LSRM FINAL ASSIGNMENT *06/12/2018*
Rick Blankestijn - 4216962

Industrial Ecology as a Systematic Interdisciplinary Research Method

I INTRODUCTION

Architecture can be seen as the complex art of how we use space and how we give shape to the world around us. Research plays an important aspect in the process of well substantiated place making, as our built environment is influenced by how we understand the world, while how we understand the world is framed by that we have built there[1]. Or as mentioned by David Wang[2]: "research brings science to our art. To move the art of architecture forward, however, we need to supplement intuition with science." Architecture itself is a constantly developing body of knowledge, to which research is a systematic inquiry directed towards the creation and development of that knowledge. Being aware of the methodological approach used within this research helps the designer structure his thoughts within his process. In addition, it makes the outcome of his research more valuable and strengthens the proposition of the designer, as he is aware in what perspective the outcomes can be used[3].

The Lecture Series on Research Methods made me critically reflect on the usual research methodologies is used. I concluded that my research approaches were often intuitive and unconscious, making me realize that improving my awareness will give me more guidance within the design process. The lectures gave me more insight in what kind of research methodologies there are, so a conscious choice for what specific method to use at what time can be made, based on what reduced information I need, helping me to gain more relevant research results. At the same time, even though all research in some way can be considered to be reductionist to be able to reduce observations to chunks of information that are manageable[4], the reductionist character of some research methods was in slight contrast with the general approach of my graduation studio.

A common habit has developed within the field of architecture to separate knowledge into domains relating to a specific subdiscipline[5], but it is important to not distant ourselves from other fields, and avoid focusing on one particular aspect while other crucial information is put aside. It is fundamental to realize that disciplines rarely benefit from working in isolation, as different perspectives stimulate you to think differently about places[6]. Within the department of Architectural Engineering (AE), an integrated approach between technology and architecture is often brought to our attention, perfectly represented in the studio's name INTECTURE. Where other studios often approach their architectural assignments from a more solitary architectural humanities approach, concerning spatial, social and historical context, the AE graduation studio requests us to focus on a thematic technological research part parallel to our design research. The goal of this research is to develop background knowledge of a specific technical aspect related to the architectural assignment, which can be used as a starting point and be converted into architectural design tools.

My personal graduation studio is concerning the city of Bandung in Indonesia, which has to face a major population growth, while being unable to cope with these numbers due to a limited amount of space. In addition to a lack in quantity of affordable and qualitative housing, the absence of a decent infrastructure to provide basic facilities is critical as well. An exemplar issue is that only 30% of the city of Bandung is covered by a sewage system, which means a majority of domestic

---

[1] Lucas, R., *Research Methods in Architecture*, (London: Laurence King Publishing Ltd, 2016), 8.
[2] Wang, D., Groat, L.N., *Architectural Research Methods,* (Hoboken: John Wiley & Sons Inc., 2014), 21.
[3] Lucas, R., (2016), 8.
[4] Wang, D., Groat, L.N., (2014), 8.
[5] Wang, D., Groat, L.N., (2014), 11.
[6] Lucas, R., (2016), 9.

wastewater is untreated and discharged directly into the surrounding rivers[7]. In addition to that, local (building) materials are scarce, and the city is depending on ending resources.

The studio's context is a perfect example of a contemporary urban and architectonical challenge. Bandung represents the inefficiency of our contemporary cities, in which functions are inefficiently centralized and therefore separated, while not making use of existing resources and opportunities for smart circular solutions[8]. To be able to tackle such an extensive environmental, cultural and spatial challenge, a broad understanding of the context's problems and opportunities has to be gathered. Therefore, a research methodology is required which does not only focus on one specific element, but integrates several perspectives from different disciplines to analyse the complete context as a functioning system. For this paper, I will define the potential of the Industrial Ecology ideology to fulfil a role as an interdisciplinary architectural research method. The therefore used research question is:

How is Industrial Ecology applied as an interdisciplinary research method within the built environment to define a base for a sustainable architectural design?

II RESEARCH-METHODOLOGICAL DISCUSSION

To be able to develop a sustainable architectural design which is based on a circular system, one has to know the specific characteristics of the location he has to deal with, as an intelligent ecological design is to design with and for place[9]. The methodology of Industrial Ecology offers a good framework for this purpose.

Industrial Ecology (IE) is a multi-disciplinary scientific field which consists of two major principles: it focuses on the translation of natural ecosystems to human-made models and uses a broad systems perspective. Within a natural ecosystem there is an efficient recycling of nutrients and energy, while networks of exchange with mutual beneficial relationships are being found between different species. IE converts these elements onto the man-made industrial ecosystem, in which the species are industrial actors, and potential relationships are examined to exchange materials and energy, so waste and emissions are being reduced[10]. As this research field does not merely regard the field of architecture, *Superuse* – previously known as *2012 Architecten* - developed a research and design method to apply the Industrial Ecology principles within the built environment. Besides getting an overview of the existing flows and finding possible connections between them, it focuses on the spatial implications which have to been taken into account during the design process.

