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REVERSE LOGISTICS AND SPACE ALLOCATION FOR RECOVERY MANAGEMENT IN NEW URBAN SETTLEMENTS

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Abstract
This paper presents the authors' vision about the planning foundation for the new residential areas from the large cities outskirts, in a sustainable development framework. One considers the great generation potential of the high and very high income population in case of the used products with remained reuse value, or new and undesired products, available in the residential places. We propose a space allocation model with a hexagonal hierarchical structure for the centralized return centers in a reverse logistics. The space allocation model for the recovery centers implementation takes into consideration: the recovery habits, environmental care and sustainable development education, "moral" compensations, centralized recovery centers facilities, walking willingness of the average inhabitant of the considered area, decision makings involvement at the local Public Authority level, and local community. One reveals the importance of the data collecting stage for the potential and availability of the exhausted products (having reuse value) in a specific area with high and very high income population.

Keywords: reverse logistics; centralized return centres; recovery potential; space allocation

1. Introduction

At the end of the 20th century, Roger and Tibben-Lemke (1999) defined the reverse logistics concept as *"the process of planning, implementing and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal*". At that time, this definition did not take into consideration the package materials. De Brito (2003) completes the above definition and describes the reverse logistics as "the process of planning, implementing and controlling the backwards flows of raw materials, in-process inventory, packaging and finished goods from manufacturing, distribution or use point to a point of recovery or proper disposal".

Recently, in 2006, the Reverse Logistics Association expanded the definition beyond returns processing to include repair, customer services, parts management, end-of-life manufacturing and order fulfilment.

Nowadays there are a lot of definitions for reverse logistics, but the literature, still at the beginnings, is scarce and not well structured. It can be outlined some directions (philosophies) that have evolved during the time with respect to the domain and needs of the actors: economic agents, population, local or central public authorities, non-governmental agencies. These directions dealing with reverse logistics are depicted in figure 1 and relate to:

1. municipal waste logistics;
2. reverse logistics of refused goods, recently coming out due to e-commerce development;
3. reverse logistics of used and unused goods with recovery value:
    - out of order goods, unused for repairing,
    - obsolete and replaced goods, with recovery value, used or unused;
    - unwished goods and not returned to the early selling point.

Figure 1 outlines those stages in a reverse logistics chain that require the presence of centralized recovery centres - CRC, where either non-used products or used products having re-use value could be easily collected. In an extended and comprehensive study already mentioned, Rogers and Tibben-Lamke (1999) thoroughly examine the key elements of the reverse logistics management, where the centralized recovery centre is one of the issues of successful recovery management strategy, as one can see in the following list:

- Gatekeeping
- Compacting Disposition Cycle Time
- Reverse Logistics Information Systems

- Centralised Return Centres (CRC)
- Zero Returns
- Remanufacturing and Refurbishment
- Asset Recovery
- Negotiation
- Financial management
- Outsourcing.

