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WIM project: wood flow analysis in Heyvaert district

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Abstract. Wood is a natural material, largely used in the construction sector and for a number of daily life uses to make furniture or tools. Its stock is concentrated in urban area where are the majority of population and human activities [1]. In Brussels, wood represents the third important material used in construction sector [2]. Wood presents diverse circular advantages as a removable assembly, diversity and ease of use. Wood in Molenbeek” (WIM) project (2017-2020) is a multi-disciplinary research project in Molenbeek’s district (Heyvaert) where social and environmental issues are encountered. The aim of the project is to perform a wood material outflow and stock analysis and to assess if a local wood valorisation can be a circular solution in the regional waste management and the resilience of the district. This wood valorisation model is created with the inhabitants. Consequently, the model evolves with their remarks and ideas. The quantification is realized with a bottom-up approach to present more accurate information than regional data. Indeed, local quantification illustrates some invisible flows by using census, observations, discussions with inhabitants, social and economic actors. The bottom-up approach gives the opportunity to work with local actors to build a “circular” network in a district.

Keywords: Urban Metabolism, Material Flow Analysis, wood waste, co-create, circular economy.



1. Introduction

Urban areas concentrate population and human activities on a relatively small delimited zones. Through their urban activities, inhabitants, companies and industries consume vast amounts of materials and resources (inflows), generate equally important waste flows (outflows) and embed materials in urban material stocks (stock) [3]. In fact, urban population is responsible for more than 80% global material use while, in 2017 (only) 55% of the population lives in urban areas. The share of material use linked with urban areas could be even higher as 77% of the total population in Europe and 98% in Belgium, respectively, is urban [1]. The sociometabolic transition of urban systems from an ‘agrarian’ to ‘industrialized’ state is the driver of their overwhelming use of resource [4, 5]. Nevertheless, the rate and share of their consumption is highly problematic from environmental, economic and social viewpoints as they generate challenges on supply chains, material criticality, pollution, waste management, environmental injustice, etc. These challenges are even more pressing as 80 % of materials used in the economy (construction minerals, ores/industrial minerals and fossil energy carriers) are not renewable [6].

On the opposite side of the material spectrum, global municipal solid waste is estimated at 1,3 billion tons per year and is forecasted to reach 2,2 billion tons per year by 2025 [7]. In Europe (EU28), waste generation by economic activities and households represent 2 502,9 million tons, where construction and households activities are responsible for 34,7% and 8,3%, respectively [8]. These percentages are 40,2% and 8,6% for Belgium [8].

On a more local level, the measurement of material inflows and outflows is carried out by urban metabolism studies or urban material flow analyses. Brussels Capital Region performed an urban metabolism study in 2015 and its material inflows, outflows and stocks were estimated at 8 932 kt, 8 082 kt and 184 922 kt, respectively for the year 2011. The material stock is composed of 3500 kt metal, 1400 kt of plastic, 1100 kt of wood products and the rest of inert material (179 000 kt) [9]. In 2017, a new quantification of Brussels’ building material stock [2] (based on the three most common building typologies) was made, accounting the latter at 92 000 kt. Inert materials are the main components (74 000 kt), metal comes second (7500kt) and wood stock, third (3900 kt) [2]. As wood is the only renewable material in the building stock it is of high interest in a context of circular economy, especially as currently about a quarter of identified European waste wood (30 million tons per year) is either not recycled at all or has low value use [10]. Nevertheless, before developing more thorough circular economy strategies around this material, it is necessary to provide more detailed insights about the quality, quantity, composition and location of wood in Brussels stock.

WIM action-research project was developed to provide a more localized approach to the management of material flow. It was based on the observations that the Heyvaert district (see next section) generates an important amount of wood waste and that the current regional waste management is not in phase with inhabitants and the other users of the district. As in most cases, the current waste management is centralized and does not consider the specificities and needs of districts. As such, WIM project aimed to develop a local and decentralized solution for the reuse and/or recycling of local wood waste. The research part of the project takes into account different quantifications of the local material stock and flows but also all identifies the obstacles for reusing them more locally. The latter can be social (i.e. inhabitants do not want to reuse or work the wood), technical (i.e. wasted wood quality is too poor to be reused), economic, etc. The main objective of WIM is therefore to experiment and bridge the regional circular ambitions of Brussels Capital region, with local and place-based challenges through flows and stocks accounting models.

