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SUSTAINABLE TRANSFORMATION OF CITIES: THE CASE OF EINDHOVEN, THE NETHERLANDS

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Abstract
The question of sustainable urban development is linked to the issue of urban transformation; the challenge is to make use of ongoing transformation processes to achieve more sustainable urban environments. Hildebrand Frey is the main protagonist of the "urban cell theory" (UCT), focused on the redesign of existing cities, laying down important arguments for neighborhood borders and centers. For decisions to pursue the sustainability path, the pragmatic method will be a practical tool in bringing sustainable considerations in the realm of project decisions. This paper examines the sustainable transformation of cities upon a re-mapping of the existing city to identify the potential urban cells, restructuring of the actual city of districts and neighborhoods; focused on Eindhoven as a case study, specifically the District of Woensel, describing the operationalization of the UCT as a conceptual framework. This work is structured in three parts: 1- a preliminary analysis identifying the existing neighborhoods in the district to analyze how the existing parts of the city meet the criteria of UCT; 2- the description of how to join non-potential and potential sustainable areas of the existing city to create "large units" of the city; 3- The elaboration of results indicates that all the parts of the city are part of potential sustainable areas, obtaining hence a principal layer of the map of the sustainable city. The relevance of this approach is to contribute new insights to the debate of sustainable city borders.

Keywords: Urban form, Sustainable cities, Urban transformation, Pragmatics

INTRODUCTION: REMAPPING OF EXISTING CITY

Focusing on the urban redesign of Woensel area, a post-war district of Eindhoven, the goal of this paper is to make a re-mapping of the existing city to identify the potential urban cells on the study area. To achieve this goal it is necessary first to analyze how the existing units of the city meet the criteria of sustainability –UCT-, classifying them as a potential and non-potential sustainable areas of the existing city under evaluation of the UCT criteria; and second to lay down how to join non-potential with potential sustainable areas of the city to restructure the district by creating large units to optimize sustainability. Finally to remap the city based on this new structure: all the parts of the city should be part of potential sustainable areas, obtaining hence a principal layer of the map of the sustainable city. The contribution will present an example of a pragmatic design strategy to adjust form and structure of an

existing area, a method to implement new directions to achieve the challenges of sustainability.

HISTORICAL-EVOLUTIONARY APPROACH OF THE CITY

Sustainability regarding cities has many definitions and angles, however the re-making and adaptation of existing cities to sustainable objectives is an urgent double priority towards the global push for sustainability (Kenworthy, 2006). To meet the objectives of a sustainable city new methods, strategies and design tools are required as part of a pragmatic-based integrated planning, considering each factor converging in the physical, social and economical necessities of a community, connecting them to the environment (Burnett, 2007; Frey and Yaneske, 2007; Gunder, 2006). In this sense, sustainable development is concerned not only with social, economic and environmental qualities or inefficiencies of the city but also with urban form as it largely exists and the form and structure development should take for the city to become more sustainable.

Pragmatics as a way of thinking

Hence, at present we are generally confronted not with the task of planning and designing new towns and cities but, rather, with re-planning and redesigning existing cities, towns and settlements to make them more sustainable. Therefore the challenge is to redesign existing urban form (Barton, 2000; Breheny, 1992; Frey, 1999; Frey and Yaneske, 2007). This involves a pragmatic way of thinking: the pragmatic method will be an effective tool in bringing sustainable considerations to achieve these objectives. The task, then, is to address the real problem of the cities by a pragmatic thinking (Moore, 2010).

The assumption to achieve a sustainable city is to shape a resilient city, flexible structures of the city: future city is the existing city transformed into the direction of sustainability by the shaping of a flexible structure, able to create a solid community in the core of a healthy and pollution-free environment. Therefore, are there certain urban forms that contribute more than others to sustainability? In literature models and concepts of sustainable city form are identified; as well as there are seven design concepts related with sustainable urban form: compactness, sustainable transport, density, use of mixed land, diversity, passive solar design and greening; and also four types of sustainable urban forms: neo traditional development, urban contention, the compact city and the eco-city (Jabareen, 2006). City models that meet sustainability are distinguished, however existing cities never can be categorized as such in one or another model; cities are always openly developing, and do not necessarily following consequently a certain model. Models have proved to be abstract and theoretical and in the practice quit far away from realities. In this sense, the message is clear: to achieve sustainability requires not only new development to be guided by appropriate urban models and targets but also the review of the forms, structure, land use patterns and socio-economic conditions of existing urban areas (Frey, 1999; Frey and Yaneske, 2007).

