Improving the sustainability assessment method SBTool Urban – A critical review of construction and demolition waste (CDW) indicator

G Kamino¹, S Gomes² and L Bragança³
University of Minho, Department of Civil Engineering, Campus de Azurém, Guimarães 4800-048, Portugal

¹gustavokamino@gmail.com, ²gomesstefano@gmail.com, ³braganca@civil.uminho.pt

Abstract. Construction and demolition waste (CDW) are one of the biggest issues in waste generation that cities must deal. In EU, about 25% to 30% of all waste are derived from activities linked to construction and demolition. Such materials like concrete, bricks, wood, glass, metals, plastic and others, have high potential to be recycled or even reused in the process of urbanization. According to the Waste Framework Directive (2008/98/EC), by the year of 2020, a minimum of 70% (by weight) of CDW must be prepared for reuse, recycled or undergo other material recovery. Additionally, in Portugal, there is the Decree-Law nº 46/2008 that regulates the operations of CDW management, by prevention and re-utilization, and the process of collection, transport, storage, treatment, recovery, and disposal. Despite this, the level of CDW reuse varies greatly across the country. The SBTool-PT Urban Planning is an adaptation of the SBTool - international method of sustainability assessment - for use in urban projects into the Portuguese context. The methodology is divided into 3 dimensions (environmental, social and economic), each of then subdivided into categories (14 total) that have their own indicators. One of these indicators is called CDW, and it is related to how much of it is re-used and how it is treated. This study focuses on this indicator, reviewing his process of measurement and calculation, by comparing it with the existing rules, and others assessment methodologies. The findings of this study will validate its calculation process and indicate future developments.

Keywords: CDW, sustainability, assessment, urban, waste, indicator.

1. Introduction
Waste production is a common characteristic among most human activities. The construction industry is one of the top waste generators of the world. According to Eurostat 2015 [1], construction and demolition activities produceD in Europe 820 million tons (Mg) of waste, corresponding to about 35% of all waste generated.
The construction and demolition waste (CDW) are derived from construction, refurbishment or demolition, of any kind of building, roads or public spaces. It contains different kinds of materials, most of them inert and non-hazardous, but also non-inert and hazardous waste. On average, up to 85% of CDW is concrete, ceramics, and masonry, which can be easily reused as an inert material [2].

Although most of the CDW are inert materials, it is characterized by its high volume and weight, thus having a significant environmental impact due to logistics and land occupation.

Regarding CDW reuse, on 2008, the European Commission through the Waste Framework Directive (WFD) 2008/98/EC [3] proposed that by the year of 2020, the preparing for reuse, recycling and backfilling of non-hazardous construction and demolition waste shall be increased to a minimum of 70% by weight. Subsequent, the Portuguese Government approved a series of legislation regarding the CDW use and management in line with the WFD. This resulted in an early achievement of the 70% target projected for 2020, as seen in figure 1.

According to recent studies [4], one of the key best practices/instruments is the adoption of sustainability assessment methods that can measure the level of sustainability of CDW management operations. This paper has the objective of review the SBTool Urban CDW indicator, by reviewing the legislation, comparing it to other sustainability assessment methods and indicate future development.

![Figure 1. CDW treated – Country performance - Eurostat 2014](1)

2. Legal Framework and Policy

Published on 2008, the decree-law 46/2008 of 12 March [5], establishes the legal framework of CDW management, including prevention, reuse, and the operations of collection, transport, storage, treatment, recovery, and disposal. Its main goal is to create legal conditions for the proper management of CDW, focusing on the prevention of risky waste generation, separating at the source, recycling and other forms of recovery, in consideration of reducing the use of natural resources and minimizing landfilling.

