Vulnerability assessment of ecosystem services for climate change impacts and adaptation
Action 6: ***Assessment of Climate Change and Land Use Impacts in Urban Environments (short name Urban Environments)***
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First year data collected and documented

Heikki Setälä, Jari Niemelä, Heikki A. Loikkanen, Matti Kortteinen, Mari Vaattovaara, Vesa Yli-Pelkonen, Kimmo Kurunmäki, Hanna Ristisuo, Olli Ruth, Marjo Valtanen, Nora Sillanpää

Preface

This report “First year data collected and documented” builds on the VACCIA Action 6 (Urban Environments) literature review published in August 2009 (Setälä et al. 2009), where we addressed ways to construct ecologically and socially sustainable urban environments with keeping the interactions between climate change, runoff waters and land-use and cover change in mind. In that literature review we also outlined potentials and challenges of the common research setup, where ecological, economic and social issues are brought together in studying the interplay between urbanization, climate change and hydrological cycles.

In this report we continue examining the common research setup and develop it further. We present the data collected and documented during the first year of the VACCIA Action 6 (Urban Environments). The collected biophysical data so far consists of detailed, but not yet complete, stormwater measurement data and ecological data on pervious and impervious surfaces and soil samples in three different catchment areas in the City of Lahti. Similar study set up of three urban catchment areas has been established in the City of Helsinki, but ecological data is not yet available from these three catchment areas. During the second year of the project data will be collected from the Helsinki catchments. The three catchment areas both in Lahti and Helsinki differ in their population density and in the amount of pervious and impervious surface. The collected socioeconomic data consists of indicators of socioeconomic structures, housing, and the prices of housing from the same catchment areas in the two cities. Finally, in this report we present conclusions on the first year data.

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1. The common research setup

In the VACCIA Action 6 (Urban Environments) project we aim at finding ecologically, economically and socially sustainable ways of planning and building urban areas while simultaneously addressing the interactions between climate change, runoff water and land-use and cover change. To complete this challenging assignment we are using a novel multidisciplinary perspective and research setup, where we aim at integrating new, innovative and accurate hydrological and socioeconomic measurements and ecological research.

As it was noted in the VACCIA Action 6 literature review (Setälä et al. 2009), the aims of building sustainable urban environment in ecological, economic and social terms produce paradoxes both in their own fields and also when integrating those terms in planning and decision-making (see also Niemelä et al. forthcoming). For instance, it is not sufficient to address urban environmental development in the face of climate change solely from the perspective of minimizing carbon emissions. Discussion from such perspective bypasses important questions related to state and function of local ecosystems in urban regions. As described in the literature review (Setälä et al. 2009), urban ecosystems (based on their biological diversity and ecosystem functions) provide important ecosystem services essential for the well-being of inhabitants of urban regions. Even though it is advisable to design compact urban areas to minimize carbon emissions produced by transportation, it is also essential to make sure that local green areas and waterways are preserved for the maintenance of biodiversity that forms the basis for ecosystem services vital for residents (Yli-Pelkonen 2009).

In this project, we focus on urban runoff water (stormwater) as an indicator of the stability and sustainable functioning of local urban ecosystems. Retention of stormwater absorption is one of the ecosystem services provided by urban ecosystems (Bolund & Hunmammar 1999). Such retention function requires pervious surfaces, such as green areas (park, garden, lawn, forest) or in some cases sand surface. In urban areas, however, the degree of impervious surfaces (such as concrete, asphalt and roofs) usually increases with the degree of urbanization making it increasingly difficult to retain water. Although the impacts of urbanization on urban hydrology are rather well known, the combined impacts of climate change, urbanization, and climate change mitigation efforts (such as very compact building) on hydrology, especially on stormwater, are unclear.

A proper scale to address stormwater impacts is often only a couple of hectares. Traditionally, the measurements of quantity and quality of stormwater have been inaccurate, since the flow measurements have been done and water samples have been taken infrequently – often once a week or even once a month. This has not enabled a precise monitoring of the amount and composition of urban stormwater. The new measurement equipment and techniques used in this project make it possible to monitor the quantity and quality of stormwater in real time and with great accuracy at the three catchment areas in the City of Lahti. The same will be done in three catchment areas in the City of Helsinki, as soon as the equipments have been installed there. The data collected in this project provide completely new insights to the world urban hydrology.

Integrating socioeconomic data with stormwater measurements and linking those to the amount and distribution of pervious and impervious surfaces is the aim and challenge in our research setup. We aim to use the results and understanding gained in this project to guide city planning towards sustainable solutions. As the role of the public sector in Finnish city planning is exceptionally strong with the municipal planning monopoly ever since 1932 (Puustinen 2006), all housing areas have been as products of public planning. However, the ideologies, perspectives and aims of planning have changed considerably over time, the result being visible in our urban structure. All the catchment areas of this study can – in one way or another – be interpreted from this planning perspective. Virtually no follow-ups on the results and effects of the different planning solutions have been conducted, either socioeconomically or ecologically.

The paradigms of city planning in Finland (including the Helsinki Metropolitan Area) have overlooked the ecological perspective, and ecological consequences have not been studied to a great extent. The emphasis of aims has been related to socioeconomic development, where the perspective has also been the building project of a Nordic welfare state. The goal of urban planning has been to construct as mixed and evenly-constructed city as possible. All areas have been meant equally for everyone. Statistical follow-ups and international comparisons have shown that this goal has been for a long time met exceptionally successfully. Only recently, the supramunicipal housing markets born to region during last two decades have led to a situation where differences between various housing areas have began to grow (Vaattovaara & Kortteinen 2003).

As a result, a new possibility opens up for us: to conduct a study on the present day impacts and end results of the different solutions, and to combine socioeconomic and ecological analysis in doing this. An interesting new hypothesis opens up, too. Former, survey-based studies indicate that the majority of inhabitants in Finland would like to live close to nature in peaceful detached-housing residential areas. These areas seem to be doing exceptionally well in recent socioeconomic differentiation. However, the problem is that such wishes may lead to the increase of urban sprawl or similar development that increases the fossil fueled transportation needs and carbon emissions, and loss of the integrity of nature areas. On the other hand such wishes may also favor such ways of planning and building that are sustainable from the perspective of local ecosystems. If this hypothesis of achieving both ecological and social sustainability simultaneously holds true, the results of this project could show that housing prices and socioeconomic structures have developed most favorably in areas that have had least negative impacts on local ecosystems, i.e. that the local housing markets are favoring ecologically sustainable local developments. With the research setting we have, this hypothesis can be verified, falsified or specified. Through the analysis, specific planning solutions could be identified as the best or as the worst – and this information could be used to guide future city planning of the area.