The Industrial Ecology research method consists of several analytical tools, for which some specific steps have to be taken. First of all, the context boundaries have to be defined. The boundary determines the quantity and rate of resource exchanges within the system, and the potential links with external other systems. Within the architectural approach, mostly a geographical based determination of the boundary is made based on the scale of a community or region. In some cases, when in- and outflows of resources interfere with external systems, the boundary can be extended to be able to develop valuable conclusions based on a closed system[11].

Within these boundaries, different aspects are involved. Aside from the physical elements in the form of resources, the social interaction between different actors also plays a major role on the functioning of the entire system. Therefore a praxeological research, which examines the way the built environment is being used, is needed[12]. It gives insight in the existing relations between actors, their behaviours and the way they are living with their resources, so in a next stage this can be taken into account when looking for new synergies and intentionally existing relations are being adjusted[13].

---

[7] Prihandrijanti, M., & Firdayati, M. *Current Situation and Considerations of Domestic Wastewater Treatment Systems for Big Cities in Indonesia*, (Sydney: University of Technology, 2011), 101.

[8] Pötz, H., Bleuzé, P., *Groenblauwe Netwerken voor Duurzame en Dynamische Steden*, (Delft: Coop for Life, 2012), 31.

[9] Sendzimir, J, Bradley, G.G, *Constructional Ecology: Nature as a Basis for Green Buildings,* (London: Spon Press, 2002), 232

[10] Goossens, F., *Recyclicity: Industrial Ecology Applied in the Urban Environment,* (Rotterdam: *2012 Architecten*, 2009), 3.

[11] Li, Xiaohong, *Industrial Ecology and Industry Symbiosis for Environmental Sustainability: Definitions, Frameworks and Applications,* (Sheffield: Springer International Publishing AG, 2018), 42-46.

[12] Avermaete, T., *Architecture and Its Epistemes*: *Lecture Notes for Students*

[13] Goossens, F., (2009), 11.

After getting a grip on the social context, the next step will be to analyse the system's metabolism and flows within the system. What are the main processes, most important flows and what subsystems are there to be found? For this, a material flow analysis (MFA) is used as a tool, in which the in- and outflow of materials and their conversion and accumulation within the system is explored. This is often being visualized in diagrams containing boxes and arrows showing the total process[14].

From these first analyzing tools, an integrating following step should be made which leads the designer to a phase between the pure initial research and the design process: the modelling of the system. Here, the raw outcomes of the first two steps are combined, so analytical conclusions can be made on what way the functioning of the system is still lacking, and where opportunities to connect streams and relationships between actors can be found. Additionally, the spatial implications are being researched. This concluding research can be seen as an integration of several disciplines, as the combination of MFA, simple input-output models and actors-relationship flows are made and connected into one complete diagram[15]. A good example of a suitable tool is the so called 'Sankey' diagram, of which an example in figure 1 shows a relatively basic system of flows between food, labour and users. Even though the spatial implications in this type of diagram are not always shown or sometimes still conceptual, it gives the designer some initial guidelines in what way the built environment could or should be shaped.

