MAIN CHALLENGES OF RESIDENTIAL AREAS

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Abstract. The present article is a position paper aiming to initiate a professional debate related to the aspects related to the urban dysfunctions leading to the wear of the residential areas. The paper proposes a definition of the wear process, identify the main causes leading to its occurrence and propose a number of solutions to neutralise the dysfunctions. The three wearing phases of residential areas components are emphasized, exploring their lifecycle. In order to perform the study of urban wear, the status of the residential areas components can be established and monitored, and also the variables of the function that can mathematically model the specific wear process may be considered. The paper is considered a first step for the model adjustment, to be tested and validated in the following steps. Based on the mathematical method and model, there can be created, in a potential future research, the possibility of determining the precarity degree for residential areas/neighbourhoods and cities, by minimising the subjective component of the analyses preceding the decision for renovation or regeneration.

Key words: residential areas, dysfunctions, urban wear

1. General considerations

Within the urban settlements, the residential area (Luca, 2003) acts as a nucleus for expressing the urban functions (Fujita, 1989). The urban life takes place here, having therefore the specific characteristics of any living environment. Housing, as the structural process of human life organisation, imposes the need of ensuring the material conditions for the continuity of this process. The organisational unit of urban structure, the residential area, must function as coordinator of keeping "alive" all mobile and immobile participants in the urban metabolism process (Kennedy *et al.*, 2007; Ferrão *et al.*, 2013), participants who must satisfy the requirements of urban functions. Similar to a living being, the residential area comes to life, starts to function upon infrastructure commissioning, inhabitation of housings, provision of services, mobility conditions and other representative components of urban functions (such as recreational facilities, socio-economic and cultural-educative facilities, health facilities, services etc.). Functionality ceases upon a) occurrence of relative physical depreciation across time as a consequence of various factors of the natural environment (rain, wind); b) as a result of brutal intervention of disasters such as earthquake or fire (which is not be a debate subject in this paper); and/or c) due to obsolescence, after occurrence of certain physical components of the residential areas, such as highly used transportation means, as a consequence of technical progress.

Such process is identified as urban wear process, and its effects are visible by the existence of either districts of blocks of flats that have never been substantially renovated since their construction, or historic centres left in ruin, industrial areas that have been abandoned due to termination of operations, decayed public spaces, unsatisfactory urban services, inefficient public transport, endangered green spaces and, last but not least, ageing population or abandoned houses (Smith *et al.*, 2010). It is therefore confirmed that the city is a dynamic system (Batty, 2008), constantly changing the quantitative and qualitative values of its functions, a fact which is more visible in the transition period (Tuvikene, 2016), which led to deep transformation of the cities in Romania over the past 27 years. Identification of residential areas components (such as buildings, streets, alleys etc.) affected by the wear process may be now solved by the means of sectorial audits, occasionally conducted by the authorities, to diagnose the condition of the physical components of residential areas by comparison to their initial status and review of the other types of physical components, as well as for the population.

This is the opportunity of determining the urban dysfunctions (Friedmann, 2002; Herbert *et al.*, 2012), that will compose the "picture" of urban wear. It is representing a consequence of the action of the environment, the man, or as result of anthropogenic disasters, and is generating qualitative decreases of urban functions by affecting all the components of the residential areas. The caused identified may be certain events or processes in the development of the society (Larco, 2016) or even the indecision of the authorities on how to solve them, such as:

a) issues related to society development:

- large-scale economic activity but with low productivity, with obsolete technology and hard to adapt to the new socio-economic concepts;
- mono-industrial or heavily polluting economic activities in small towns;
- non-skilled/poorly skilled or disqualified labour due to economic inactivity;

- infrastructure for housing or built-up environment (Sandu, 2010) of admissible quality, but improperly maintained;
- centralised, bureaucratic and non-innovative administration;
- poor community spirit;
- public services centralised in terms of operation and financing, with technologically and economically inefficient effects.

b) issues related to indecision of the authorities:

- lack of political experience;
- increased effects of environmental deterioration (Carter *et al.,* 2015);
- decrease of housing stock;
- lack of professionalism of the local administration (obsolete, incapable of modern urban planning, slow in implementing reforms, lacking initiatives etc.);
- insufficient involvement of communities, hence inability of the local authorities to educate people through proper processes and procedures.