The socioeconomic development of the City of Helsinki and Helsinki region in general has been studied well, but data on the City of Lahti and Lahti region are so far scarce, since there proper studies on the development of urban structure there have not been conducted. During this project the aim is also to study and understand the development of the Lahti region, so that comparisons could be made to Helsinki region and other similar sized regions in Finland. Observations so far indicate that the development situation in Lahti region is perhaps more open than in other similar regions. This is a positive sign and means that the socioeconomic structure of the population in the area has not been disintegrated so clearly and strongly as in the regions of Helsinki, Tampere and Oulu.

In practice, we are collecting detailed socioeconomic data on the developments of the socioeconomic structures and the prices of housing from the same catchment areas in which the urban runoff data and other ecological data are collected from the City of Lahti and the City of Helsinki. We will then perform an integrated analysis based on all the data gathered. The rationale behind the research setup is also practical: we are searching for planning and construction solutions that could be sustainable both from the perspective of local ecosystems and economically and socially.

As we get more data and the project proceeds, we will assess the proper ways to make the integrated analysis. Furthermore, we will attempt to link the results from these catchment areas to the socioeconomic and ecological development on the municipal and regional scales. Based on the results of the analysis, we aim at opening new discussions on the future development of urban planning.

2. Results and discussion

2.1. Data collected in the catchment areas

Data collection took place at three catchment areas in the City of Lahti and three catchment areas in the City of Helsinki. Figure 1 illustrates how the urban regions of Helsinki and Lahti are situated in the greater Helsinki Metropolitan Area. The City of Lahti, with a population of 100 000, is situated ca. 100 km north-east of Helsinki. The surface area of Lahti is 154 km^2 and population density 647 inhabitants/km^2. The population of the City of Helsinki (the capital of Finland) is 577 000, its land-surface area 213 km^2 and population density 2 707 inhabitants/km^2. Helsinki and Lahti regions are well connected via a motorway and a fast railroad.

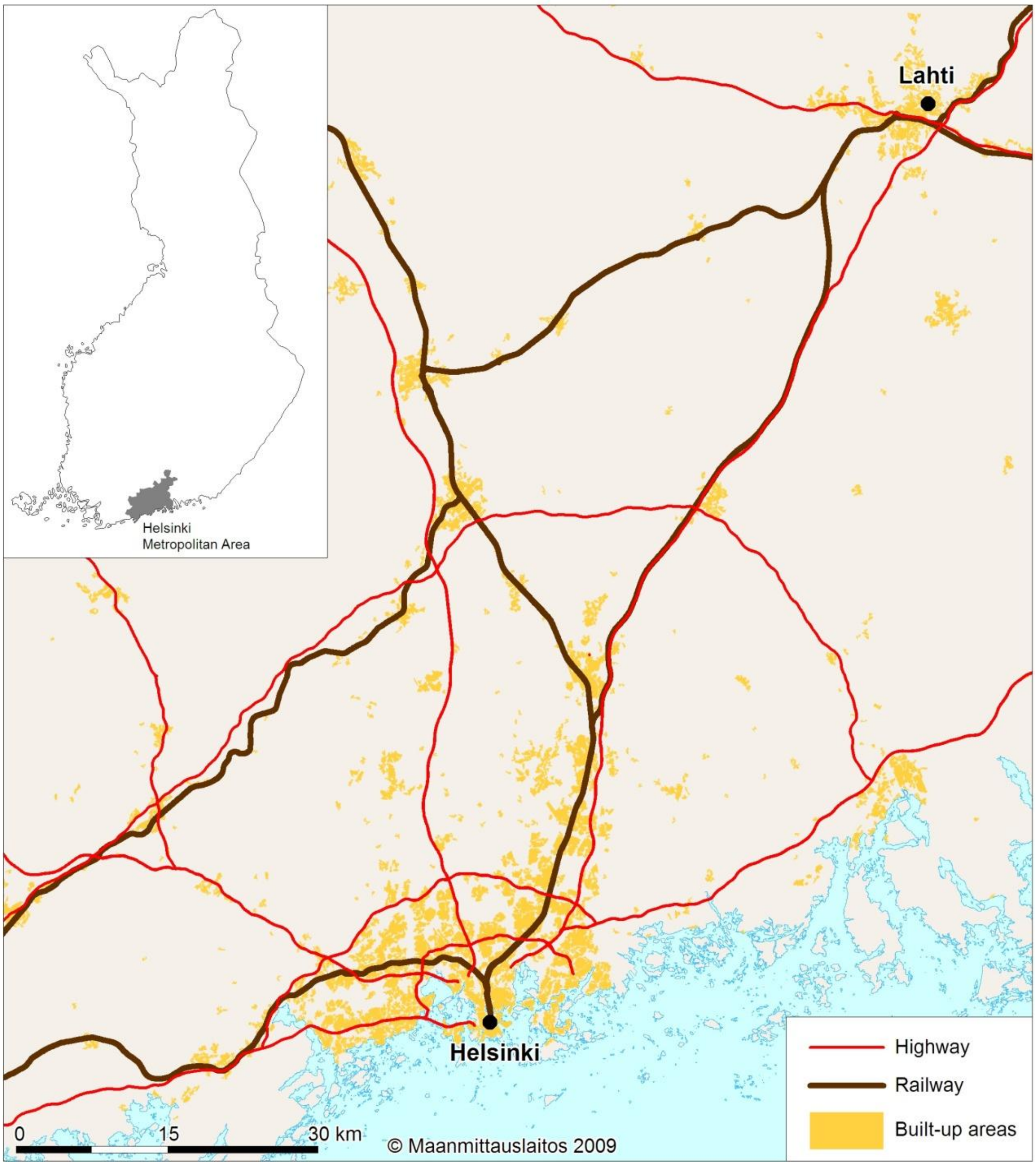


Figure 1. The Helsinki Metropolitan Area illustrating the urban regions of Helsinki and Lahti.

2.1.1. Catchment areas in Lahti

The three studied catchment areas in the City of Lahti were selected to present different population densities and different degrees of sealed surfaces (amount of pervious and impervious surfaces), and are accordingly called low-density, medium-density and high-density catchment areas. In terms of land-use the sites can also be referred to as low-, medium- and high-intensity areas as land-use intensity determines the proportion of permeable and impermeable soil in the area. Names in brackets (Kilpiäinen, Paavola, Taapelipolku) indicate the names of the districts where the catchment areas are located (see Figure 2).