1.1. Heyvaert District and Social-economic context

The Heyvaert neighbourhood of Brussels in Molenbeek-Saint-Jean owes its name to its main street, the Heyvaert street, which covers the neighbourhood from north to south. This socially and economically insecure district situated nearby the city center runs over approximately 41 hectares where, in 2017, 5136 people lived [11]. It covers the area between the Anderlecht slaughterhouses (South), The Porte

de Ninove (North), the Canal of Charleroi (West) and Mons' causeway (East) (area defined by 'Industrie', 'Rosée ouest' and Rosée est' statistical sectors). This district is mostly known as the place of the Euro-African second-hand car exportation business [12]. Heyvaert is also home to a large population of migrants, undocumented people and foreign-born individuals [13]. These individuals are choosing to live in the area as it is one of the cheapest neighbourhoods of the capital due to poor living conditions, including bad housing, disturbance caused by the car exportation business, little greenery, and clandestine waste disposal. Heyvaert district is a mix of large city blocks inherited from the industrial era with industrial buildings, traditional houses, residential buildings and parkings dedicated to the second-hand car exportation business.

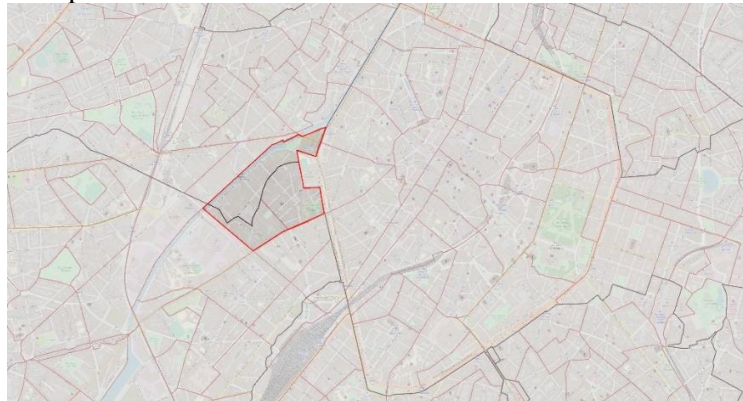


Figure 1. Localisation of Heyvaert district and its statistical sectors. Basemap from [Openstreetmap]. Source: authors and the 'monitoring of districts'[11]

In Heyvaert, most citizens share the impression to live in a “garbage neighbourhood”. At the beginning of the project, the most outspoken inhabitants of Heyvaert told that clandestine wastes were being produced by “outsiders”. According to them, these people who did not live in the neighbourhood would come to Heyvaert and dispose of their waste illegally. Because of the nature and the quantity of waste on the streets, the reasoning is not enough to explain the abundance of furniture left behind. Nevertheless, the perception of waste produced by “outsiders” illustrates the tension between residents and non-residents in Heyvaert. The abundance of waste found in Heyvaert can also be explained by the lack of awareness of the current waste legislation, the lack of means to dispose of their waste as well as the frequent moves of inhabitants. In addition, the frequent moves of people do not allow the inhabitant to develop a sense of community or of belonging. As a result, most of the residents are not really attached to the neighbourhood and the district is not being taken care of by its population.

1.2. State of the Art

Since the late 1990's, research has developed a number of accounting of urban flows and stock methodologies that are grouped under the umbrella term of urban metabolism. The term 'metabolism' is based on an analogy of cities with organisms' metabolisms in terms of resource consumption and excretion of waste. The quantification of flows and stock is an essential element to better manage resource and waste management in cities. These assessments are based on different purposes and focuses often depending on available data and possible assumptions [14]. An important review of the methodological approaches on material stock analysis was done by Augiseau et al. [14]. Augiseau divides studies into 4 groups according to purposes [14]:

1. 'Forecasting and comparing future input and output flows';
2. 'Estimating the present stock to identify the characteristics of anthropogenic stock in term of material composition';
3. 'Estimating the future stock composition to forecast the evolution of anthropogenic stock';
4. Studying urban metabolism, including flows of construction materials.

The studies are also characterized by four parameters: spatial scales, times scales, materials and dissipatives [14]. All the presented researches are minimum at the scale of a city (i.e. Vienna) and often during few years. To reach research goals, six methodological approaches are identified [14]: static bottom-up flow analysis, static top-down analysis, bottom-up stock analysis, dynamic retrospective or prospective flow analysis using a flow-driven model, Dynamic retrospective or prospective flow analysis using a stock-driven model, Top-down retrospective or prospective stock analysis using a flow-driven model [14].