The perpetuation of these problems creates favourable conditions for the occurrence of multiple dysfunctions of the residential areas components. Their accumulation results in aggravation of unsolved problems, decline of economic activities, accumulation and non-solving of social issues, as well as irreversible deterioration of the environment. In addition, there may appear increased effects of ecological abnormalities, increased underground economy, increased corruption and social segregation with significant adverse effects on all urban functions and "proliferation" of dysfunctions.

The solutions to counteract all such problems may be found either in the experience of other urban communities faced with this kind of situations (Gillete, 2010), either in studies conducted by authorised institutions (Brescia, 2015). They refer to applying provisions of urban development, which also include operations for removing the effects of wear, such as:

- cooperation between the ministries in charge of urban development;
- activation of proper institutional capacities;
- implementation of the specific legal framework through legislative changes;
- creation of specific working tools, such as strictly necessary regulation in the field of urban planning;
- provision of human resources, specialised institutions that can ensure communication on urban issues (development, acknowledgement, identification and solving of urban dysfunctions) through dialogue on applying certain practices and compliant with professional ethics of protecting the general interest of the urban community, educating the partners (including political ones) involved in urban development;
- implementation, by the specific authorities, of concrete sustainable (Woodruff *et al.*, 2016) policies or programmes, substantiated by pilot projects in the field of urban development;
- provision, by the authorities, of support to the partners from the civil society and mass-media in guiding and educating the public opinion for the purpose of preserving urban health.

Pooling the results of the efforts made in applying the above mentioned actions in a programme, to eliminate all dysfunctions resulted from the urban wear process, requires a detailed analysis of each measure, to identify possible generating factors of at least one dysfunction.

The counteracting phases of urban wear may start with a study on the existing situation, continuing with design of adopted solutions, execution of provided works and their completion, acceptance and commissioning thereof, thus replacing non-functional components of urban metabolism with new ones in a new lifecycle.

The first step in the phase of dysfunctions studying, after ascertaining and recording the date of occurrence, consists in determining their characteristics, scaling (Margineanu, 1982) of the urban wear phenomenon and identifying the factors generating dysfunctions in the residential areas, among which: population, housing, transports, education, health, service provision, recreation.

Fig. 1 presents part of the dysfunctions of the residential area components and the generating factors related to their occurrence (see Fig. 1).

2. Materials and methods

The present position paper was elaborated following the study of various scientific publications, documents and articles published by researchers who investigated the city, residential areas and neighbourhoods, together with their dysfunctions that may appear in the housing process. The model proposal was based on the behaviour of residential areas components (buildings for housing, education, health, streets, equipments and infrastructure etc.), similar with the behaviour of equipments and installations in a lifecycle which goes through a run-in time, maturity time and ageing time.

The position paper aims to initiate a debate related the possibility of designing a mathematical model of the across time wear process of the residential areas similar with the wear process of equipments. Also other important questions are arising: May the investments in the regeneration process (Arbaci *et al.*, 2012) of a residential area be prioritised? Can we objectively determine the degree of precarity for a residential area, in order to establish the selection criteria for financing urban renovation or regeneration integrated projects?

3. Results and debates

3.1. Determining the parameters of the urban wear phenomenon. Modelling

The common factor of urban dysfunctions is generally found in the wear of the built-up environment plus the human wear through the ageing process of the inhabitants. In such conditions, the urban metabolic process becomes extremely slow and urban vitality, defined as the extent to which a city, or a part of it, feels alive or lively (Montgomery, 1995; Selezneva, 2011; Zhou, 2012) decreases.