The main points [6] of the decree-law 46/2008 are the following:

- The responsibility to manage CDW belongs to the producer (article 3).
- Uncontaminated soils and rocks must be used at the construction site or another site (article 6).
- Incorporation of recycled CDW at construction works must comply with national or Eu standards (article 7).
- CDW which cannot be reused has to be sorted at the construction site (for reuse or recycle) or delivered to a licensed waste operator (article 8).
- CDW landfilling is only possible after sorting and its subject to taxation (article 21).
- Creation of innovative mechanisms in planning (articles 10 and 11).
- Permit exception for certain CDW management operations (article 13).
- Information duty through an electronic platform (SIRAPA) (article 15).
Other legislation and policy were published following the decree-law 46/2008, regarding CDW management. On table 1, it is shown these legislations and its main objectives.

Table 1. Key CDW Legislation and policy

| Legislation | Objective |
|-------------|-----------|
| Decree-Law 46/2008 [5] | Establishes the legal framework for waste management resulting from construction works or demolition of buildings or collapses. |
| Decree-Law 18/2008 [7] | Establishes the elaboration and implementation of a CDW prevention and management plan of all public construction works. |
| Decree-Law 73/2011 [8] | Defines CDW and introduces the target of incorporating at least 5% of recycled materials or materials containing recycled components. |
| Decree-Law 26/2010 [9] | Obliges the CDW holder from private construction works (with mandatory permit) to keep a record on CDW generated. |
| Ordinance 417/2008 [10] | Defines the documentation which certifies CDW transport and reception at private waste management facilities. |
| Ordinance 40/2014 [11] | Criteria for the inventory of materials containing asbestos and their characterization, in the design phase. |
| National Waste Management Plan for 2014-2020 [12] | Includes the national Waste Prevention Strategy. In this plan, is included a general description of CDW and the target set to the WFD. |

3. SBTool Urban

The SBTool Urban is a methodology for sustainability assessment of urban areas on the Portuguese context, applicable on existing or not urban areas, based on the SBTool PT-PU [13], focused on the sustainability evaluation of urban planning operations.

The fundamental guidelines of the SBTool Urban methodology are [14]:

1. Improve the space organization for the urban tissue consolidation;
2. Promote the environmental quality of the urban area;
3. Improve the quality of life of urban inhabitants;
4. Instigate the economic competitiveness on the territory;
5. Promote the urban sustainability and its assessment.

The methodology is applicable to the planning of new urban areas, as well as to the evaluation of existing areas, and to the planning of interventions in urban areas aiming at their requalification or regeneration. The adoption of SBTool Urban in the project phase stands out by establishing strategic guidelines that are useful for the planning and implementation of measures that make urban areas more sustainable.

The structure of the assessment and certification system is organized according to the three dimensions of sustainable development - environmental, social and economic - each of which is called a group of corresponding categories and indicators [15]. In total there are 12 categories, with 39 sustainability indicators, and 49 evaluation parameters. For each category and indicator, relative weights were assigned through a quasi-objective method, designed to find a balance between usability and scientific correction. Table 2 identifies the dimensions, categories, and indicators used in the SBTool Urban methodology.

3.1. Construction and Demolition Waste Indicator (CDW)

The CDW indicator has the objective to promote the CDW reuse on site, reducing the use of virgin materials and its impacts of extraction, transport, and disposal. Otherwise, it also intends to promote the CDW reclaiming when onsite reuse isn’t possible.
Table 2. SBTool Urban Methodology – Dimensions, Categories, and Indicators