In addition to purpose, this identification is based on two other parameters. Firstly, the quantification can be the result of a static or a dynamic model. For this latter, a distinction is done between a study using flows to define the stock and the opposite [14]. The second concept is to know if the quantification uses a bottom-up or top-down approach. This definition is no direct link with the space scale. Bottom-Up approach work on processes of material use to enable precise actions to take while Top-Down working with large scale data as Eurostat to propose an overview [14]. The approaches present different advantages and weaknesses and according to the purpose, an approach can be more relevant than another. Bottom-up approach resolves the problem of the ‘black-box’ of the top-down approach but often requires more accurate data. The accuracy of the data can be the main danger of this approach because the data is already the result of an aggregation of information from different sources.

WIM project presents an original proposition with a small spatial scale and no available data on wood. The main mission of its quantification is to construct a model from observations and surveys. Because of the temporal and spatial boundaries (cities of ten thousand inhabitants), the study on Saxon cities [15] presents some interesting similarities with the WIM project. A typology approach (bottom-up) is used to develop a material flow analysis for buildings, infrastructure, and the urban structure [15]. Typologies are used to describe different urban structural types (UST). He attributes parameters to the different UST for studied elements (i.e. population density or length of technical network). These parameters are based on empirical and statistical data. The result is a model representing stock and flows for an urban fabric [15]. This bottom-up approach proposes to decompose the heterogeneity of a city to a set of different homogeneous units. This decomposition helps the understanding of flows and then, the final aggregated representation enables to have an overview on the situation.[15].

In Brussels, a bottom-up material stock analysis for the very common building typologies defines that 3900 kt of wood [2] are stocked in the typologies while a previous top-down material flow analysis give the result of 1100kt [9] for the whole wood stock. This underestimation was announced by this research and largely depends on the top-down approach working on regional, national or European data [9]. The pragmatic proposition of WIM project is to start from scratch at the smaller urban spatial scale to identify wood stock and outflow of a neighbourhood.

1.3. Aim and scope

The aim of this paper is to present a bottom-up approach which quantifies flows and stock of wood from different origins for a defined area. This approach is used to quantify wood for the WIM project in Brussels’ district of Heyvaert in order to guide this project in improving upcycling and reusing this material locally. In this paper, the wood flow analysis only considers: 1) a part of households/users outflows (wood in bulky items) and stock for furniture, 2) stocks as well as outflows from the construction sector, 3) outflows for tertiary sector. It does not take into account the technical and transport infrastructures, logistic sector (partially in bulky items), dissipative flows (partially in bulky items) and inflows [16]. Another specificity of this research is that some quantifications were done in collaboration with inhabitants which can explain some simplifications and rougher estimations.

1.4. Structure

Section 2 first describes the proposed bottom-up approach including data requirements, quantification methods. Section 3 presents results and the limitations of the case study. Section 4 concludes the paper.

2. Bottom-up Approach and Heyvaert district modelisation

The aim is to analyse the stock and the outflows of wood waste in the Heyvaert district for further potential reuse. The wood products are divided into material categories: construction elements and furniture. ‘Furniture’ is used to represent all non-construction products such as furniture, various everyday tools (i.e. broom, kitchen tools). As presented above, logistic products are not taken into account. In a theoretical city, by a top-down approach, the quantification could be done with data from the two products groups but in Heyvaert district, these categories are subdivided and mixed. For example, it is usual to see construction products and furniture mixed in the bulky items on street or in the containers of construction site. Hence, bottom-up approach seems to be the more accurate approach to quantify at small scale. Because the wood can be used on large sample of products and shapes, the quantification of wood must take into account various parameters.

These processes are identified as the construction, economic activities, the consumption (inhabitants and district users) and the interaction between the processes. The figure 2 illustrates the processes of wood use in the metabolism of Heyvaert district. There are three local actors (inhabitants, construction and economical activities) and one supra-local actor (logistic). This actor carries the in- and outflows for construction and economical activities. For the inhabitant, it is not presented because of a too large uncertainty on the origin and destination of the products of inhabitants. WIM project is an additional actor who tries to impact the management of waste in the district. The bulky items can be seen as a part of the dissipative flow of material from four sectors (inhabitant/users, construction, economic activities and logistic). Because of the lack of data at this scale and the goal of co-creation with inhabitant, the research is based on surveys and observations apart from construction stock which uses the methodology developed by Stephan and Athanassiadis [17, 18]. Accurate data were available for construction sites enabling to propose a model using typologies similar to Deilmann’s approach [15, 19]. In addition to the quantity of flows, qualitative criteria are added to determine how much of these flows were truly available for reuse.