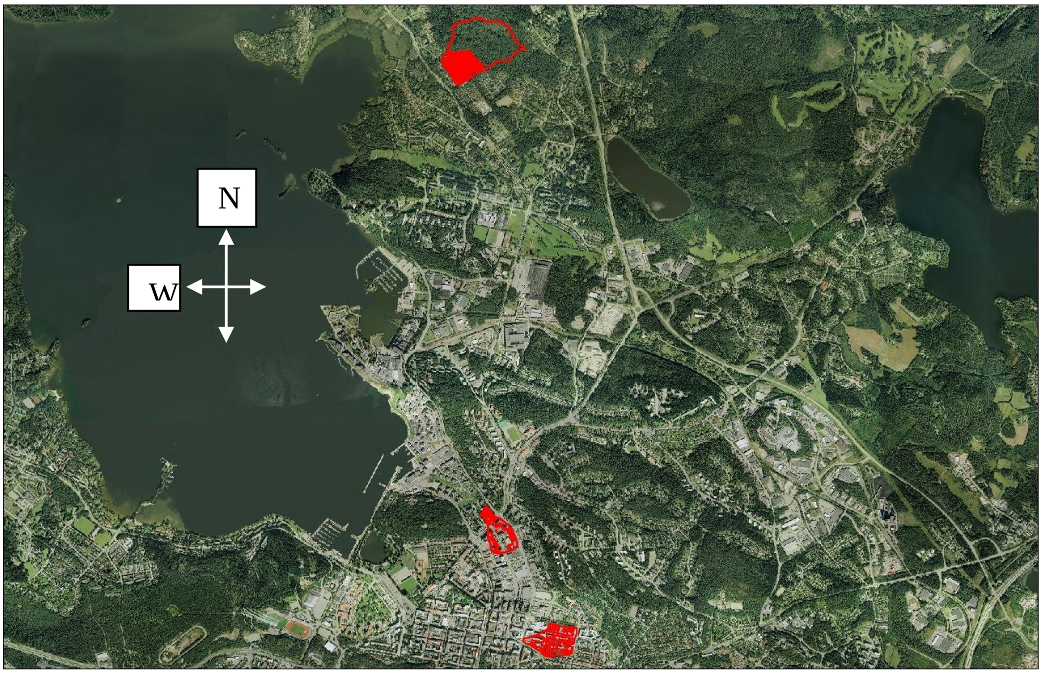


Figure 2. Aerial photograph of the northern part of the City of Lahti. The three study sites (catchment areas) are shown: the uppermost area = Kilpiäinen (low-density), the lowermost = Paavola (medium-density) and the area in between = Taapelipolku (high-density). The city centre is located southwest from Paavola catchment.

Figure 3. Low-density catchment area (Kilpiäinen) in a rural/residential area in the City of Lahti. The catchment border is illustrated by a magenta/red line. Areas within yellow lines are roofs. Streets and other impervious surfaces on the ground are marked with an orange line. The white bar = 100 m.

Low-density catchment area (Kilpiäinen): This area is situated in the rural/residential area in the City of Lahti. Only one third of the catchment area is built area and thus it has a low population density (ca. 700 inh. / km^2) and little impervious surface cover. Amount of pervious surface is high (ca. 90%) (Figure 3). Buildings are mainly single-family houses with spacious gardens, built mainly after the Second World War, especially in 1970's and 1980's.

Medium-density catchment area (Paavola): This area (Figure 4) is situated in an urban/suburban area in the City of Lahti, where population density is somewhat lower than in the high-density Taapelipolku catchment area (ca. 9 900 inh. / km^2 vs. 11 000 inh. / km^2 in Taapelipolku), and there are more pervious surfaces and their distribution is less fragmented than in the Taapelipolku catchment. Building base is two-fold, with wooden single-family and small apartment buildings from 1920's to 1950's on the eastern side and very recent high density housing blocks on the western side.

Figure 4. Medium-density catchment area (Paavola) in an urban/suburban area in the City of Lahti. In this figure blue line indicates the border of the catchment. Areas inside red (urban park), magenta (bushes) and yellow (lawn) lines are pervious soils. The white bar at the upper right corner = 100 m.

High-density catchment area (Taapelipolku): This area is situated in the city core of Lahti, where the population density is high (ca. 11 000 inh. / km^2) and pervious surfaces are rare and highly fragmented (Figure 5). The area has gone through an urban renewal process from an early 19th century industrial and business site to a housing block area built within the last two decades.

Figure 5. High-density catchment area (Taapelipolku) in the city core of Lahti. Red line indicates the border of the catchment and areas inside blue lines are pervious surfaces. The yellow bar at the low right corner = 100 m.

2.1.2. Catchment areas in Helsinki

The three studied catchment areas in the City of Helsinki also differ in their population density and the amount of pervious and impervious surfaces, and are thus called low-density, medium-density and high-density catchment areas accordingly. Names in brackets (Veräjämäki, Pihlajamäki, Itä-Pasila) indicate the names of the districts where the catchment areas are located (Figure 6).

Figure 6. Aerial photograph of the northern-central part of the City of Helsinki. The three study sites (catchment areas) are shown: the uppermost area = Pihlajamäki (medium-density), the lowermost = Itä-Pasila (high-density) and the area in between = Veräjämäki (low-density). The city centre is located ca. 3 km to the south of Itä-Pasila catchment area.

Low-density catchment area (Veräjämäki): This area is situated in a suburban area in the City of Helsinki, where population density is ca. 2 400 inhabitants per km^2. Veräjämäki residential area is an example of such suburban planning and construction from the 1980's, where buildings are mainly detached, single-family houses and the layout of residential blocks allows room for garden-like green areas in around the blocks (Figure 7).

Medium-density catchment area (Pihlajamäki): This area is situated in an urban/suburban area in the City of Helsinki, where population density is ca. 5 500 inhabitants per km^2. Pihlajamäki residential area represents an early idea of suburbs from the 1960's with predominantly apartment blocks and with relatively high proportion of green spaces (Figure 8).

High-density catchment area (Itä-Pasila): This area is situated in the core urban area in the City of Helsinki, where the population density is high (4 200 inhabitants per km^2) and pervious surfaces are rare and highly fragmented. Itä-Pasila area represents planning typical in the 1970’s: compact steel-concrete structures, massive decks etc. (Figure 9).