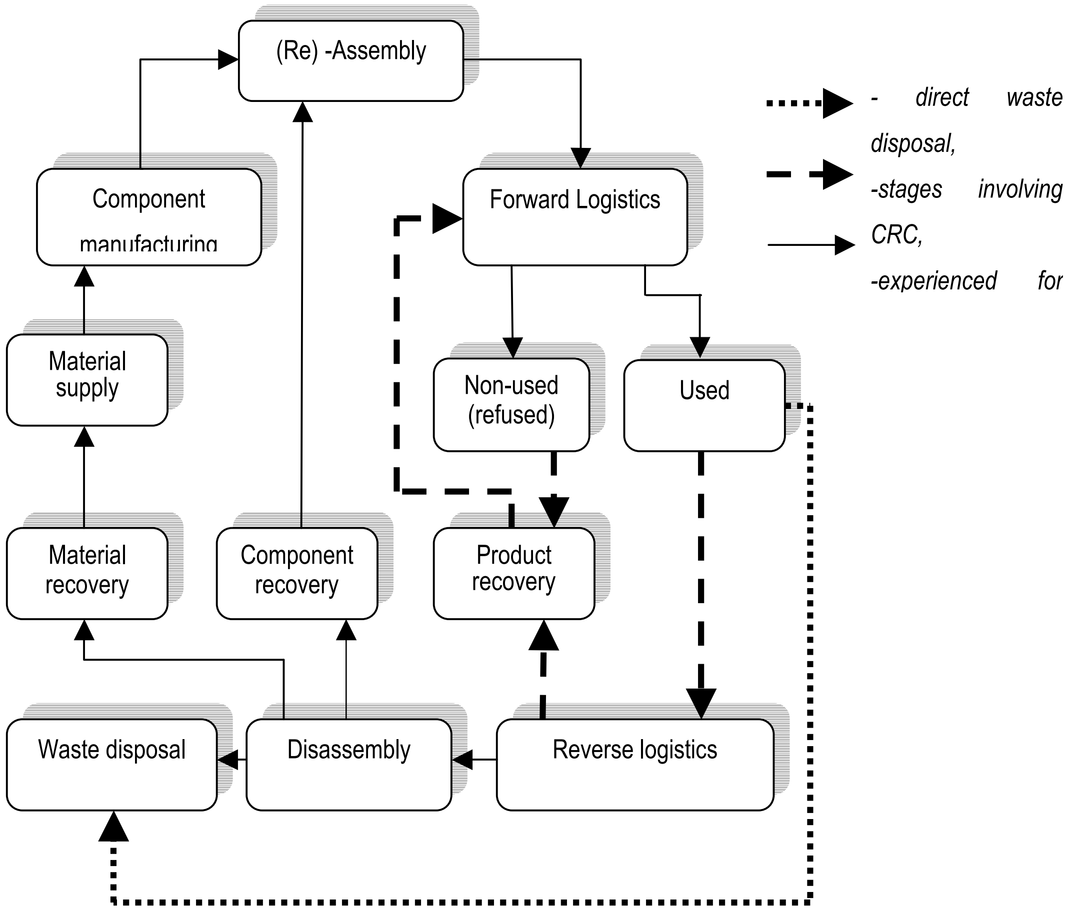

FIGURE 1 : DIRECT AND REVERSE LOGISTICS CHAIN (BASED ON FERRER 1997).

Another important issue, rather as an environmental principle, is the "Extended Producer Responsibility" - EPR. This principle has the meaning (Sands, 2003) of the legal nuance to the term, in a sense that "binds acts of international organizations, state practice and soft law commitments". In the EPR programs, producers' liability, physical, financial and informative responsibilities are extended to cover the end-of-life phase of their products to various degrees (Manomaivibool, 2009). The infamous of the waste electrical and electronic equipment Directive 2002/96/EC of the European Union puts a rather comprehensive scope of responsibility on the producers. The transposition of the waste electrical and electronic equipment – WEEE Directive into the national legislations and the implementation in the 27 member states varies considerable (Huisman et al. 2007).

Starting with the experience of the European EPR program of WEEE, this paper considers that there are at least three necessary elements of any other EPR program (related to any other end-of-life products):

1. controlled downstream activities,
2. resource flows from identifiable producers to downstream activities,
3. monitoring and reporting mechanism.

In this paper one considers that the first element of any EPR program - "controlled downstream activities" – finishes at the Centralised Return Center. This responsibility has to be a private one, distinct from the CRC responsibility that has to be at the Local Public Authority level. A comprehensive legal interface between these two responsibilities is an important requirement.

For the second element of the EPR program and its efficiency, in this paper we propose a hierarchical structure of the CRCs, related to the generation potential in case of end-of-life products. In this way there is a resource flows structuring process of the producers for the recovering activities.