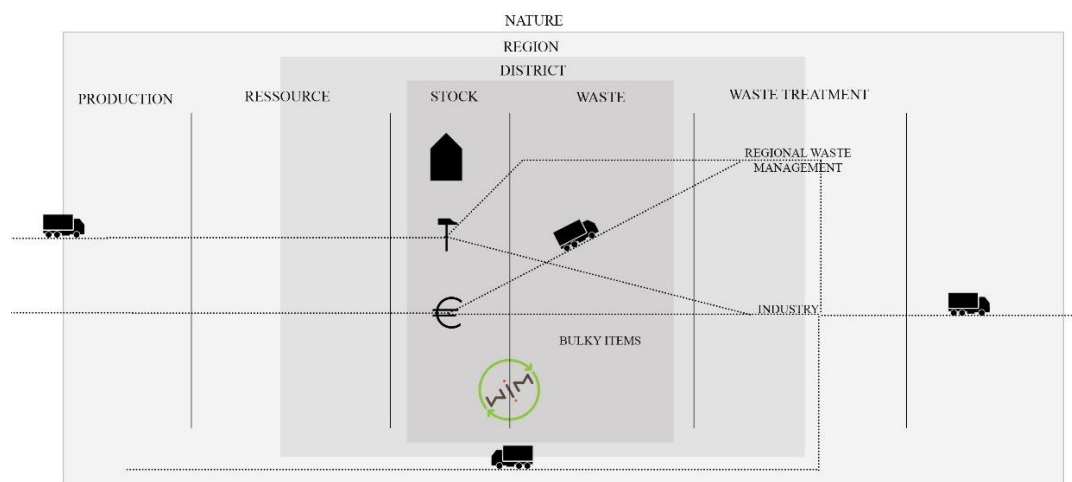


Figure 2. The processes of wood use in the metabolism of Heyvaert district with the different sectors (inhabitants, construction and economical activities and logistic) (source: authors)

2.1. Bulky items

The wood bulky items quantification is the genesis of the WIM project with the vision to reuse and upcycle wood from neighbourhood’s waste with the different actors and specially the precarious population to create a resilient neighbourhood. The method is to establish a routine. Every week, a trip is done in the district (0,399 km²) following the same tour (4,5km). The wood waste is pictured with geo-tracking and encoded in a questionnaire. This questionnaire has to define the type of products, its

location, its origin and its quality. The wood products categories are: pallets, furniture, doors, structural elements and panels. Subcategories are also defined but are not developed in this article. For example, the subcategories of panel are: massive, glulam, multiplex, OSB, MDF, chipboard, alveolar, other.

The quality parameters are defined to organize the collection in the neighbourhood. Interesting parameters exist to evaluate the quality of wood waste as : particle size, particle shape, bulk density, moisture content, net calorific value, mechanical impurities, ash content, colour wood species and chemical parameters[10]. These parameters are complicate to evaluate on site and are not all relevant because the first goal is to reuse wood. WIM project forces to simplify the tools and to define criteria that are essential to define management decisions for the stock. WIM promotes the reuse and upcycling by a local action and then, regional downcycling deals with wood waste that WIM does not use. In this case, WIM reduces the analysis of the stock to 5 criteria:

1. general condition: visual evaluation with a grade between 1 (bad) and 3 (perfect/new) to define whether the object respects some conditions such as flatness, moisture, presence of knocks.
2. Size: dimension for panels, structural elements and doors; 1 to 3 for the furniture.
3. Surface treatment/coating.
4. Quantity: number is important in the reuse of specific objects (i.e. moulding or table strand)
5. 'Ready to use?': It is to analyse what it is necessary to do to have new material. Hence, if it is not.
6. possible to repair, majority of the objects have to be dismantled, remove mechanical impurities, clean pieces or plane to obtain new clean flat material without impurities.

In addition, the origin is defined by two parameters: kind of product (furniture, construction or logistic) and sector (inhabitant, street, construction and economical activities).

2.2. *Workshop register*

This register is not an additional study but the quantification of inflow of wood products in the WIM workshop to measure environmental impact. The wood products brought by users are compared to the outflow of WIM workshop to identify imbalance of quantity, disinterests of some products.

3. Results & Discussion

3.1. *Construction stock and flows*

One construction project is quantified. The wood stock established on the base of the presumed quantities of a building of 129 housing and a kindergarten in construction. The future wood stock represents more than 200 tons. A contact is taken to obtain the final quantities, the outflows and maybe some technical sheets to improve the assumptions on dimensions, bulk density and other parameters. The first analysis indicates that some specifications can have large impact. For example, a fire safety door, composed of chipboard (tubular or not), is more than twice heavier than a standard door (alveolar) and does not present the same potential of reuse and recycling.