This way of thinking -pragmatic vision- is not really completely new in the urban planning and design. In the history, specifically in the post-war period, many authors have made criticism about the post war planning thought in the late 1950s and early 1960s, owing to the

inflexible planning of the cities. In fact, there were two levels of criticism of postwar urban development that emerged in the 1950s: 1- on the quality of the design of the new development; 2-on the emphasis of physical planning. According to these both fundamental disagreements, town planners typically exhibited very little understanding of the cities, because they had been preoccupied with simplistic "utopian visions" instead of trying to understand and address the problems of real-life cities. Indeed, the main criticism was the lack of understanding of real-life cities and preference for a tidy, ordered view of urban structure (Taylor, 1998).

CONNECTION TO FREY: URBAN CELL THEORY (UCT*)*

Hildebrand Frey is the main protagonist of the "urban cell theory" (UCT), a theory that emphasizes pragmatism and focuses on the redesign of the existing cities~~,~~ through the promotion of urban and suburban cores. In short, H. Frey advocates a recalibration of urban components to a higher level of aggregation –urban cells- that~~,~~ might be instrumental for achieving balanced relationship among transport, urban form and environment hence a more sustainable city. Urban Cells are units of urban district level –neighborhoods- that meet certain criteria to achieve sustainability in the city. In addition, these criteria are divided in five key criteria: key planning, social, environmental, design and economic criteria. If a district meets these criteria, then the urban unit –or neighborhood- is sustainable (Frey, 1999).

From cells to modules

Nevertheless, the biological connotation in regard of a city is not really acceptable as a city is not a living thing, only the people that use it are, because the city is not able to repair itself. Also a "cell" is not alive. A cell remains or becomes alive if there are two or three live cells adjacent to it, otherwise it dies. Fewer than two adjacent cells imply the cell dies from insulation; more than three and it dies from overcrowding. Thus, the "cell" as part of a structure is not necessarily the most important element of that structure; much more important may be the links between "cells" or "modules" that generate a complex structure. Indeed, this means that all living organisms could be viewed as systems, for any organism depends on and is therefore related to its environment. For this reason, it would be interesting to represent an image of the city as an active functioning thing: as a system (Batty, 2005; Buchanan, 2002; Frey and Yaneske, 2007).

In our interconnected world there is a practical difficulty in deciding where to draw the boundary of a complex system. Nevertheless, conventional science seeks for simplifying systems to a comprehensible few interactions that still yield useful results. In this sense, this simplicity is termed modularity, which is a strong interaction among elements within a module but only a relatively weak interaction with elements outside (Frey and Yaneske, 2007).

The concept of module is referred to something that has its own structural and functional integrity while being part of a larger system (Frey and Yaneske, 2007). The existing city is

clearly complex and highly ordered (Batty, 2005); in addition, the city, as many natural phenomena, has a hidden structure that develops "unconsciously" (Buchanan, 2002). For this reason the city has to be understood as a modular construction: modules with own structural and functional integrity while being part of a larger system. This modular structure makes the existing city more resilient; having the ability to adapt to changing circumstances, while providing for the basic needs of residents and ensuring quality of life. Plans are developed for a 100 year period to ensure the city and the city region's long term survival as well as integrity, normal functioning, and self reliance (Frey, 1999; Frey and Yaneske, 2007).

Urban cells theory criteria

According to what was mentioned above, the UCT establishes key criteria for each component of sustainability in the city. Below there is a detailed explanation of the UCT criteria (Frey, 1999).

1. Key planning criteria for sustainable neighborhoods; this principle for sustainable neighborhoods includes the following:

Inclusion of open land: by 40% of developable land kept as forest and agriculture; the reason is to achieve preservation of land, local production of food and timber, and to reach a degree of self-sufficiency and local economy.

A threshold population: by a gross population size between 4.000 and 10.000, in average 7.000 inhabitants, with districts around 25,000-35,000 inhabitants; the main reason is to support local services and facilities into the neighborhoods -provided there is sufficient disposable income.

Accessibility in walking distance: Accessibility in walking distance to local services and facilities, including public transport node/stop with distances between 400-800m, says 600m. This generates areas of about 110-120 ha and with a gross population density of 60 per/ha over total land, 100 per/ha or 42 dwellings per ha over developable land; the main reasons are to improve the local access -to local facilities- and district/regional access -to city centre and other provision centers in the conurbation- for those not highly mobile, and to obtain a reduction of car dependent local and regional travel.