Figure 7. Low-density catchment area (Veräjämäki) in a suburban area in the City of Helsinki. The catchment border is illustrated by a green line. Red lines illustrate the main stormwater sewer pipeline system.

Figure 8. Medium-density catchment area (Pihlajamäki)_in an urban/suburban area in the City of Helsinki. In this figure green line indicates the border of the catchment. Red lines illustrate the main stormwater pipeline system.

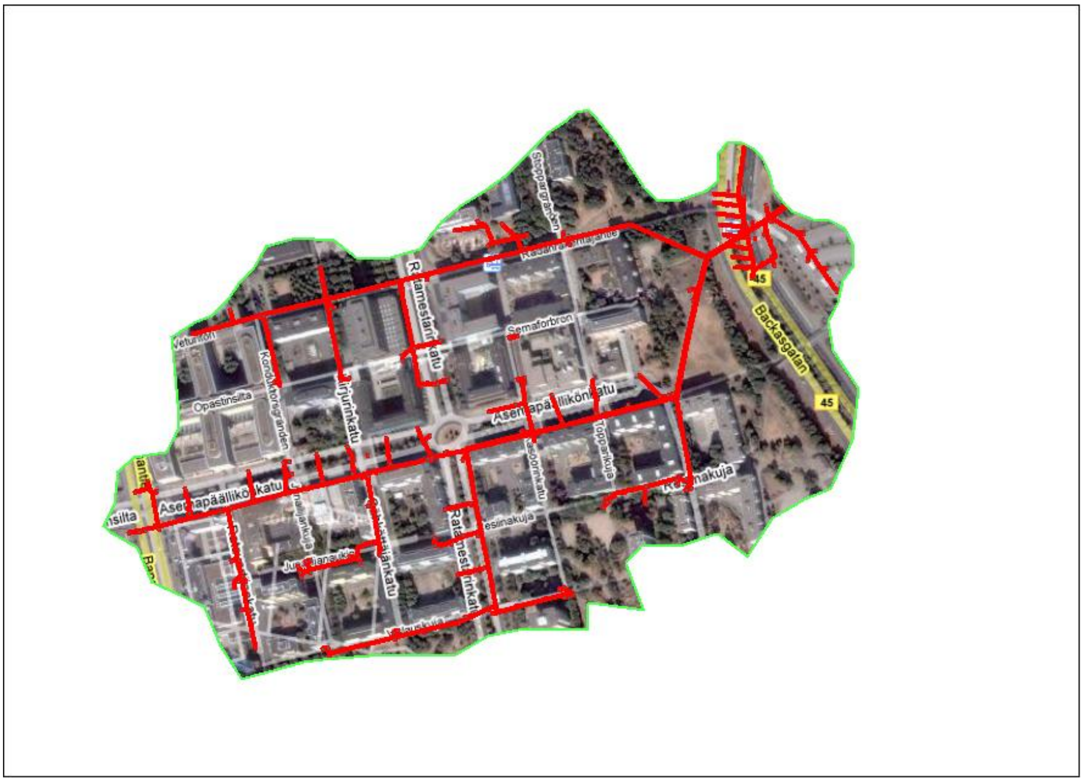


Figure 9. High-density catchment area (Itä-Pasila) in the core urban areas in the City of Helsinki. Green line indicates the border of the catchment. Red lines illustrate the main stormwater pipeline system.

2.2. Ecological data: pervious and impervious surfaces in Lahti

MapInfo software was used to define the amount and distribution of pervious and impervious surfaces in the three different catchment areas in the City of Lahti. The data were then verified by field observations. Statistics on population densities in these catchment areas were obtained from the City of Lahti (Table 1). Data from the City of Helsinki are not yet available, but will be after the second year.

Table 1. Population densities in three catchment areas in the City of Lahti (low-density catchment area (Kilpiäinen), medium-density catchment area (Paavola) and high-density catchment area (Taapelipolku)).

Catchment density	Size (km^2)	Population density ($inhab./km^2$)
Low	0,2043	700
Medium	0,0696	9 900
High	0,0613	11 000

Amount of pervious and impervious surfaces in the three catchment areas in Lahti are shown in Table 2. Total amount of pervious areas consists of green areas (park, garden, lawn, forest) and sand areas (e.g. sand-surfaced parking areas). Total amount of impervious areas consists of road surfaces and roofs (of buildings). Figure 10 illustrates a) the percentages of different types of surfaces of a total catchment area and b) the absolute coverage (km^2) of the surface types in a catchment area.

Table 2. Amount of pervious and impervious surfaces in the three catchment areas in the City of Lahti (low-density catchment area (Kilpiäinen), medium-density catchment area (Paavola) and high-density catchment area (Taapelipolku)). (* = includes parking areas with sand surface), n/a = data not available)

Catchment density	Size (km^2)	Park (km^2)	Garden (km^2)	Lawn (km^2)	Forest (km^2)	Total green (km^2)	Sand (km^2)	Total pervious (km^2)	Roads (km^2)	Roofs (km^2)	Total impervious (km^2)
Low	0,2043	0	0,0310	n/a	0,1515	0,18251	0	0,1825	0,0089	0,0129	0,0218
Medium	0,0696	0,00237	0,01620	0,00124	0	0,01981	0,00456	*0,0244	0,0228	0,0225	0,0453
High	0,0613	0,00262	0,00317	0,00064	0	0,00643	0,00222	0,0086	0,0368	0,0159	0,0527