| DIMENSION        | CATEGORY                           | INDICATOR                                      |
|------------------|------------------------------------|------------------------------------------------|
| Environmental    | C1. Urban Design                    | I1. Passive Solar Planning                      |
|                  |                                    | I2. Ventilation Potential                       |
|                  |                                    | I3. Urban Network                               |
|                  | C2. Use of Land and Infrastructure  | I4. Land Natural Aptitude                       |
|                  |                                    | I5. Density and Flexibility of Uses            |
|                  |                                    | I6. Urban Land Reuse                            |
|                  |                                    | I7. Built Heritage Revitalization               |
|                  |                                    | I8. Technical Infrastructure Network            |
|                  | C3. Ecology and Biodiversity        | I9. Green Spaces Distribution                   |
|                  |                                    | I10. Green Spaces Connectivity                  |
|                  |                                    | I11. Autochthone Vegetation                     |
|                  |                                    | I12. Environmental Governance                  |
|                  | C4. Energy                          | I13. Energy Efficiency                          |
|                  |                                    | I14. Renewable Energy                           |
|                  |                                    | I15. Centralized Energy Management              |
|                  | C5. Water                           | I16. Potable Water Consume                      |
|                  |                                    | I17. Centralized Water Management               |
|                  |                                    | I18. Effluent Management                        |
|                  | C6. Materials and Waste             | I19. Material’s Impact                          |
|                  |                                    | I20. Construction and Demolition Waste          |
|                  |                                    | I21. Urban Soil Waste Management                |
| Social           | C7. Exterior Comfort                | I22. Air Quality                                |
|                  |                                    | I23. Exterior Thermal Comfort                   |
|                  |                                    | I24. Noise Pollution                            |
|                  |                                    | I25. Light Pollution                            |
|                  | C8. Safety                          | I26. Safety in the Streets                      |
|                  |                                    | I27. Technological and Natural Risks            |
|                  | C9. Amenities                       | I28. Service Proximity                          |
|                  |                                    | I29. Leisure Equipment                          |
|                  |                                    | I30. Local Food Production                      |
|                  | C10. Mobility                       | I31. Public Transportation                      |
|                  |                                    | I32. Pedestrian Accessibility                   |
|                  |                                    | I33. Cycling Network                            |
|                  | C11. Local and Cultural Identity    | I34. Public Spaces                              |
|                  |                                    | I35. Heritage Enhancement                       |
|                  |                                    | I36. Social Inclusion and Integration           |
| Economic         | C12. Employment and Economic        | I37. Economic Viability                         |
|                  | Development                         | I38. Local Economy                              |
|                  |                                    | I39. Employment                                 |

The calculation process of this indicator is done by combining two values. The first is the percentage of incorporation of recycled inert materials on public space materials, which is calculated dividing the weight of recycled or reused inert materials incorporated on public spaces, by the total of inert material in public spaces. Them, the percentage is normalized considering 75% the best practice and 25% the usual practice.

The second is a verification list concerning the produced CDW destination and the used CDW origin, as seen on table 3. The score on this list is totalized and normalized, considering 25 credits the best practice, and 5 credits the usual practice.

These two values are combined in the proportion of 60% of the percentage of incorporation of recycled inert materials, and 40% of the CDW management verification list. The result is presented on a scale of level A+ to E, according to the table 4.
Table 3. SBTool Urban – CDW management verification list

| Item | Requirement | Credits |
|------|-------------|---------|
| 1.   | Destination (max. 80km) of CDW produced and not used on-site (choose one option): | |
| 1.1  | Collection, separation and targeting of 10-49% of CDW produced at site for recovery (recycling or recycling) | 5 |
| 1.2  | Collection, separation and targeting of 50-89% of CDW produced at site for recovery (recycling or recycling) | 10 |
| 1.3  | Collection, separation and targeting of 90-100% of CDW produced at site for recovery (recycling or recycling) | 15 |
| 2.   | Origin of CDW used on-site (choose one option): | |
| 2.1  | CDW used originated on-site | 15 |
| 2.2  | CDW used from external origin, max 80km | 10 |

Table 4. CDW Indicator Evaluation

| Level | Rate   |
|-------|--------|
| A+    | \( G_{RCD} \geq 1,00 \) |
| A     | \( 0,70 \leq G_{RCD} \leq 1,00 \) |
| B     | \( 0,40 \leq G_{RCD} \leq 0,70 \) |
| C     | \( 0,10 \leq G_{RCD} \leq 0,40 \) |
| D     | \( 0,00 \leq G_{RCD} \leq 0,10 \) |
| E     | \( G_{RCD} \leq 0,00 \) |

4. Urban Assessment Methodologies and Comparison

In the worldwide context, several sustainability assessment tools are used to evaluate operations of urban planning and design. Although their different origins and calculation methods, these tools have a lot of common objectives, such as to promote the sustainable development regarding environmental, social and economic impacts; to quantify measures for determining sustainability levels and to support all kind of stakeholders on the decision-making process. Thus, by comparing different methodologies, it is possible to visualize each one strength and weaknesses points.