This kind of research based on requirements specification and quantity monitoring presents great interests and advantages because national and regional organizations work on standard documents since 2014 for building and 1999 for transport infrastructure. These requirements specification and quantity monitoring are in constant evolution, but the structure of the documents is approximately the same. Hence, it is possible to propose a standardization in the quantification of material that could be the first step of the circular management of the construction project. Indeed, the circular management will have to fight the current cyclical behaviour of construction and demolition [15].

3.2. *Bulky items*

Currently, 10 tours have been done in Heyvaert district. The first observation is that the wood waste is visible. It is not hidden but placed next to trees with the other trashes, along inhabited buildings or construction site. 193 observations of wood products are done with 408 wood products for a total of 4 tons. The main part of waste is furniture or dismantled furniture in panels. The furniture in waste are

principally composed of chipboard panel. Indeed, the majority of trashed furniture is recent furniture of which the lifespan is probably low. More than 2 tons in 2,5 months are chipboard panels. These panels are assumed to originate from inhabitants which would mean that during a year, more than 10 tons are thrown by inhabitants and this would represent 5kg per capita. The preponderance of chipboard panels forces a strategic reflection while, in addition, the percentage of recovered wood for particleboard can vary in Europe from 10% (Poland) to 89% In Italy, 10 to 30% of the total global timber trade is illegal and particleboard is technique to complicate or make impossible the traceability [10, 20].

Another important information is the presence of logistic products and especially pallets. 71 pallets are found trashed but there are much more in the shops or on construction site. 71 pallets represent 600kg which are directly linked to logistic activity and indirectly to economic activities and construction. Logistic is assumed as a specific sector depending on its own rules. These rules are never far from the optimisation of space and price. Hence, wood is used but cardboard or plastic pallet exist and could change the vision of this sector. Finally, the undefined wood waste also represents a large part which is difficult to estimate. The evaluation is done by a direct transcription from visual observation to quantity (kg). These waste flows are mainly along construction site and are mixed together.

3.3. Workshop Register

As presented in the figure 2, WIM is developed to create an addition actor between different local sectors and the regional waste management. Because of the social approach of this project, the terminology is important and the use of the word 'waste' is very limited. Hence, WIM interacts with the different actors before resources/stock (positive vision) becomes a waste (negative vision) and only few cases when wood products are unusable for the workshop, the word 'waste' can be used. At this moment, wood is a local waste but it could be a resource in the regional management. A part of it is recycled in particle boards and normally the rest is used in energy production.

WIM workshop develops the reuse. At its maximum capacity, 10 users and 2 carpenters work. This capacity and the desired quality of carpentry defines the current limits of the results. In the same time scale than bulky items observations, 859 kg were collected in WIM. 280kg are from bulky items, 401 kg from construction site, 54 from shops and 124 from inhabitants/users. This quantity is not limited due to the quality of wood but to the storage limitation and the limits of the current workshop production. At this stage, the current collecting results cannot yet be used to extrapolate policies but illustrates that in its current organization, WIM cannot propose to manage locally all (wood) waste flows of the district. New experiments are developed to present WIM not only as a workshop but also as a 'second-hand seller and an operator to link the different sectors. For example, an experiment to connect a deconstruction site with timbers and inhabitant searching material to build a mezzanine. This experiment was a success because contractor deconstructs timbers in large length and the inhabitant accept to take time to refresh elements (nails, screws, sanding...).

4. Conclusion

The quantification is in progress, but the first results illustrate that wood is already present at local scale while only wood from bulky items could represent 20 tons per year for a district of 5136 inhabitants. Local management can enable and endorse upcycling and reuse as local actions limit all logistics from the regional waste collection and management company and maintain a better quality of the collected wood. This is encouraging but the results also illustrate the waste challenge while waste from households represents only 8,6% and construction site 40% [8]. Therefore, local actions and management can improve upcycling and reuse in the regional management but are not enough to replace it. The waste minimization can also be a result of local actions as awareness campaign or local policies.

New policies (local, regional or national) are significant to develop a more circular district as Heyvaert. Indeed, Heyvaert is in development with an urban mutation from an industrial district to new neighbourhood with new housing projects (social or not), facilities (nursery, school) and parks. All these changes complicate to forecast the future material flows and stocks, but urban permits could be a way to illustrate the evolution. This new housing will increase the number of inhabitants but also the

furniture stock and flows. A decoupling is necessary between the needs in urban development and material consumption to develop the future circular cities.

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