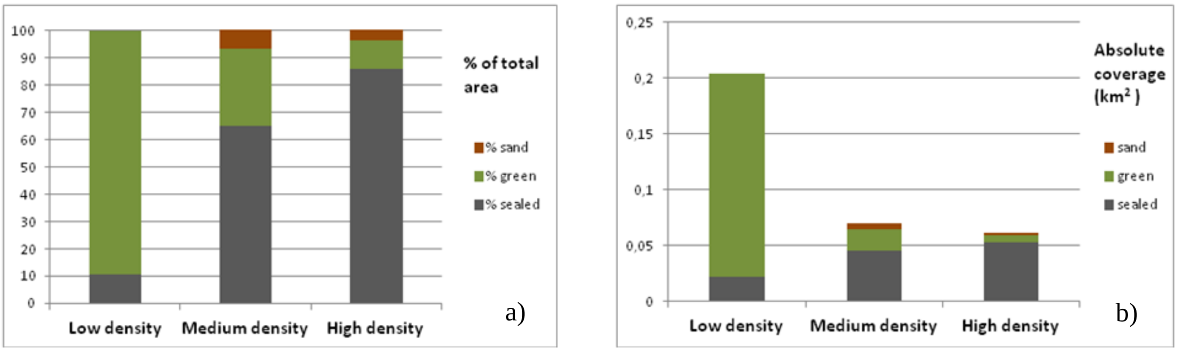
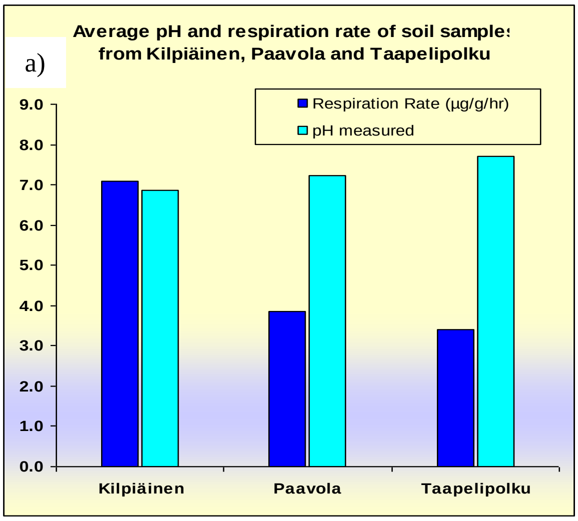


Figure 10. a) Percentages, and b) absolute coverages (km^2) of pervious (sand and green) and impervious (sealed) surfaces of total areas in three catchment areas in the City of Lahti (low-density catchment area (Kilpiäinen), medium-density catchment area (Paavola) and high-density catchment area (Taapelipolku)).

Based on the data from these catchment areas, it appears that the higher the population density is the lower is the amount of pervious surface. This is not surprising, but if the high-density area was designed differently, it would be possible to increase the amount of pervious surfaces even when maintaining the same population density. It is also interesting to observe how the quality of pervious surfaces varies in the different catchment areas (such as the amount of pervious sand surfaces and different types of green surfaces).

Figure 11 illustrates soil sample variables taken from the three catchment areas. The more urban (high-density) the catchment area is, the higher is the pH and the lower is the respiration rate (microbial activity) (Fig. 11a). Also the ratios of moisture at field capacity, organic matter in soil and soil moisture decrease with urbanization (Fig. 11b).



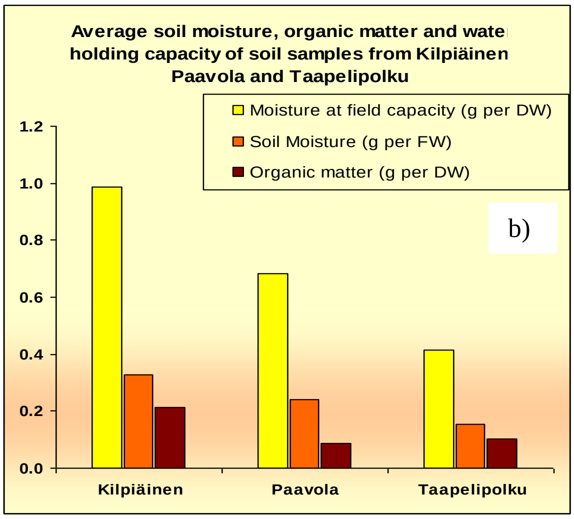


Figure 11. Average a) pH and respiration rate of soil samples, and b) soil moisture, organic matter and water holding capacity of soil samples from the three catchment areas in the City of Lahti (low-density catchment area (Kilpiäinen), medium-density catchment area (Paavola) and high-density catchment area (Taapelipolku)).

2.3. Urban runoff data in Lahti

Urban runoff data are at this time available only from Lahti catchment areas. Data from Helsinki catchment areas will be available after the second year.

2.3.1. Urban runoff quantity

The stormwater runoff data presented below are not affected by the surface area of the catchment. As with precipitation (calculated as mm of water falling into a given area), stormwater runoff is also described as the amount (mm) of water flowing out of a system (in ecological literature often termed as "outflow"). The flow was measured using an ultrasonic flow meter installed in a manhole of a sewer pipe at the catchment outlet.

The amount of runoff differed clearly between the three study sites (Figure 12). Irrespective of the season, the high- and medium-density sites leaked substantially more of the rain water out of the system as compared to the low-density area. For example, in September the difference between the low-density and the high-density area was over seven-fold. The difference in the quantity of water flowing out of the two urbanized catchment areas was less pronounced. However, the annual total (cumulative) runoff was larger in the high-density (283 mm) than in the low-density area (233 mm). The annual runoff in the low-density site was 85 mm only. In the more urbanized areas urban runoff peaked during the summer months while in the low-density area maximum monthly runoff took place during the spring season. At the low-density site 17% of the annual precipitation escaped the system via runoff, while in the medium-density and high-density areas the numbers were 43% and 54%, respectively.

It is well established that in cold climate natural ecosystems with pervious soils the outflow maximum occurs during the spring snowmelt period (Westerlund & Viklander 2008).

Consequently, the yearly pattern in the stormwater runoff in the low-density area indicates that this site, as depicted from its hydrological cycle, was still in a relatively natural state. Runoff seemed to correlate positively with precipitation in each of the three catchments but the runoff peaks were more pronounced in the more urbanized catchments reflecting the low permeability of soil surface in these two areas (Figure 12).