The factors generating dysfunctions, as presented in Fig. 1 can characterise the residential area or the district, when intrinsic wear occurs, or characterise the generating factors of neighbouring areas whose parameters influence the wear of the area under analysis, thus causing associated wear. The two categories of wear can be linked by a direct relation, complementary to the analysed process, leading to its intensification, respectively increased parameters (for instance, existence of a road or of a high-capacity transport route in the proximity, high-capacity socio-economic facilities such as supermarkets, stadiums, large recreational facilities etc. outside the urban area), thus intensifying the wear process of the area (Walliser *et al.*, 2012).

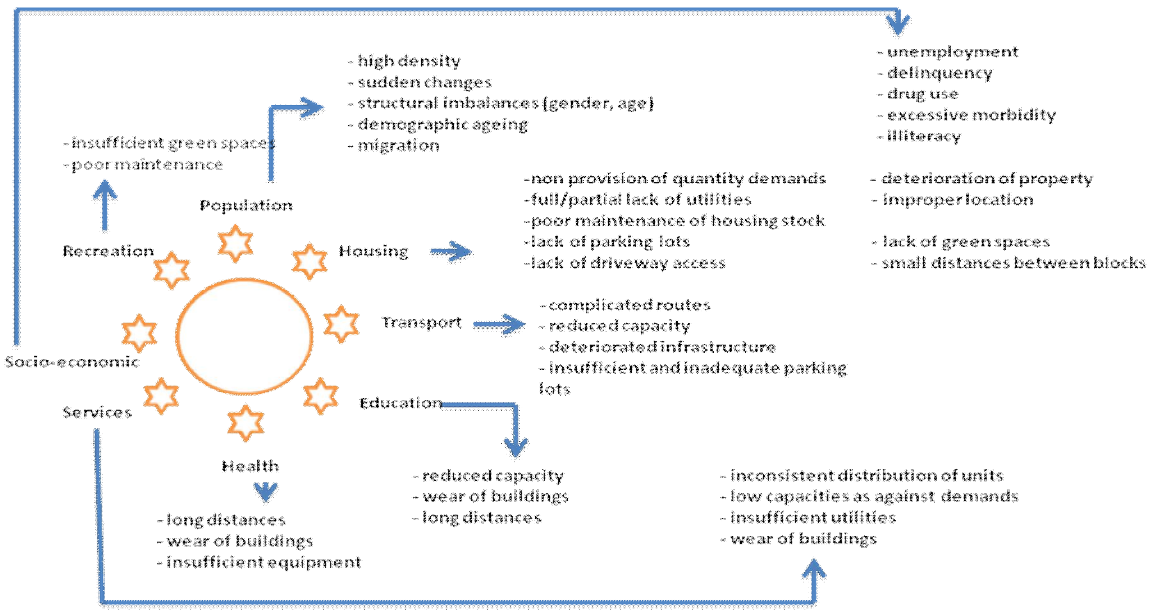

Fig. 1. Factors generating dysfunctions in a residential area – "Cavity of comfort"

The intrinsic wear (specific only to the residential area) may be influenced by the number of components of the residential area, as well as by the existing residual parameters of the built-up environment, thus maintaining the so-called agglomeration of components. At the same time, the associated wear, considered for the entire urban structure, determines a reduced intrinsic wear of the urban area by "losing" itself in the overall functional urban space. Hence the necessity that the studying of urban wear to be conducted on the overall urban structure (Hlaváčeka *et al.*, 2016).

Lack of regular findings in the practice of built-up environment performance monitoring, which could provide statistical elements to scale the phenomenon, makes us believe that, currently, the degree of comfort (consequently the degree of wear) can only be determined at the level of the residential area, based on the dysfunctions of its components identified over a well-established period. They can constitute the fundament of a database for a possible analysis of the urban comfort degree, defined as sum of levels of wear of the residential area components, and could be the starting point in analysing the sustainability of urban regeneration projects.