4.1. CDW on other urban assessment methodologies

To make the comparison, it was selected other three different urban sustainability assessment methodologies, the LEED-ND[16], developed on the United States by the US Green Building Council (USGBC), the BREEAM Communities [17], developed on United Kingdom by BRE Global and CASBEE for Urban Development[18], developed on Japan by Japan Sustainable Building Consortium (JSBC) and Japan Green Building Council (JaGBC).

Regarding the CDW management, all systems have indicators that are counted to score credits on the final evaluation. As seen on table 5, they have different approaches and priorities and may not separate CDW from others reused and recycled materials, so they cannot be considered CDW management exclusive indicators. This analysis contemplated the indicator that scores any kind of CDW reuse or recycle.

The corresponding LEED-ND CDW management indicator is called Recycled and Reused Infrastructure. According to the manual, its objective is to avoid and minimize the environmental impact of extracting and processing virgin materials. The only credit is given if at least 50% of the total mass of infrastructure materials are from recycled and reused contents. There is not an intermediate rate on this indicator.

On BREEAM Communities, the indicator Low Impact Materials are the one that considers CDW reuse and recycle. It is divided into two parts, the first called Sustainable Materials, that calculates the
use of low impact materials (specified according to its document Green Guide to Specification) on the public realm, and the second called Road Construction Materials, that considers the locally reclaimed or constituted from recycled materials incorporated on the road construction materials. Only the second part measured CDW reuse and recycle, and both parts have three credits, each corresponding to different percentages of material use.

CASPbee, the Japanese urban assessment method, has the least appropriate indicator that can be related to CDW reuse or recycle. Under the category of Resources Recycling, the indicator Recycled Material, verify the utilization of recycled materials in structural frame materials and non-structural materials. It is calculated by the number of items that have Japanese certification for low impact materials, thus, there is no specific points for CDW reuse or recycle.

| System         | Indicator                          | Parameters                                                                 | Score Method                                                                 |
|----------------|------------------------------------|-----------------------------------------------------------------------------|----------------------------------------------------------------------------|
| LEED-ND v4[16] | Recycled and Reused Infrastructure | At least 50% of the total mass of infrastructure materials should be from recycled content and on-site reused materials. | 1 credit if the requirement is completed.                                    |
| BREEAM 2012[17]| Low Impact materials               | Road construction materials should be at least 15% (by volume or weight) locally reclaimed or constituted from recycled material. | 1 credit for at least 15%, 2 credits for 25-30%, 3 credits for greater than 30%. |
| CASBEE [18]   | Resources Recycling                | The utilization status is evaluated, regarding the number of articles used. Recycled materials are evaluated, but there are no specific points for CDW re-use. It can be evaluated the utilization status for structural and non-structural uses. | 5 levels of utilization status. Level 1 for no recycled materials used, level 2 is not applicable, level 3 for one article, level 4 for two articles, level 5 for four or more articles. |
| SBTOOL Urban [14] | Construction and Demolition Waste | Percentage (weight) of reused or recycled inert materials incorporated in public space materials. CDW produced destination and CDW used origin. | 60% of the score given according to the percentage of inert reused or recycled incorporated in public space, being a maximum of 75% and a minimum of 25%. 40% of the score given according to a criteria list based on the origin and destination of CDW. |

4.2. SBTool Urban Comparison

The three assessment tools analyzed have specific issues that should be addressed. Regarding the CDW reuse and recycle specific calculation, LEED-ND considers CDW and other recycled content, BREEAM considers locally reclaimed CDW and others, and CASBEE considers all recycled materials with a specific certification. Therefore, none of them treats the CDW management as the main issue.