Mixed use: by 40% of developable land for non-residential uses, 60% for housing, which results in a net population threshold density of 167 per/ha or 70 dwelling units per ha. The main reasons are to improve access to work places, services and facilities, specifically for those not highly mobile, and give the possibility of the interaction of different uses/users generating "urbanity".

Local facilities: The presence of local facilities into those areas (neighborhoods), such as: local shops/mini-supermarket, bank auto-teller, post office counter, primary school, police station, community facilities and park, access to open green space, play areas, sport areas and workplaces. The reasons are mainly to allow an ease access to local services and facilities, as well as reduced car-dependent mobility, and to have access to city level facilities with public transport.

2. Key environmental criteria for sustainable neighborhoods; this principle for sustainable neighborhoods includes:

Energy conservation: Energy conservation by the use of clean renewable energy such as solar, wind, geothermal, among others. The reasons are mainly focused in the conservation of natural resources and the reduction of pollution through burning of fossil fuels, these could help to reduce energy consumption of a typical dwelling and create more sustainable neighborhoods.

Water conservation/management: Water conservation and management will be achieved through rainwater collection, as well as the reuse of grey water, and recycling of waste water (including sewer) after treatment. The reasons are principally to become a reduction of water waste, the preservation of water resources, and the reduction of the waste of potential fertilizers.

Waste recycling: Waste recycling by separating and reusing waste materials such as paper, glass, plastic, metal, and food products. The reason is mainly to achieve a reduction of waste mountains, as well as land fill sites.

Establish or re-establish biodiversity: Establish biodiversity through maintenance and enhancement of local fauna and flora. The reason is to achieve a symbiotic relationship between city and nature.

3. Key social criteria for sustainable neighborhoods; this principle for sustainable neighborhoods is specified as:

Social inclusion: by social mix to avoid exclusion or marginalization of socio-economically weaker groups of people. The main reasons are principally to obtain a reduction of tension between those that have and those that have not, and economically weaker groups of people benefit from the inclusion of people with disposable income that support local services and facilities.

Safety and security: by the activation of legible public spaces, laying down activated edges, good lighting and design spaces. The reasons are to improve the living quality and to get a reduction of real or perceived fear of crime.

Participation of community: by people involved in local decision making and local democracy. The main reasons are that the community holds ownership of neighborhoods, to obtain more responsibility of local people for their environment, as well as to increase the sense of belongingness, and to reduce vandalism.

4. Key design criteria for sustainable neighborhoods; this principle for sustainable neighborhoods includes:

Legibility and imageability: Legibility and imageability of the built form of the neighborhood, as well as a sense of centralization and belongingness, improved access, and a meaningfully built form. The reason is to reach a better quality of life.

Adaptability: Adaptability of the built fabric and neighborhood layout; say adaptable, expandable housing. The main reasons are to reach the possibility to adapt to changing needs and aspirations and to changing external conditions, as well as to obtain durability of buildings and neighborhood.

5. Key economic criteria for sustainable neighborhoods; this principle for sustainable neighborhoods includes the following:

Affordable housing: To reach affordable housing by a mixture of different tenure and housing types, from villa to semi-detached, terraced tenement, etc. The main reason is to be a support for social and income mix.

Keeping profit in the area/neighborhood: through credit systems in a local economy, by local production and services, both formal and informal. The reason is to reach that profit can be used for improvement to the neighborhood and its facilities rather than disappearing into the pockets of distant international companies.

TRANSFORMATION OF DISTRICTS IN THE CITY OF EINDHOVEN: UCT APPLIED TO WOENSEL

The aim is to demonstrate the existence of potential urban cells on the study area. First, it is necessary to find out which of the existing neighborhoods meet the criteria of UCT. The area selected is Woensel, a district located in the north of the city centre of Eindhoven, the Netherlands (Figure 1).

As a preliminary analysis, the district of Woensel is described as a great postwar expansion area of Eindhoven largely made since 1960 (Figure 2), being an existing environment with a clear transformation phenomenon by dispersion. Woensel is an incomparable area in relation to others in terms of population, with 101,218 inhabitants (M.L.M.G. Boumans, 2005), being the half of the total population of Eindhoven (208,000 inhabitants); in this sense Woensel is one the largest settlements in the region; not only the Eindhoven's largest district concerning population, but also even larger than some settlements of the region, such as the city of Helmond with 86,000 inhabitants, located in the east of Eindhoven.

