economic players compatible with different degrees of profitability.

4.5. Functional mix

In recent decades, there has been a steep reduction in the presence of commercial activities within the perimeter of the neighbourhood. The addition of new activities should probably be accompanied by financial incentives. In Scenarios S2 and S3 the percentage of spaces dedicated to job creation is significantly higher (Table 5).

Table 5: Summary of percentages for business activities

	Existing	S1	S2	S3
% GFA activities	6%	6%	24%	30%

This is explained by legal limits linked to health protection, which prohibit the construction of housing units on plots directly adjacent to the railway tracks. This result in a business activity zone within the perimeter of

the neighbourhood and at the same time enables a quiet zone to be created in the south.

4.6. Energy

Table 6 shows energy, consumption and savings, and greenhouse gas emissions in the different scenarios according to the description of each. Consumptions of existing buildings have been estimated to 210 kwh/m^2 based on the construction period and on consumptions of buildings owned by the City of Lausanne. The new buildings' energy consumptions are fixed by the standard aimed, they vary depending on the compact form factor. Enhanced performance in terms of consumption and energy agents enables the neighbourhood to be densified, while still reducing its consumption of primary energy and $C0_2$ emissions.

Table 6: Annual energy saving in each scenario (Ae = energy reference area / PE = Primary energy, including operating and building materials energy)

	Existing	S1	S2	S3
Ae [m^2]	53,146	53,146	75,298	112,000
Increase in Ae [m^2]		-	22,152	58,854
PE [KWh]	20,738,406	8,229,308	9,629,746	12,881,780
Total PE saving [KWh]		12,509,099	11,108'660	7,856,626
Total NRE saving [KWh]		14,875,009	13,717,389	11,192,913
GWP tot [Kg CO_2 eq]	4,144,868	730,520	789,460	970,377
Total GWP saving [Kg CO_2 eq]		3,414,348	3,355,408	3,174,491

Allowance in the calculation for the reduction of mobility linked to urban densification would further enhance the positive trend of the overall energy balance. The consumption of primary energy linked to heating is the only category to see a significant reduction (Fig. 5). This reduction is linked to the refurbishment of the energy-efficient renovated buildings for energy purposes and the high performance standards of the new buildings. Since the new buildings satisfy Minergie-P standards, their heating needs are only 60% of those required by the current standards in Switzerland (SIA 380/1). The difference between the three scenarios is low because the assumptions of renovation, construction and energy sources are identical in all three scenarios. Only the percentage of refurbished and rebuilt buildings varies.

Electric power accounts for over half the primary energy consumption in all three scenarios: 51% for the first, 56% for the second and 62% for the third. This highlights the importance of actions to be taken in this area in parallel with the efforts made to reduce heating consumption.

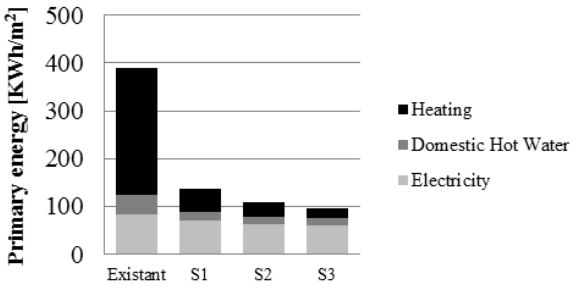

Figure 5: Energy consumption in each scenario

4.7. Summary of the results

The summary table of the results shows a progression in the different scenarios towards greater sustainability (Table 7). Scenario S3 enables greater sustainability to be achieved under every heading, except health and comfort and investment costs. On the one hand, air quality cannot be improved by an intervention in the neighbourhood, but requires changes on a broader scale. On the other hand, higher investments increasing rents reasonably, do not allow high net yields. In Scenario S2, the assessment under five headings is not favourable. It would be necessary to change the limits of land regulations to enable this scenario to be optimized so as to achieve more efficient and harmonious densification.

Table 7: Evaluation of sustainability of the three scenarios

Headings	Existing	S1	S2	S3	Data
Resources	-	-	+	+	Findings
Site and architecture	0	0	0	+	Assumptions
Health and comfort	-	-	-	0	Assumptions
Land and landscape	0	0	0	+	Assumptions
Infrastructures	-	-	+	+	Estimates
Building concept	+	+	0	+	Estimates
Investment costs		+	0	0	Assumptions
Communal life	-	0	+	+	Assumptions
Identity	0	0	0	+	Findings
Viability	0	0	+	+	Findings
Security	0	+	+	+	Assumptions
Energies	-	+	+	+	Assumptions
Water and waste	-	+	+	+	Estimates

The performance of a detailed diagnosis enabled targeted interventions to be defined. Although it is based on a relatively modest degree of intervention, Scenario S1 already brings an improvement for 3 out of the 6 priority headings.

5. CONCLUSION AND PROSPECTS

Comparative evaluation of three urban renewal scenarios enabled us to show the multiplicity of dimensions which must be taken into account in such a process. The results obtained show a convergent

progression between the degree of intervention and the degree of sustainability.

The research highlights the limits of town planning development based solely on densification on a plot by plot basis. A significant increase in the sustainability of a neighbourhood may imply a need to question some aspects of the regulations and some limits of the individual plots of land. This finding clearly shows the interest of the public and private players concerned to explore jointly the opportunities for synergies held out by a scale of intervention exceeding that of each individual building.

In view of the complexity of the dimensions to be taken into account and evaluated simultaneously, a tool which assists decision-making is particularly useful to give a structured and coherent vision of a heterogeneous set of data. One of the challenges posed for such a tool is the need to be able to consider not only the strictly quantitative aspects but also qualitative dimensions linked notably to identity, well-being and life in the neighbourhood concerned. A multi-criteria evaluation of that kind does not release the players from the need to make choices and potentially accept responsibility for some arbitration between the different dimensions of the operation. However, it does enable decisions to be taken in a more aware and more explicit manner.

In its present configuration this research demonstrated the fact that the SméO tool was appropriate on the scale considered here. Designed essentially for projects for new neighbourhoods it did, however, prove that it is partially adapted to the evaluation of a process of renewal of an existing neighbourhood characterised among other factors by greater needs in terms of diagnosis and by a greater role for the pre-existing situation in operations to transform the neighbourhood. Economic evaluation should be developed to take into account a wider range of aspects in a life cycle prospective. This finding encourages us to continue the research in order to develop a method of evaluation and a tool to facilitate decisions which will be better adapted to urban renewal operations. That work will be presented in future papers.

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