3.1.1. Lifetime of residential areas components

The relatively high number of residential areas components requires careful monitoring in order to remove those dysfunctions that prevent a good quality of urban life (Higgins *et al.*, 2014).

Similar with the phenomenon of occurrence of dysfunctions for urban equipments and installations (Nitu *et al.*, 1974; Palakodeti, 2015), in the residential areas the component dysfunctions may follow an exponential distribution rule in the form:

$$F(t) = 1-e^{-\lambda t} \quad (1)$$

where:

λ = constant parameter, representing the deterioration intensity of the residential area component affecting housing, which is an estimate of the reversed average time of operation of the component, in order to have a pre-established urban comfort (without dysfunctions)

t = operating time of components.

Analyses made on urban equipments and installations (Nitu *et al.*, 1974; Lima *et al.*, 2014; Bitros *et al.*, 2016) confirm the existence of wear in 3 phases, namely:
a) adjustment or run-in time of the equipment or installation, when precarious defects occur, time also called "youth", when the deterioration intensity λ drops until it reaches a value specific to the guaranteed operating time, namely commissioning or provisional acceptance, after removal of certain structural non-conformities and reaching of usage parameters;
b) the lifetime, specific of functional maturity, when random defects occur (for the residential areas these may be consequences of unpredictable events such as earthquakes, fire etc.), respectively λ = constant, specific of the lifetime without dysfunctions;
c) ageing time, when the equipment or installation suddenly starts losing its initial capacity of use, by occurrence of dysfunctions, when λ becomes variably ascending (see Fig. 2).

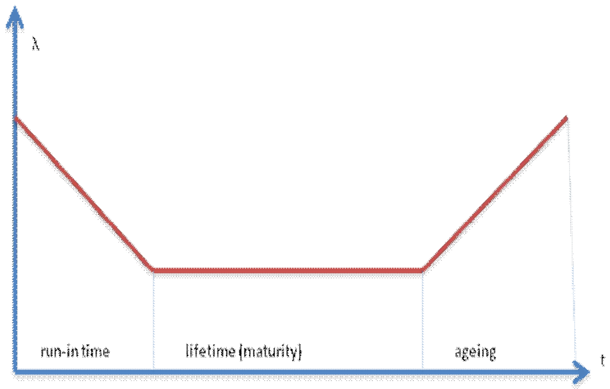

Fig. 2. Variation of the intensity of dysfunction occurence for a residential area component

Similar with the behaviour of equipments and installations in a lifecycle which goes through a run-in time, maturity time and ageing time we may consider the behaviour of residential areas components. The three phases (run in time, maturity and ageing) may be applied for each of the residential areas component (buildings for housing, education, health, streets, equipments and infrastructure etc. but also for population).

If we add to this diagram the contribution of other unpredictable events such as those presented above, we can say that the lifetime of a residential area component represents the influence of three main factors that can generate dysfunctions, namely:

- Design and/or execution flaws of the component
- Random events
- Reaching the ageing time.

In the current practice of the components of a residential area, the intensity of the processes of occurrence and increase in the number of dysfunctions – known under various name (failures, incidents in the utility and transport/mobility safety services, high isochrones to the interest centres, ageing population, degradations of buildings caused by atmospheric factors etc.) may be modelled using relations such as:
λ (t) = constant; λ (t) = a×t (proportional to time); λ (t) = $b \times t^{b-1}$ (exponential to time) etc.

In the case of the residential area, which depends on many components, specific to each urban function, the performance of a function such as those mentioned above, influenced by the three main factors, can be obtained by modelling λ, according to a relation containing an ascending factor and a descending factor – both exponential, namely:

$$\lambda(t) = b_1(t) + b_2(t) = \frac{b_1}{2} e^{b1t} + \frac{b_2}{2} e^{b2t} \qquad (2)$$

where b_1 and b_2 are the parameters characterising the dysfunction related to the lifetime (Nitu *et al.*, 1974).

b_1 = parameter of ageing acceleration, specific to the wear period
b_2 = parameter of deceleration, specific to the run-in period
and the distribution function (1) of dysfunction occurrence F(t) will be:

$$F(t) = 1 - e^{\frac{1}{2}b_1 t - \frac{1}{2}b_2 t} \qquad (3)$$

in observance of the distribution function conditions, namely:
$\lim_{t\to\infty} F(t) = 1$
$\lim_{t\to 0} F(t) = 0$.