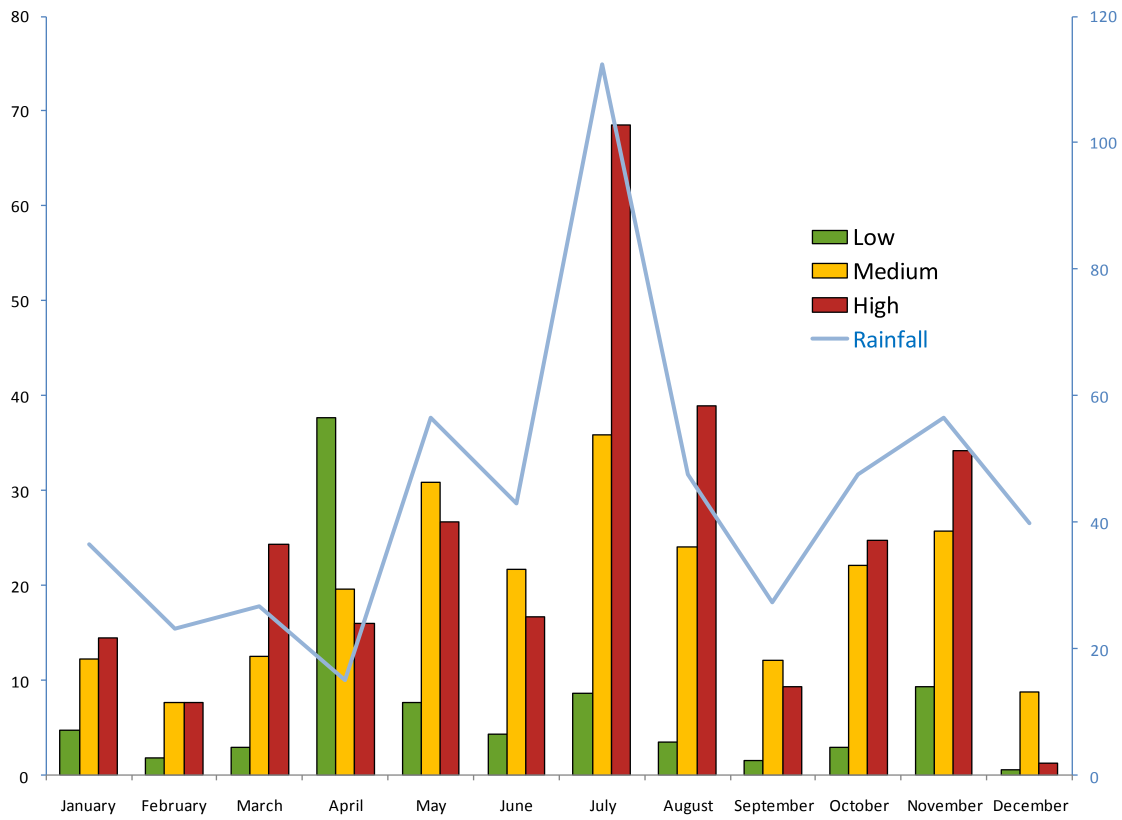


Figure 12. Monthly precipitation (rainfall) (mm; illustrated by the line; right-hand vertical axis) and urban runoff (mm; illustrated by the left-hand vertical axis) at the three catchments with different land-use intensities (low-, medium-, and high-intensity areas) in 2009.

2.3.2. Urban runoff quality

At this stage of our project only a limited set of runoff quality data is available. However, the conductivity data described below can be applied as an indicator for the concentrations of soluble nutrients (e.g. nitrate and phosphate), metals, and chlorides in the water. We have also taken water samples during each rain event using an automatic water sampler, but these data are under analysis at the time of writing this report. Furthermore, data for water turbidity (an indicator of the amount of solids in the stormwater) are unavailable at the time being due to technical problems with the turbidity sensor.

The conductivity of the runoff water was measured at 10 second intervals during the whole study period (2009) using a conductivity sensor. As with the quantity of the urban runoff, conductivity of the stormwater was clearly reduced in the low-density area as compared to the more urban sites (Figure 13). In most cases the mean monthly conductivity of the water was less than 10% of that in the urban catchment areas. Interestingly, of the two urban sites, the conductivity of stormwater at the medium-density site was constantly higher than in the high-density site. However, the winter time makes an exception with clearly highest conductivities measured at the high-density sites. While waiting for the results of the accurate water analyses we may speculate that the two peaks (January and February) are due to chloride used in road salt at the high-density areas with a dense network of roads.

The low conductivity of stormwater runoff at the low-density urban site is likely due to (i) a lower deposition of urban-borne pollutants and (ii) the much higher proportion of pervious, living soils that purify the stormwater.

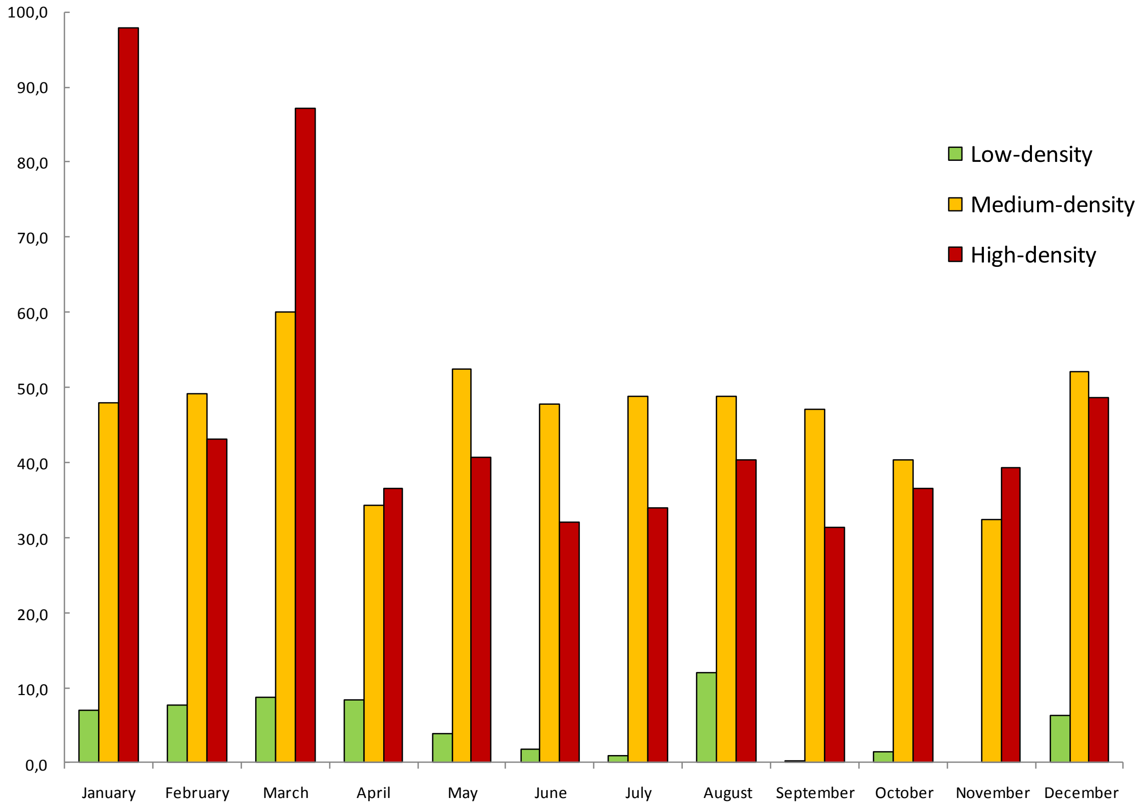


Figure 13. Monthly means (2009) of stormwater conductivity (mS/s) at the three catchments of differing (low-, medium-, and high-density) land-use intensity.