On location of the CRCs there is a recent work (Aras and Aksen, 2008) addressing to it in case of private company that aims to collect end-of-life products from the consumers. The remaining value of the used products that can be saved by recovery operations is the company's main motivation for the collecting operation. This work considers that each consumer, that is an end-of-life products holder has an inherent willingness for return, based on both financial incentive offered by the recovering company for the returned item and also the proximity to the nearest collection center.

In our paper one considers the rich people from the outskirts residential settlements and their habits to drop-out the end-of-life products having still important usage value. This type of individuals has not important financial incentive and, in most of the cases, these financial incentives "destroy" their willingness to return those end-of-life products (Berglund, 2006).

They prefer some "moral" incentives and one considers in this paper the rich residents with "moral" attitude related to the recovery activities. For this approach, the CRCs have to promote a self-image of the rich community's members, by an intensive and adequate promoting program. As a consequence of this approach, the CRCs have to have very modern facilities (e.g. sorting equipments, spotlessness' facilities, frequent mass media reporting, etc.) in order to assure the recovering activities' success, measured by the number of "donors" in the area and also by the recovered financial value of the end-of-life products.

The recycling behaviour literature concludes that moral norms and attitudes are more important than social norm (Tucker, 1999; Barr et al. 2003). There are also some papers which report that external conditions (e.g. recycling infrastructure) are important for moral recycling decisions thus establishing a link between convenience (economic and financial) and moral motivations (Derksen and Gartell, 1993). Moreover, there is a behaviour pattern in household waste generation (Márques et al. 2008) and also the socioeconomic stratum of any community, which are important factors related to the behavioural attributes and consumers habits.

2. Romania recovery experience and CRCs necessity

In Romania the recovery management is limited to the only three products' industries, which are:

I) collecting and recovery of old cars (usual older then 10 years) and parts of them, following some stages of reverse logistics process - Fig.1;

II) collecting and recovery of electronics and electrics products;

III) packaging waste recovering.

For the first products category, the Public Authority supports the fixed cost of car recovery from the public budget and the financial program is well-known as "crock" program. There are some recovery centres, and all stages of the reverse management are accomplished by private operators.

The second products category is periodically collected, in front of the final user's house. The obligation for providing location of the recovery centres is on the Public Administrative Authority at local level. According to the Romanian Government Resolution no.448/ 2005, every county has to provide at least one recovery centre for electronics and electrical equipment; as well as each of the city having more then 100,000 inhabitants. In Bucharest, the minimum number of such centre is at least six, one for each of the administrative sector. The producers and distributors support all the involved costs for all reverse management activities.

Besides these product types for the recovery there are no other initiative for materials which still have usage value. Moreover, there is no planning measure to reserve some space for the purpose of the recovery centre settlements into the outskirts of the new urban areas.

During accelerated economic growth periods, as emergent economies have known, the urban settlements go to the fringe, creating huge residential areas. These are acquiring in time (in a non-regular environment) new spatial functions such as commercial, educational and social ones. Some of them are set up simultaneously with the residential development stage. This kind of real estate evolution is presented in the recent development of Bucharest suburbs.

The following two types of residential areas rising up in suburbs are distinguished:

- low density zones, with lodgings like villas, having large space and high income inhabitants;
- high density zones, with lodgings on many levels, usually four or eight levels, having large flat surface and inhabitants with high income, at least greater than the average income of the city's inhabitants.

It is well known that, all over the world, the crowding effect encourages economic development at a higher rate than the rest of the region, and therefore provides incomes above the average of the region. Such a population, with higher income, has a greater potential for the disposal of medium and long term products than the rest of the urban population. It becomes obvious the necessity to alleviate the recovering process of the exhaust goods (which a special section will be allocated for) by preservation or allocation of specific spaces for the recovering management, key element into an integrated reverse logistics chain.

The need for spatial allocation study of the Centralized Recovering Centres (CRC), integrated into a coherent plan for developing the suburbs of large urban areas, comes from the requirements of the sustainable development.