The relation of uninterrupted operation probability will be

$$R(t) = e^{-\frac{1}{2}\left(e^{b_1 t} - e^{b_2 t}\right)} \qquad (4)$$

In terms of the lifetime of residential areas component within the built-up environment, it is subject to the wear rule, and may be represented by the mathematical function of lifecycle in the form:
$f(t)=k_i t^a e^{-bt}$ (5)
where k, a, b are the parameters of the function and t is the time.

By mathematical processing required to identify the critical points of the function value (maximum, inflexions etc.) and matching with the normal evolution of the physical wear phenomenon, according to the lifecycle, we can determine the critical points of the evolution in time of the lifecycle and/or the life expectancy at a certain time of residential areas components subject to wear (buildings, roads, facilities etc.), namely:

- time of reaching maturity (without occurrence of any dysfunction), point that may be determined by the mathematical method of cancelling the derivative I of the function, namely reaching of the value $t_{max} = a/b$
- time of occurrence of the first dysfunction, namely point of inflection of the curve variation, by the mathematical method of II deriving of the wear function, time that will have the value $t_{inflection} = \frac{a+\sqrt{a}}{b}$. This is the time when decline begins (see Fig. 3), when it is necessary that the authorities to start the operations of restoring the metabolic components to their functional parameters through reconditioning or regeneration or modernisation etc.

A possible application in housing field, to establish parameters for determining the specific times characterising the urban wear process requires the definition of the significance of the three parameters, namely k, a, b.
k_i – multiplying factor of function amplitude (5) without possibility to influence the lifecycle but with the capacity to influence the lifetime without occurrence of dysfunctions
a_i – amplitude factor in direct relation with lifetime, level of housing and degree of comfort of the area, respectively.

Considering the fact that the residential area is a result of balanced urban metabolism, the wear status of the residential area S_{raw} can be expressed with the relation:

$$S_{raw} = \sum_{i=1}^{n}\left(k_i\ t^{a_i} e^{-b_i t}\right) \qquad (6)$$

i= number of factors generating dysfunctions related to a residential area component.
The values of a_i, b_i and their variation range can be determined by the graph of generating factors, with consideration of certain statistical indices representing them in the wear process and whose annual variations indicates the imbalances of urban functions. In this respect, the generating factors can be identified according to the Fig. 1 related to the “cavity of comfort” and the

imbalances identified through variations of the specific parameters of each dysfunction related to an urban function (for instance, average age of the population, density of population, density of services, of recreational areas and similar ones by increasing the accessibility isochrones etc.).

The parameters of urban wear function, namely a_i, b_i, k_i characterizes its value for a certain moment in time t, respectively they announce the probability for dysfunction appearance in the studied urban area, excluding however the wear caused by disasters.

The parameters have a complex structure; each has its own variation, different from the others. Their size and variation mode are empirically determined by field observations, with informal character, in Bucharest urban residential areas. An example, extracted from a future research, showing the identified parameters, for two factors which are generating urban wear, is presented below (see Table 1):

Table 1. Example of proposed parameters

Generating factor	**Parameters**	
	a_i = amplitude factor	**b_i = evolution factors of dysfunction**
Population	Mean age/life expectancy (%)	Population density (inh./sq.km)
Housing	No. of existing units/necessary units x utilities coefficient	The average age of buildings /normal age x area occupied by the buildings/ total area of x M

If all the utilities exist in the area, then the utilities coefficient is 1. In a subjective evaluation we may conclude a possible quantification for the coefficients necessary for comfort assurance: water supply ≤0,2; sewerage ≤0,2; power ≤0,2; thermal energy ≤0,3; telecommunications ≤0,05; TV cable ≤0,05.