Woensel is almost entirely a residential area with services and facilities for the community, such as schools, parks, churches, shops, post offices, trade facilities, hospital, among others. The district has its own district center -shopping center Woensel-, providing for the upper district facilities. Woensel offers few places of local interest, being almost entirely a residential area; Eindhoven's main entertainment venues and industry are in other parts of the city.

Figure 1: *Woensel district located in the north of Eindhoven city center.*

Figure 2: *The area of Eindhoven's development in 1950 inside of today's city boundaries (based on Morfologische Atlas Eindhoven, 2005)*

The first part of the analysis was focused on identifying the existing neighborhoods on the district, recognizing around of 27 urban quarters that make up the district of Woensel, divided in two main zones: Woensel-North and Woensel-South (M.L.M.G. Boumans, 2005). Neighborhoods centers are recognizable by the identification of functions: the location of post offices, police stations, primary education schools, trade and other facilities. Generally, four or five neighborhoods are grouped to form a district, four or five districts are grouped together to form towns, and over town centers are located the major transport routes between towns (Frey, 1999). In this case, Woensel district is made up by two "great areas", and each area is set up by around twelve and fifteen neighborhoods respectively. Woensel district centre -shopping center Woensel- is located in one of the main transport routes, allowing a good connection with Eindhoven city center. The connection between Woensel-center with other town centers is poor, because Eindhoven is currently a mono-centric city, the public transport connections are exclusively aimed at Eindhoven center (Figure 3).

With the identification of the existing neighborhoods boundaries, then it is possible to start with the next level of the investigation, related with the analysis of how existing units meet the criteria of sustainability –UCT.

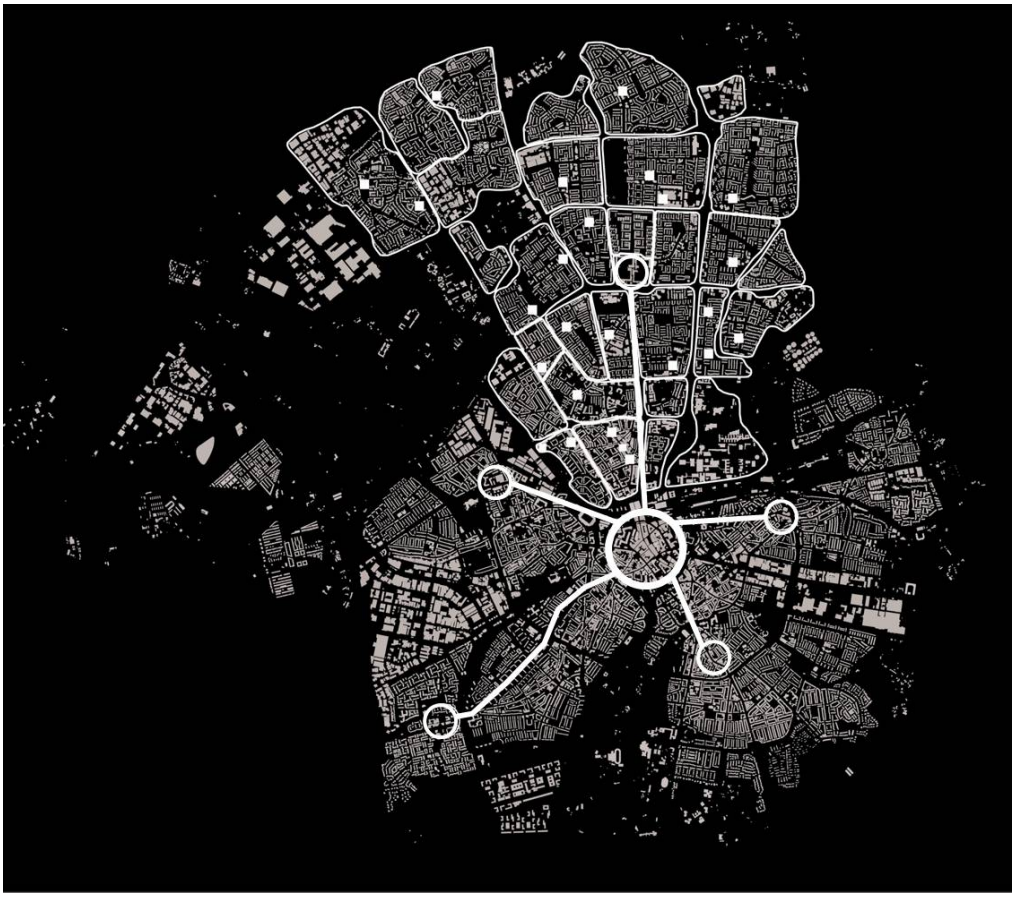

Figure 3: *Location of existing neighborhoods boundaries and centers, and main center district connections.*