In the meaning of our paper, the Centralised Return Centres are defined as the processing facilities devoted to the handling returns quickly, easily, comfortably and efficiently. CRC is a modern centre, associated with information system, having multiple functions in multiple-reverse logistic chains. We define the main features for CRC, as follows:

1. CRCs are very closed located to residential area for lightening the recovery process,
2. there is no recovery fee or compensation for end users,
3. there is a strong marketing system (such as mass-media programs, primary schools program, etc.) in the community in order to increase the positive self-image as morally responsible persons among the community members,
4. CRCs may have additional functions for the community management,

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5. CRCs locations have a hierarchical structure, according to the certain socio-economic characteristics of the residential area, such as density of the households, population's structure and income, multifunctional facilities in the area, inhabitants' usual habits.
6. the responsibility of the CRCs' space allocation, facilities providing and community programmes in order to increase people motivation is on the Public Authority at every local level and this is called in this paper as "downstream responsibility",
7. there is also a "downstream responsibility" of the CRCs: these are on manufacturers and operators involved in different products' markets. Both type of responsibility have to be clearly mentioned in a specific law system.
8. CRC may have the same location with distribution centre for the forward logistics to facilitate the recovery of the frequent products.

3. CRCs' location model

3.1. Generation potential of the unnecessary materials

In this paper, the *unnecessary materials' generation* is defined as the used or new (unused) goods from the original consumer (user), with usage value that can be saved in a new life cycle by a new consumer or a new industrial process following some adequate operations (testing, repair, refurbishment, remanufacturing, etc.). The unnecessary materials are granted without any financial compensation, but with moral community compensation.

In a certain rich community (or *analysing zone*), *i* there is a high potential for the unnecessary materials' generation, related to the following variables:

P_i - the number of inhabitants living in that certain zone, *i*,

W_i - the wealth per capita in that zone, including not only current income of the people but also the gained assets and wealth,

H_i - the households structure, in zone *i*,

E_i - the level of the population education, in zone *i*,

EE_i - the dummy variable to reflect any systemic program in favour of the environmental education or promoting, taking value 0 in case that there is no program or on contrary, value 1 if there are some environmental education activities in that zone.

A mathematic model of the multiple regressions including all the above variables is a satisfactory one for practical evaluation. Thus, the generation potential for unnecessary materials in that *i* zone, G_i has the following expression:

$$G_i(P_i, W_i, H_i, E_i, EE_i) = \alpha_1 P_i + \alpha_2 W_i + \alpha_3 H_i + \alpha_4 E_i + \alpha_5 EE_i \quad (1)$$

The zone identification is similar to the "transport analysing zones" (Ortuzar, 1994). The analysing zone is a continuum space occupied or planned to have the same type of residential activity (the same characteristics of the buildings, e.g. the same number of flours and the same building density in space). The simplest intuitive observation is that: a zone having only villas with three floors will produce a lower volume of waste and unnecessary materials comparing to the same space area occupied by very high blocks with more then 10 floors (up to now in Romanian real estate industry there are no very high buildings).

The zones' separation is the responsibility of the Planning Department at local or central Public Authority, and this is already made in the PUG (General Urban Plan).

In the regression model (Eqn.1), the coefficients α_i have to be estimated from sample data. It is widely recognised that both procedure and registration instruments used to collect information on field have a direct and profound influence on the results derived from any data collection effort.

A future research for the data collecting process fundaments is required. The same type of population, having the same characteristics and habits related to the dispensing of undesired products, has to be found in a previous stage of the data collecting process. Moreover, a provisional work on the individual behavioural changes related to the environmental care, has to be also included.

The zone's *centroid* and its two spatial coordinates (relative latitude and longitude) is the formal representation of a certain zone *i*, named Z_i, in a city outskirts space $S = \{Z_1 \cup Z_2 \cup ... \cup Z_n\}$, with *n* zones. The entire generation potential is concentrated in the zone centroid as a hypothetic point in space. The zone centroid is determined as the centre of the area (e.g. the regular quadrilateral has the centre of the area located right on its diagonals' intersection).