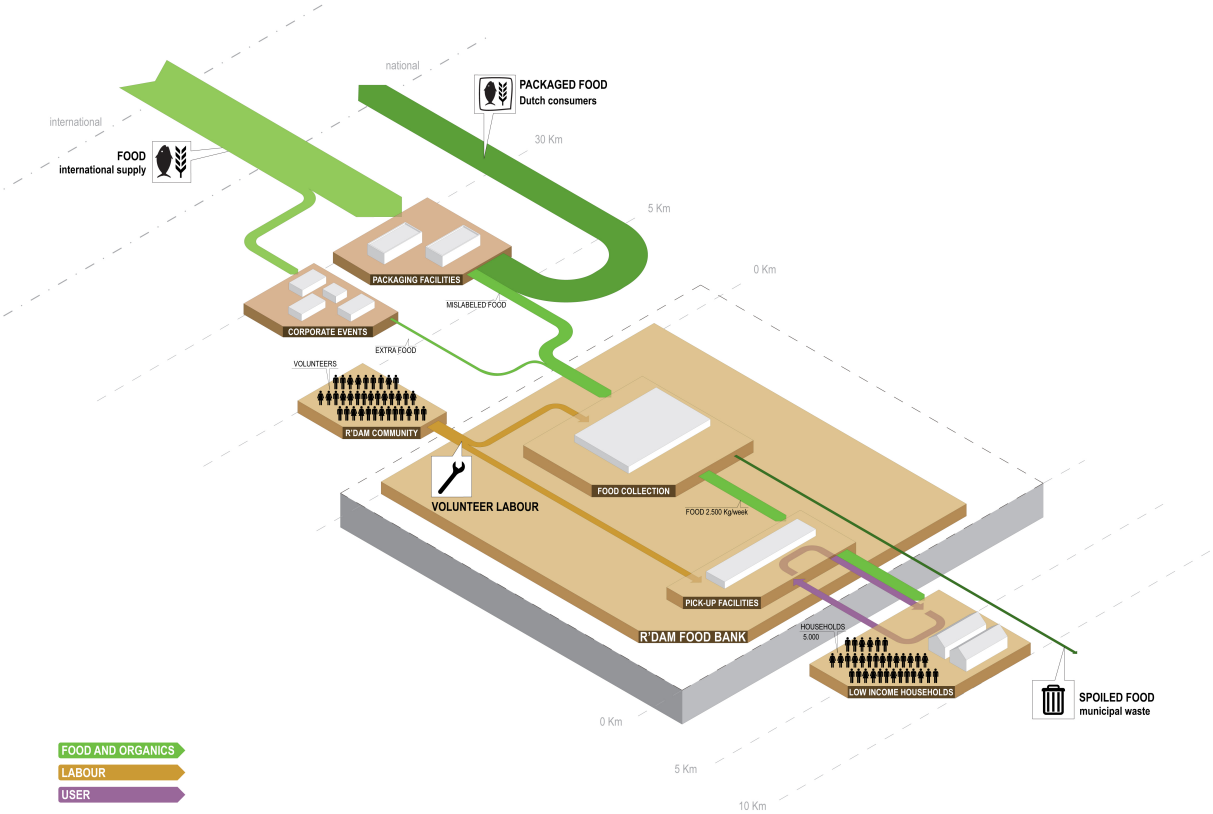

Figure 1: Three dimensional 'Sankey diagram', designed by 'Superuse' to show the different relating flows between food and organics, labour and users concerning a food bank in Rotterdam. Retrieved from *3D Sankey Diagrams* at *superuse-studios.com,* on December 4th, 2018, http://superuse-studios.com/index.php/2012/04/3d-sankey-diagrams/

The Industrial Ecology methodology can be considered as an architectural context-led research in the terminology of Ray Lucas[16], as an important feature is to determine the typical physical, historical and social aspects of the site. As every site has its unique flows and system, a suitable design can only be made by researching the uniqueness of the site. However, one can focus on typical conditions which can be found elsewhere, and learn from typological relating case studies.

---

[14] Goossens, F., *Recyclicity: Industrial Ecology Applied in the Urban Environment,* (Rotterdam: *2012 Architecten*, 2009), 17-18.

[15] Goossens, F., (2009), 18.

[16] Lucas, R., *Research Methods in Architecture*, (London: Laurence King Publishing Ltd, 2016), 12.

III RESEARCH-METHODOLOGICAL REFLECTION

Even though the Industrial Ecology research method has quite a young history being applied to the field of architecture, its integral way of thinking between disciplines and thereby developing an ecological framework is not a new concept within the built environment. On an urban scale, decentralized ecological models for city development were already initiated in the beginning of the 20th century. Famous is the Garden City of Ebenezer Howard, which contained space for agriculture, procession of waste from the city and water purification[17]. Another example is the social 'Kolonialpark' of landscape architect Leberecht Migge, which focused on efficient city models which reused organic city waste, and integrated water purification within green areas. Comparable to that, Le Corbusier applied an integrated approach onto his 'Ville Contemporaine', in which his building blocks harmonized with agriculture aiming for self-sufficiency[18].

Even though being initiated about 100 years ago, these ecological approached concepts already had the goal to improve the inefficiency of our contemporary city models. Decentralized models for food production and reusing waste as resources were developed, in order to react on the rapidly growing cities as well as the food and resource shortages due to the financial crisis and the First World War. After the 1930's, this sustainable approach commenced to stagnate. Due to the uprising of new technologies, new centralized solutions arose including food production, waste procession and waste treatment. In addition to this, the Second World War caused a high pressure on the mass production of housing and infrastructure[19].

While these developments caused the loss of technical importance of a circular way of thinking, simultaneously the architectural discipline had developed itself towards a new modern twentieth century into a solitary, abstracted discipline, disconnecting itself from previously closely related disciplines like landscape architecture[20], drifting architects away from a cross-disciplinary research and design approach.