Fieldwork and evaluation table

In the next level of the research, the analysis was focused on how the existing neighborhoods of the district meet the criteria of sustainability, to classify them as potential and non-potential sustainable areas according to the UCT-criteria. For the applicability of the UCT on the study area it was necessary to make an evaluation over each identified unit. In this sense, the evaluation consisted on making an analysis on the place by fieldwork and literature review from institutional and academic data by desk research. The analysis was focused on environmental, economic, social, design and planning aspects of each neighborhood of Woensel, according to UCT.

The results of the analysis were placed on an evaluation table. The table consists of assessing the aspects of each neighborhood under the criteria of UCT –social, economic, environment, design, and planning- establishing what areas meet the criteria and what areas do not meet the criteria. Then, we obtained estimated percentages of every neighborhood evaluated under each criteria of the theory, obtaining a total average for each area.

As a result of this analysis an estimative approach was obtained; describing areas that meet above 50 percent of the criteria denominated as “potential areas”, while areas that meet less than 50 percent of the criteria are “non-potential areas”. The graphic below shows a summary of this evaluation (Figure 4).

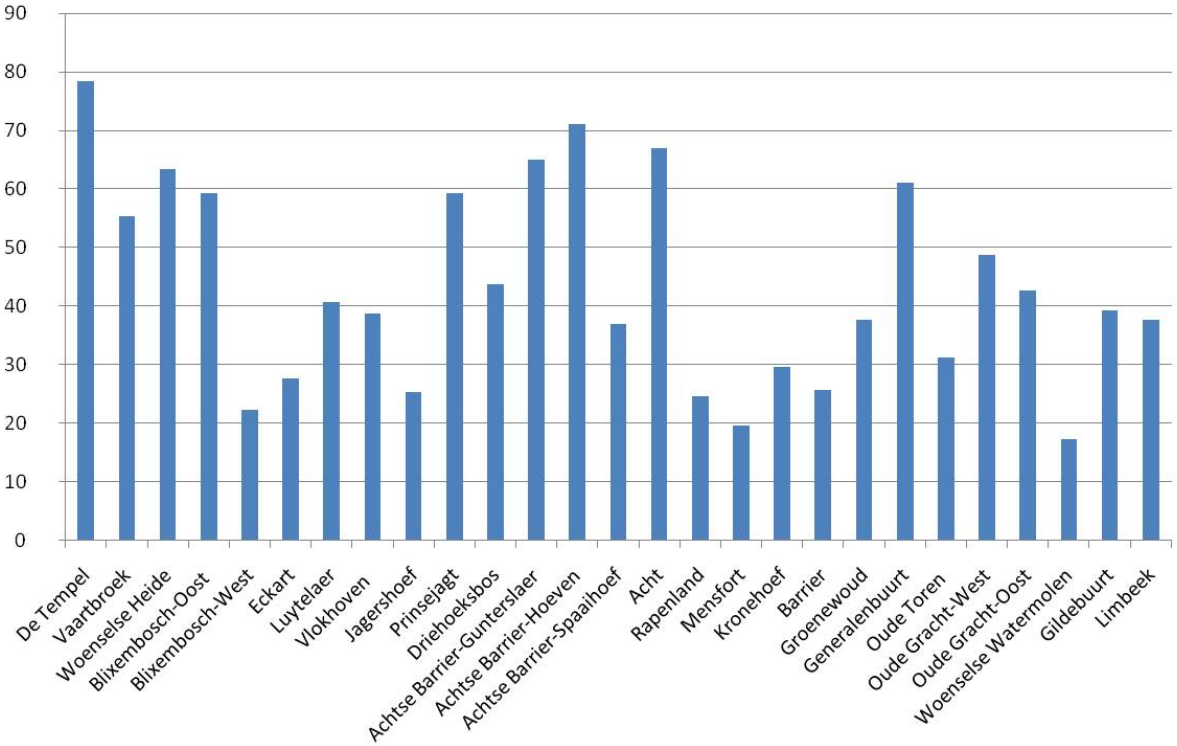

Figure 4: *This graphic shows the evaluation of neighborhoods under UCT criteria.*