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In figure 2, there is a schematic representation of the analysed space *S* with its separated zones, Z_i and each zone centroids, C_{Zi}, and their relative coordinates, (x_{Zi}, y_{Zi}). The symbol of the zone centroid is a small triangle.

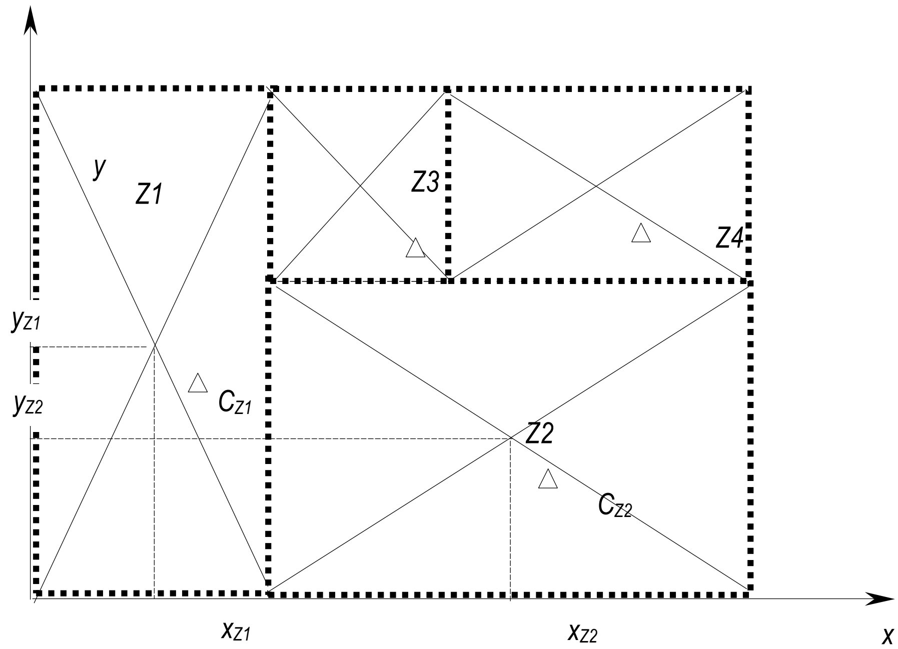

FIGURE 2: THE FORMAL REPRESENTATION OF THE SPACE, *S* AND ITS RESIDENTIAL ZONES, IN A RELATIVE SYSTEM OF COORDINATES (*X*,*Y*) (POPA, 2008)

The smaller zones are considered, the better modelling of the average distance between households and the nearest CRC location is. Moreover, the smaller zones are considered, the better accuracy is, in order to find the proper location of the CRC.

In case that the four zones (Fig.2) with different generation potential, G_i, are aggregated into a single zone, there will be expected errors related to the values aggregation and also to the accepted travelled distance modelling.

The detailed streets network is necessary for the accurately walking distance modelling purpose.

3.2. Hierarchical structure of CRCs' locations

For the beginning stage of the planning process for the new settlement development into the city outskirts we propose to use a normative model of the locations with a hierarchical structure (Lösh, 1938; Christaller, 1933). According to the model of the "central location", the CRCs are located in the vertices of the hexagon, and the higher level vertex is located just in the centre of the structured hexagon (Fig.3).