The temperature of stormwater was also followed throughout the study year 2009. It can be seen (Figure 14) that stormwater temperature roughly follows that of air temperature (data not shown) and that it always stays some degrees over zero (freezing) temperature. Stormwater was always warmer at the two urban sites than in the rural site, the difference varying between 1-2 °C. This difference may be due to the higher average air temperature at the urban sites (the urban heat island effect). It is also known that the sealed surfaces (roads and roofs) absorb large amount of solar radiation, thereby warming up the rainwater before entering the stormwater drainage system.

As with matter (solids, ions etc.) stormwater can thus transfer considerable quantities of energy out of the system. Thermal pollution due to stormwaters has been reported to be responsible for the deterioration of the water quality of urban brooks and small streams (Alberti 2008).

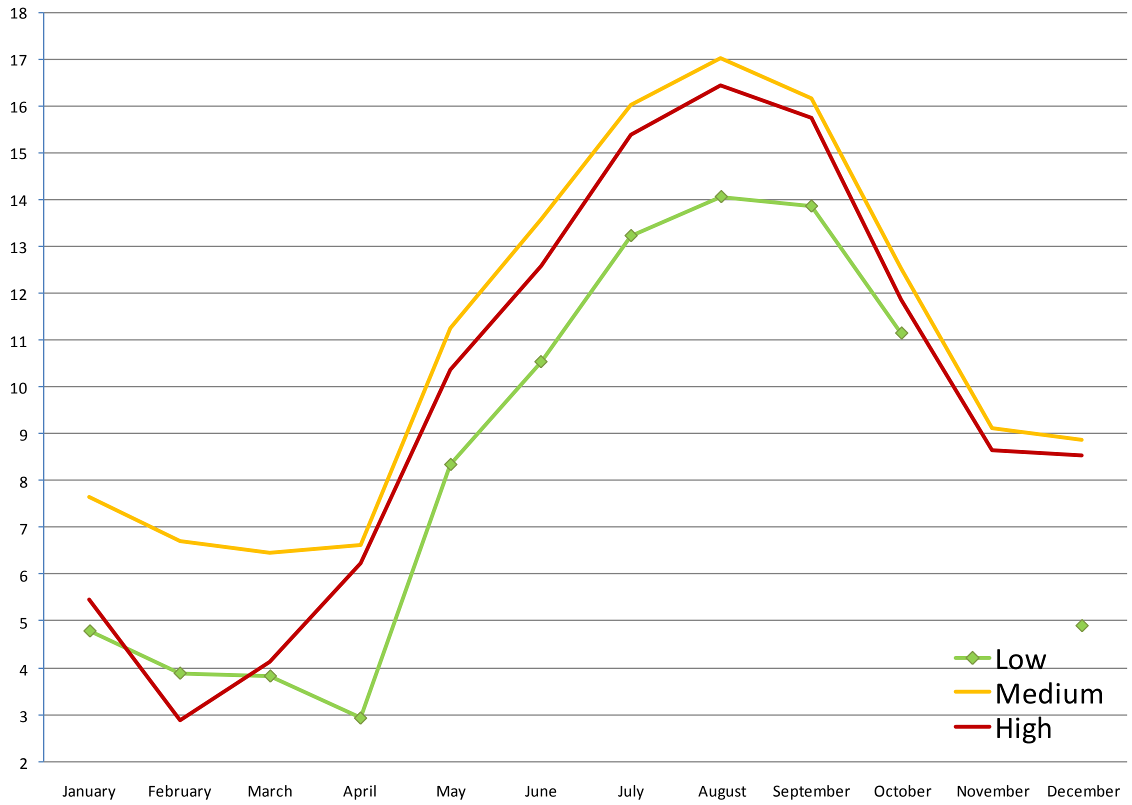


Figure 14. Monthly means (2009) of stormwater temperature (˚C) at the three catchment areas of differing (low-, medium-, and high-density) land-use intensity in Lahti.

2.4. Socioeconomic patterns

The socioeconomic data gathered so far aims at profiling the chosen areas with key indicators of their social and economic structure. The focus is on residential aspects, as most of the case areas are mainly in residential use. In this first phase, we are looking at the areas as part of their respective statistical city districts, to get a general view of them as part of the city. The statistical districts are defined by the cities themselves and used for censuses and gathering statistics. Thus, they are not fully comparable units between the cities.

In the next phase, we shall look inside the areas in a more detailed scale coinciding better with the limits of the water catchment area. This will bring up inner variations as well as more subtle trends that may be important in linking the ecological data with the socio-economic data. A first look at this level is here made for the case areas in Lahti, with 250 m x 250 m statistical squares. The square grid is produced by Statistics Finland (the national statistical institute) and the data is aggregated to square units. It offers a uniform and thoroughly comparable data between the case areas but does not contain all the essential indicators. For socioeconomic data concerning people, this will most likely be the most precise level where data can still be published without endangering individual residents' anonymity and privacy. The squares representing the catchment areas (see Table 3) were selected so that they covered most of the buildings in the catchment area and overlapped with neighboring areas as little as possible. In Kilpiäinen, almost the whole housing area fitted inside one statistical square. In Paavola and Taapelipolku, delimiting the catchment area from the square grid was less accurate, as they are inside dense urban structure and covering the water catchment area would have meant including big parts of neighboring areas. Eventually, two squares were selected for each area on the basis of delimiting criteria explained above.

The population and land-use densities of the case areas were already presented in Tables 1 and 2, and according to those figures the case areas are also here classified as low-density (Kilpiäinen and Veräjämäki), medium-density (Paavola and Pihlajamäki) and high-density (Taapelipolku and Itä-Pasila). The case areas in Lahti are presented in Table 3 and those of Helsinki in Table 4. In the following text we will first present key indicators of the building stock as well as demographic and socioeconomic structure of the population. Thereafter, we will shortly discuss the determinants of housing prices and present related information concerning the case areas.