Finally, the results of this analysis were translated in an evaluation map (Figure 5). The map describes the potential and non-potential sustainable areas in the district identified by different colors. Dark areas are described as potential, while light ones are non-potential, according UCT-criteria. According to figure 5, as a conclusion of this first level, nine neighborhoods are potential sustainable areas in Woensel. Those areas meet most of the 50 percent of the UCT criteria.

Figure 5: *The evaluation map showing potential and non-potential sustainable areas of Woensel district.*

As an example, the urban quarter called De Temple is potentially one of the most sustainable areas, meeting all the planning criteria; also this area presents a potential concerning green and biodiversity aspect, with the Henry Dunant Park. However concerning design, this area is a typical postwar neighborhood, with monotonous row housing development and public spaces, but with a good proximity to local services and facilities by walking distance. In relation with the UCT of H. Frey, those potential sustainable areas in figure 5 meet around three or four aspects of the planning criteria, regarding good population number, local facilities, mixed-used, good accessibility by walking distance and open land space. For instance, the urban quarter of De Tempel is one of the largest population areas in Woensel with around 5,000 inhabitants; good number to support local services and facilities. In addition, there are eleven areas in Woensel that meet this criteria; most of them have also a community organized in relation to participation in local decisions, good green areas especially in some edges of the district, as well as work places as modest business on the area (Figure 6). However, one of the most important aspects is the “green” condition of Woensel-north. Most of the urban quarters located in Woensel north meet the biodiversity criteria. Indeed, there is a good presence of green areas, such us parks, forests, and sport areas close to the boundaries. Also, green corridors are on the main avenues and streets, connecting neighborhoods.

Nevertheless, the situation in Woensel south is different. In figure 5, this area presents most of the non-potential sustainable areas of the district; mainly characterized to be residential areas, with a poor accessibility and quality of design concerning public spaces and architecture, as well as lack of green and leisure areas, unsafe public spaces, the absence of social mix and less number of inhabitants that could support local services and facilities (Figure 7).

Figures 6 and 7: *Urban quarter De Tempel; and typical neighborhood in Woensel-south*

Therefore, neighborhoods in Woensel are predominantly with residential functions and hardly with mixed-use; with just eleven urban quarters with a good base of population and presence of eligible amenities center. In the second level of the investigation, the analysis was focused in how to join potential with non-potential sustainable areas of the existing city to restructure the district by creating ‘’large units’’, to make a balance of them and to improve non-potential areas to optimize sustainability.

At this level it was necessary first to recognize principles to the process of design, applying to these areas, and thus to restructure Woensel district. These principles are derived from the UCT-framework and pragmatic redesign considerations in relation to the city, specifically to the assumption of the city as a resilient structure: the future city is the already existing city transformed into the direction of sustainability, (Frey, 1999; Frey and Yaneske, 2007; Moore, 2010). In the city, the places are important elements; people define themselves by the place they live in and value the unique characteristics which give continuity with the past and relationship with the present. Every citizen has had long associations with some part of his city, and his image is soaked in memories and meanings. Sustainability is the history of the city (Frey and Yaneske, 2007; Rossi, 1993; Tarvernor, 2007; Tweed and Sutherland, 2007). To preserve and enhance the physical and spatial balance of the existing built environment, redesign can help to promote sustainable development by improving the quality of the existing environment and sense of place.

Following the UCT-framework, strategies were made to restructure Woensel by two steps:

1- According to the UCT criteria, the interaction among urban quarters –or cells-, say four or five of them, form a district with a core which might become the focus for a much larger population of 25,000 – 35,000. The district center would be linked with neighborhood centers by public transport; such districts would have a sufficiently large catchment area to accommodate commerce and other equipment and services (Frey, 1999). In this sense, Woensel north zone has a large size and the presence of facilities is striking. The stores not only provide assistance for all typing on the large amount of housing in this area, but also for the lack of facilities. In Woensel north reside about 70,000 inhabitants. This number could be divided into two districts with potential units and own centers, with a population of 35,000 inhabitants each one. This approach would create enough support above district facilities in the area (Figure 8).