M is a coefficient estimating the comfort of the area, with values between 0 and 1, taking into account that for 0 the area is unacceptable, for 1 the area has a very good comfort.

The graphical representation of the variation of each dysfunction generating factor can provide an image of the status evolution of a residential area, can indicate the factors to be acted upon to reduce or anticipate the phases preceding dysfunctions by specific works undertaken to increase the degree of comfort in the area.

The degree of wear characterises in fact the precarity of the residential area and can be determined based on the related information. Obviously, special residential areas (such as "gated communities" (Sanchez *et al.*, 2005; Roitman, 2010; Datta, 2013), closed-access areas) will have minimum values, as most of the requirements of proper housing are met, and the marginalised residential areas will have maximum values.

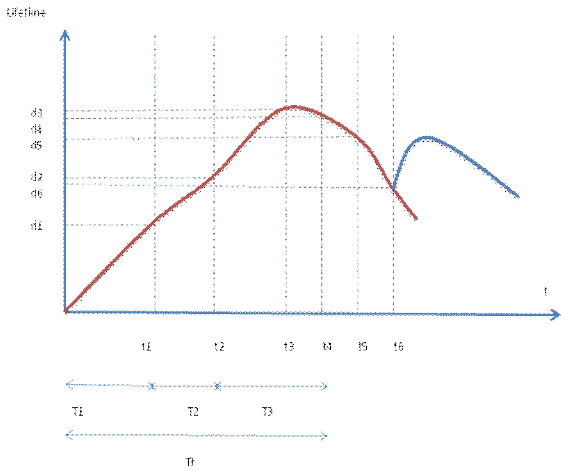

Fig. 3. Lifecycle of a residential area component

T_1 = time required for functional tests

T_2 = time required to reach maturity parameters and functional capacity

T_3 = time required to reach maximum use, when ageing can begin and malfunctions and decline, respectively, can occur (time t_5)

t_6 – beginning of rehabilitation for a new lifecycle

4. Conclusions

In order to start the debate related to urban wear, we can consider that the status of residential areas components can be monitored and ascertained. The components may be considered as variables of a function that can mathematically model the specific wear process. Mathematical models of wear, in the long run, are applied to exponential distribution, and the intensity of dysfunction occurrence may be defined as the density of probability conditioned by the existence of dysfunctions in a time range (t, t+x) so that $\lambda(t) = \lim_{x \to 0} \frac{\tau(t_x)}{x}$ where λ (t) has the significance mentioned in (2) and the distribution function (1) is in the form of (3).

In any urban community, irrespective of size and structure, the quality of housing, considered in terms of the degree of wear of residential areas components, is strongly influenced by dysfunction generating factors – in particular the population, the socio-economic status and, last but not least, the education and the services provided under the coordination of the local elected representatives. Therefore, it is necessary to regularly ascertain the degree of wear of the residential areas components. It can be ascertained either by regular urban audits documenting the degree of wear of the above mentioned components, or by establishing simple or complex statistical indices consisting of statistical indicators existing in the records of the authorised administrative structures and containing in their "substance" the effect of dysfunction generating factors and their ageing times, as a consequence of the quality of specific departments.

The graphical representation of wear for each component can provide an image of the residential area, it can provide conclusions on the intrinsic and associated wear, it can indicate the factors to be acted upon, and one can anticipate the development of wear phases and point out to the severity of dysfunctions and their effects on the housing level.

The mathematical method and model can create the possibility to determine the degree of precarity of residential areas, as well as of human settlements, by minimising the subjective component in the analyses preceding the renovation decision. At the same time, the degree of wear for various functions can be taken into account in determining the criteria for selecting the urban regeneration projects eligible to be financed based on competitions related to funds allocation. These are future steps in the research and will be performed following data acquisition for specific residential areas.

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