Towards the scoring, the three systems cannot be used to evaluate the CDW reuse and recycle individually. The verification system relies on credits that have a very wide range of results. LEED-ND just gives one credit, which can be understood as a yes/no indicator; BREEAM has three credits if only considered road construction, and CASBEE has five levels, but they don’t relate to the amount or proportion of CDW reused or recycled. From another perspective, as they don’t require a precise measure, they are easy and fast to calculate.

The SBTool Urban Construction and Demolition Waste indicator has a better coverage of CDW management characteristics than the other three systems. It considers not just the amount of CDW used on construction site, but also the destination of those produced, and the origin of those used but not
produced on-site. Use of other low impact materials has their own indicator, called Materials Impact, that is under the same category.

Despite the common objectives for the systems, the CDW indicator of SBTool Urban differs from others as it can be used as a standalone indicator to evaluate a CDW management operation. It results in a level rate from E to A+, considering the amount of inert reused or recycled, and CDW produced and used management. Therefore, compared to the others urban assessment methodologies, the SBTool Urban CDW indicator proved to comply with more requirements of a proper CDW management operation.

5. SBTool Urban CDW indicator critics

Although the SBTool Urban CDW indicator is more complete than its correspondents on other methodologies, there are some observations to do. The Waste Framework Directive (WFD) has set a target of 70% for CDW recovery by the year 2020 [19], and according to the last data [1] this number has already been reached. This CDW recovery ratio data isn’t used to obtain the SBTool Urban CDW indicator, because the percentage of inert reused or recycled incorporated in public space materials refers to materials from any origin. Therefore, a project may have a good level on this indicator, by using CDW from outside the construction site, and not achieve the 70% of CDW recovery. It’s understood that this can be a rare situation, but the amount of CDW produced on-site should also be considered, not just the amount used.

For future developments, it should be considered to stimulate the CDW recovery of different materials, by establishing targets of recovery by waste types. According to an evaluation of European recovery target for CDW [20], the practice of setting one target for all materials by a percentage of weight tends to benefit the recovery of the heaviest materials – such as mineral ones. This should be studied carefully, since this is to be used on an urban assessment methodology and it may complicate the calculation beyond its necessity.

6. Conclusion

CDW reuse and recycle are a reality and a necessity in the construction industry. Towards the improvement of the quality of the environment and reduce the extraction of virgin materials, it is imperative that governments and associations stimulate and regulate CDW management, reuse and recycle.

Subsequent the 2008 EU Waste Framework Directive, the Portuguese government established a series of legislation regarding waste management, treatment, recovery, and disposal. The decree-law 46/2008 is the main legislation that established the legal framework for waste management resulting from construction works or demolition of buildings. After that, other legislation and policy were adopted intending the regulation of the sector and stimulating new practices of CDW management, and even defining targets for incorporation of recycled materials.

There are several urban sustainability assessment methodologies that evaluate the reuse and recycle of CDW among their indicators. To compare with SBTool Urban CDW indicator, three other systems were analyzed, LEED-ND, BREEAM Communities, and CASBEE. They all have strong and weak points but cannot properly assess the CDW management by themselves. Their data are much simpler than that used by SBTool Urban, meanwhile, it is easier to calculate, it doesn’t consider aspects like CDW origin and destination. CASBEE, in special, has a classification method rather unorthodox, that counts the number of recycled articles, and don’t indicate CDW management operations.

The SBTool Urban CDW indicator proved to be an adequate calculation tool to assess the levels of CDW management, being part of a whole system or not, at the same time it is simple regarding its needs. It considers both the proportion of CDW used on urban space, the origin of them and the destination of CDW produced and not used. It is on par with the Portuguese legislation and helps to improve environmental sustainability to levels beyond it is required.
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