2- From the districts established, we can start to join non-potential with potential areas to create large units of urban quarters. A neighborhood needs to be recognized as an essential building unit of the city (Barton, 2000; Frey, 1999). It is important so as to know which units have relationships with each other, identifying the existing urban structure relationships. The analysis was made by examination of layers, included the existing development patterns, in terms of greening, infrastructure, density, compactness -built-up areas- and local centers of provision, in relation to cluster potential with non-potential areas. The sketch reflected in figure 8 (Figure 8) describes the overlap of both steps, via layer-by-layer the existing city form is recorded and examined; this enables the examination of the relationship of each of these layers with the overall.

A global inventory of equipment and services provides a characterization of the new districts, made up by “new large units” recognized as essential building units of the city. Thus, the lack of facilities, as well as a poor social mix and limited variation in housing types and public spaces presented in Woensel, could be improved by the revitalization and enhancing of some potential places hence transforming them into “hierarchy” centers of each new district established.

Figures 9 and 10: *Commercial Woensel center; and Woenselse markt in Woensel south*

Figure 8: *This sketch shows the overlap of the two steps of the strategy and also the creation of large units~~,~~ by the joining of potential with non-potential urban quarters.*

Three main key zones are described in figure 8, clustering Woensel-north in two districts and enhancing Woensel-south with an own main center. The first district proposed could be defined as “recreational center”: Sport Park Woensel –located in the north-west- is the current area for active recreation within Woensel. If Sport Park Woensel is upgraded with mixed uses, adding trade and culture facilities, then it could be a new center of district. In relation with the second district proposed, the existing Shopping Woensel center is joined with care facilities -Catherina Hospital in Rapeland. Thus it would become, in an improved current, the center of the district defined as “commercial center”. Both districts have own centers and will have less dependence on Eindhoven city center (Figure 9).

Finally, in the third district proposed to Woensel south the objective is to recover this place as a “cultural area”, an important place of reference in the city. In fact, some of the non-potential areas in Woensel south have “cultural potential”; this potential could help to define the character of the place; every citizen has had long associations with some part of his city. Some existing neighborhoods have important cultural value, for example Woenselse-markt. Presently Woenselse markt is located in Gildebuurt, an urban quarter in Woensel south. This area is an important trade corridor with local services and facilities and transformed into a market place some days in the week. On this area there are other neighborhoods with important culture values, such us Oude Toren, with an important historical value from around the 12th Century when Woensel settlement was founded (Boumans 2005). The proposed

district, thus, would have an important cultural character, with trade and facilities as reference into the city (Figure 10).

CONCLUSIONS

Hildebrand Frey established the UCT as a tool for the redesign of existing cities, laying down important principles for neighborhoods and districts structure. The operationalization of the theory is used as method for exploration on Eindhoven, specifically the district of Woensel. The elaboration of results indicates that Woensel could become part of sustainable areas.

The new Woensel is described in the final map (Figure 11), laid down with three different new districts, created by large units set up through the interaction among non-potential with potential sustainable areas. Every new large unit will be a resilient structure, adaptable during the time; this means that to meet better the criteria of UCT, the larger units will have the possibility to adapt to changing needs and aspirations. Also these large units provide local services and facilities within walking distance to the edge, local centers with mixed-uses and public transport stops. Main connections routes have been preserved and upgraded, used as boundaries for the large units extension, and as main links connection with the rest of the city.

The current main routes are upgraded as green corridors, allowing not only good vertical and horizontal connections among the new areas, among large units centers to district centers, but also good access among district centers, and from them to suburban municipalities of Best, Son and Breugel in the Region.

Regarding the borders of Woensel, they have been developed to improve the borders with the countryside. Borders are maintained and enhanced as a conservation green area; hence the districts are limited by natural boundaries. The reasons are:

- To keep some current uses as open land development such us forest, and agriculture.
- The objective is to create dense green areas at the district borders, as roots for the green corridors and main green points into the city.

To establish green spaces as a second structure incorporated to the existing one; to protect large urban units from the noise pollution coming from main routes connections by green corridors, as well as to provide and enhance green existing areas as “key breathing spaces” into the city; creating clear connections among the main green spaces at the larger units.