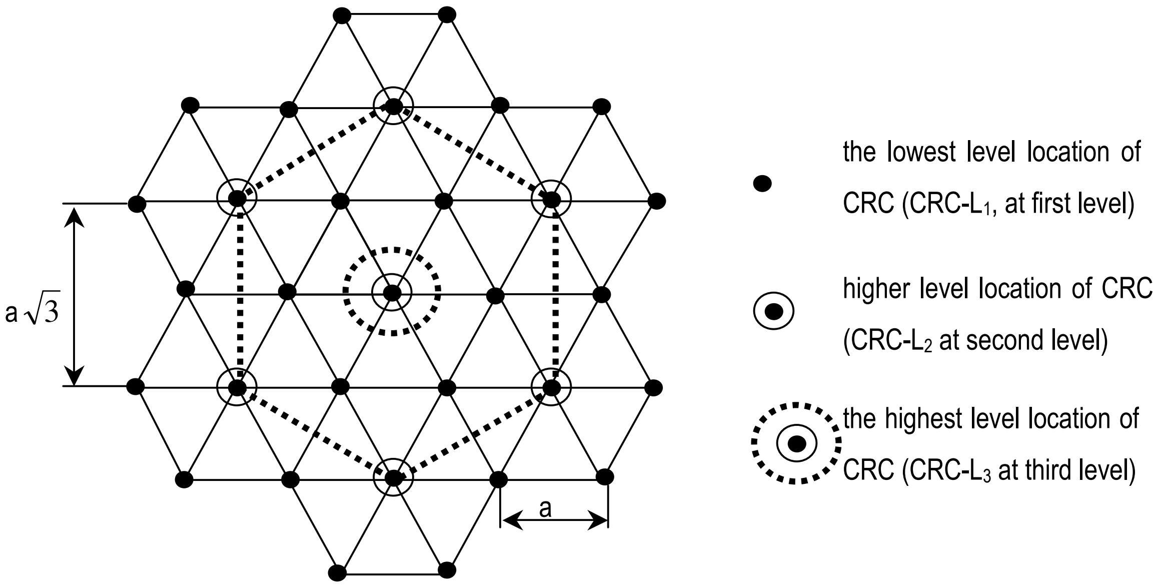

FIGURE 3: THE HEXAGONS' STRUCTURE WITH THREE HIERARCHICAL LEVELS (CHRISTALLER, 1933).

At the lowest level, CRC-L_1 applies to the recovery products used with highest frequency. These undesired products are different from waste (garbage) which is disposed/recovered through other processes. We refer here to the paper, packages, clothes, shoes, lingerie, clothes' accessories, etc.

The CRCs-L_1 locations are determined by the longest accepted walking distance for the average age individual, carrying an average weight. This distance is a/2, represented on figure 3. The CRCs- L_1 may be associated in a simple way to the forward distribution centres (e.g. small shops in the neighbourhoods) and they have only sort and grouping spaces and facilities.

At the second level, there is CRC-L_2 with additional functions (besides CRCs-L_1 functions) provided by the special equipments for disassembly, testing, packaging, etc. They have transport facilities for the periodic transfer in a logistic chain toward the next level CRC or towards the special outside manufacturing centre.

At CRC-L_3 may associate commercial function for the new products but also distribution function of the remanufactured products. Here in CRC-L_3, there are also lower level centres' functions and higher capacity transport (e.g. for furniture recovery). In case of the CRC-L_2, there is a good communication

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network to facilitate the population ordering (by e-mail or telephone). This highest level centre may have associated some social or religious organisations activities.

Starting from the base element, a/2, that is the walking distance from the residential location to the nearest and lowest level centre, the entire hierarchical structure is quite easily designed.

The walking distance a/2 is defined by the willingness to walk a distance within a time budget, on a certain streets network with walk sides. It is estimated taking into account:

- the average time budget for an average individual (with already described characteristics: high and very high income and wealth, high education, environmental education in favour of sustainable development etc.);
- the willingness to walk or to drive within this time budget;
- the generation potential of the recovery products, G_i.

The future research for a/2 length determination is necessary.

4. Conclusions

The paper presents a framework for the planning fundament of the new residential settlements into the cities outskirts with a sustainable development approach.

For a successful reverse logistics process, we propose a space allocation model with hierarchical structure of the centralised recovery centres. The recovery centres locations depend on:

- generation potential for the recovery products,
- inhabitants characteristics,
- “moral” incentives for recovery process induced into the wealthy population,
- streets network structure,
- transport and other reverse logistics facilities at recovery centres,
- information flows in the reverse logistics system,
- involvement of the local Public Authority and, community members.

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