However, from the 1990s onward, the architectural research perspectives changed once again. Where in the 1970s and '80s varying sustainable-related research topics outside of the architectural realm had fluctuating flows of interest, these research topics became more unified in new integrating approaches from the 1990's on[21], framed within new conceptual models including Industrial Ecology. These initiatives basically retrieved an interest in a traditional aspect, which in previous times were already proposed by prominent names within the (landscape) architectural field like Frank Lloyd Wright, Ian McHarg and Lewis Mumford; going back to the basics, a return to organic, nature-based design[22].

Industrial Ecology as a systematic research approach provides a good framework which corresponds to these principles, as it tries to develop a shift within the perspective on buildings, from seeing it as static machines or works of sculpture towards conceptualizing them as "dynamical living systems that are the very nature of Nature"[23]. It focuses on the development of a healthy built environment based on ecological principles, therefore maximizing resource efficiency and minimizing waste during building's assembly, operation and disposal processes.

---

[17] Pötz, H., Bleuzé, P., *Groenblauwe Netwerken voor Duurzame en Dynamische Steden*, (Delft: Coop for Life, 2012), 29.
[18] Pötz, H., Bleuzé, P., (2012), 30.
[19] Pötz, H., Bleuzé, P., (2012), 30.
[20] Balmori, D., Sanders, J., *Ground Work: Between Landscape and Architecture,* (New York: Monacelli Press, 2011), 35.
[21] Wang, D., Groat, L.N., *Architectural Research Methods,* (Hoboken: John Wiley & Sons Inc., 2014), 7.
[22] Sendzimir, J., Bradley, G.G., *Constructional Ecology: Nature as a Basis for Green Buildings,* (London: Spon Press, 2002), 23
[23] Sendzimir, J., Bradley, G.G., (2002), 231.

IV POSITIONING

The research method of Industrial Ecology slightly differs from most research methodologies discussed in the lectures of this course, as it is an integral approach focusing not only one a small architectural aspect, but on the built environment as a whole system. However, it does complement the mindset presented by Fransje Hooimeijer of the landscape as a system, also described in her corresponding paper 'Drawing the Subsurface' (2017). Here she states that there should be a conscious step from technology to design, by developing a so called 'Technical Profile' of a site, in which the knowledge of engineers and designers is connected and being visualized to allow an interdisciplinary research and design process[24]. The architectural Industrial Ecology based approach can be seen as such an interconnecting method, as being the extension of scientific thought, containing the same rigorous and critical analysis as a scientific method, but strengthening this by additional mapping of the intricate architecture of living systems, eventually translating it into a designers tool[25].

As mentioned earlier, the architectural field partly disconnected itself from other disciplines, in which a common habit was to separate knowledge into domains relating to specific sub-disciplines, but this approach seems to shift nowadays. Within our educational system students are dispersed among different studios each with their specific main focus, but cross-disciplinary research and design is being stimulated, with as a perfect example my shared graduation studio including urbanism, architecture and landscape architecture students. This mixture of different perspectives allows us to strengthen each other's knowledge about sub-aspects within the context-led research, complementing my chosen Industrial Ecology research methodology which allows integrating the more technical Architectural Engineering mindset with the other sub-disciplines. The architectural focus on humanities concerning the spatial, social and historical contextual information is perfectly supplemented by the systematic approach of landscape architecture on ecological systems, while the urban view allows us to integrate the social-economical interests on a bigger scale.

The joining of forces enables us architects to develop a systematic approach and interdisciplinary position to get a broad understanding of the built environment, and stimulates us to avoid narrow, partial analysis, which leads to bad designs with undesirable consequences. As Balmori and Sanders stated[26], different disciplines should avoid having separate agendas, but integrate their specialties to allow efficient models for cities and buildings to be developed which can function as "linked interactive systems that heal the environment". New architectonical strategies like Industrial Ecology should dissolve the boundaries between the aesthetic, technological and natural, and rather utilize technology to cooperate with natural processes, while introducing these processes into architecture. For this, an integrated research method should be applied which lets us understand the complete (natural) system of a site, before deciding what spatial and technical interventions are appropriate to be applied. As Sendzimir and Bradley[27] propose in 'Constructional Ecology', architecture of the 21st century should reconsider Louis Sullivan's *form follows function* towards a revised contemporary statement: *form follows flow*.

---

[24] Hooijmeijer, F.L., *Drawing the Subsurface: An Integrative Design Approach,* (Bucharest: SUB-URBAN 2017), 62.
[25] Sendzimir, J, Bradley, G.G, *Constructional Ecology: Nature as a Basis for Green Buildings,* (London: Spon Press, 2002), 232
[26] Balmori, D., Sanders, J., *Ground Work: Between Landscape and Architecture,* (New York: Monacelli Press, 2011), 8.
[27] Sendzimir, J, Bradley, G.G, (2002), 231.