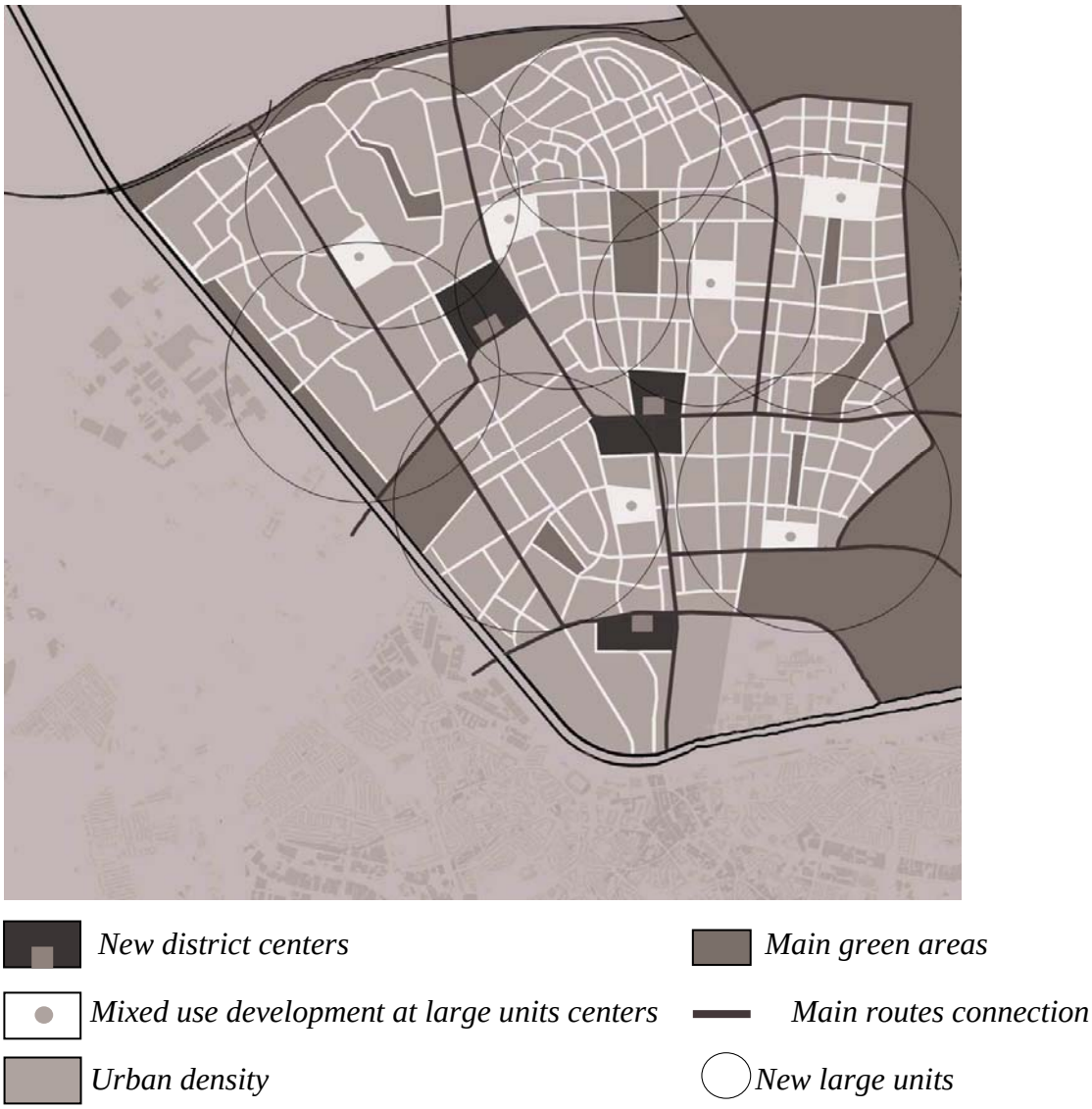

Figure 11: *The principal map of sustainable city borders.*

The design concept for Woensel attempts to generate clear district centers, assigned as mixed used development, which are linked with each other by new central routes. These routes would accommodate the major public transport line, linking the new centers with the city center as well as with the suburban municipalities in the region. Therefore, the new redevelopment structure (Figure 11) shows a clear density development, with peaks at districts centers as well as at the large units centers; which accommodate mixed use, to give each new area an identity and a sense of centrality.

In general, UCT is a useful tool for pragmatic urban sustainable redesign. This tool clearly takes as a starting point that the future sustainable city is the already existing city, establishing operational criteria to each component of sustainability in the city.

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