Variable	KILPIÄINEN (Low-density)			PAAVOLA (Medium-density)		TAAPELIPOLKU (High-density)		City of LAHTI
	Year	Statistical district 203	Squares in the catchment area (1)	Statistical district 107	Squares in the catchment area (2)	Statistical district 113	Squares in the catchment area (2)	
1. Number of buildings	2006	364	51*	52	58*	35	32*	14 781
2. Share of residential buildings, %	2006	96	100*	85	90*	57	59*	87
3. Total floor space of all buildings	2008	104 158	--	64 210	--	119 540	--	8 239 522
4. Share of floor space in residential buildings, %	2008	98	--	81	--	56	--	61
5. Number of jobs in the area	2004	129	6	350	288	776	696	45 049
6. Inhabitants	2006	2 006	126	850	1 236	1 399	1 376	98 766
7. Population density (inhab. / km^2)	2006	1 393	2 016 / 672**	7 083	9 888	10 762	11 008	639
8. Share of pop. under 15, %	2004	19	4	5	6	18	17	16
9. Share of pop. over 65, %	2004	12	16	41	40	16	23	17
10. Average size of households	2005	2,2	2,6	1,5	1,4	1,8	1,7	1,9
11. Unemployment rate, %	2004	13	12	15	15	17	15	15
12. Average annual income of households	2005	N/A	57 883	N/A	25 645	N/A	25 697	N/A
13. Share of pop. with university degree, %	2005	N/A	24	N/A	14	N/A	11	13
14. Share of rental apartments	2005	31	0	40	61	65	73	41
15. Share of apartments in housing blocks	2005	43	0	97	98	99	100	71
16. Average floor space per person (m^2)	2005	N/A	46	N/A	38	N/A	33	N/A
17. Average size of apartments (m^2)	2005	N/A	121	N/A	55	N/A	57	N/A
18. Average price of apartments, per m^2	2010	1 421	--	1 964	--	2 152	--	--
19. Average price of 2-room apartments, per m^2	2010	1 633	--	1 921	--	2119	--	--
20. Average total price of apartments	2010	118 767	--	119 334	--	113 920	--	--

* In year 2005

** Population density in the square containing all the buildings in the catchment area and in all the three squares located inside the catchment area.

Table 3. Socioeconomic indicators of the case areas in the City of Lahti.

Variable	Year	VERÄJÄMÄKI (Low-density) Statistical district 285	PIHLAJAMÄKI (Medium-density) Statistical district 383	ITÄ-PASILA (High-density) Statistical district 173	City of HELSINKI
1. Number of buildings	2008	329	232	81	38 404
2. Share of residential buildings, %	2008	92	86	41	83
3. Total floor space of all buildings	2008	161 406	384 007	702 471	43 545 311
4. Share of floor space in residential buildings, %	2008	88	86	25	59
5. Number of jobs in the area	2002	535	1 042	8 174	373 381
6. Inhabitants	2008	2 864	7 443	3 833	568 531
7. Population density (inhab. / km^2)	2008	2 387	5 513	4 166	3 044
8. Share of pop. under 15, %	2004	19	15	11	16
9. Share of pop. over 65, %	2004	13	15	17	14
10. Average size of households	2005	2,2	1,8	1,7	1,9
11. Unemployment rate, %	2004	7	12	12	10
12. Average annual income of households	2005	63 276	33 115	32 123	42 258
13. Share of pop. with university degree, %	2005	43	21	24	24
14. Share of rental apartments	2005	45	50	59	47
15. Share of apartments in housing blocks	2005	59	94	98	86
16. Average floor space per person (m^2)	2005	37	33	35	35
17. Average area of apartments (m^2)	2005	84	60	57	63
18. Average price of apartments, per m^2	2010	2 723	2 081	2 849	N/A
19. Average price of 2-room apartments, per m^2	2010	2 787	2 208	2 808	N/A
20. Average total price of apartments	2010	251 897	127 942	160 714	N/A

Table 4. Socioeconomic indicators of the case areas in the City of Helsinki.

Before going into figures describing the actual population, we take a look at the **building stock** and their use. As we can see from Table 3 (variables 1-5), the amount of buildings as well as their residential use (measured both as building units and floor space) varies between the areas in Lahti. In Kilpiäinen, the statistical district is considerably bigger than the other two, both in terms of population and number of buildings. However, the part of the district inside the actual water catchment area is the smallest one both in area and population. The amount of buildings is now at the same level with other sites, as the residents there live spaciously in single-family houses. In this smaller area of Kilpiäinen, the whole building stock is in residential use and there are very few workplaces in the area, which separates it further from the other two case areas in Lahti. Paavola and Taapelipolku have more mixed functions in them, although a majority of buildings is in residential use also in them. In Paavola, less than a fifth of buildings as well as floor space is in other than residential use, but there are still several hundred workplaces located in the area. In Taapelipolku, the mix of functions is more even, as just a little over half of the building stock is in residential use and there are over 700 workplaces in the area. In this respect Taapelipolku compares well to its counterpart in Helsinki, the high-density area of Itä-Pasila, where residential use is actually in minority inside the region (Table 4). There are also over 8000 workplaces in Itä-Pasila, mainly in offices and shops. This sets Itä-Pasila apart from the rest of the case areas in both cities, although we already know that most of the district inside the actual water catchment area is in residential use. At the statistical district level, however, the very high population density in the residential areas of Itä-Pasila is not visible. The other two case areas in Helsinki compare quite well with their corresponding areas in Lahti, although it should be noted that Pihlajamäki has four times more buildings and is considerably bigger area than its' counterpart in Lahti.

The second set of indicators in Table 3 (variables 8-10) describes the **demographic structure** of the areas. The share of residents under 15 years seems to be rather high both in Taapelipolku and in Kilpiäinen, but at closer look it becomes clear that in Kilpiäinen children are mainly living outside the actual water catchment area. Still, the average size of households is at highest precisely inside the catchment area of Kilpiäinen. Paavola seems to be an area of small households. Its' younger population is considerably small also when compared to the case areas in Helsinki, which all have at least 10% of population under 15. The closest correspondent in Helsinki is Itä-Pasila. But it is the remarkably high share of elder population in Paavola, which profiles it as a residential area of adult families: 40% of the total population is over 65 years old, when the second highest share is only 23% (in the statistical squares of Taapelipolku). In Helsinki, no case area has the share of elder population over 20%. Still, the low- and high-density case areas in the two cities compare quite well with each other at the level of statistical district.

The next set of indicators describes the **social status and affluence** of the residents (variables 11-17). All the indicators seem to implicate that Kilpiäinen is the area with the highest social status and level of affluence among these case areas. The average annual income of households is more than twice of that in Paavola and Taapelipolku, and almost a quarter of the adult population has a university degree. Unemployment rate is also the lowest in Kilpiäinen, though not with such a wide gap as with previous indicators. Household income level and family size typically explain housing choices. As for tenure, in affluent Kilpiäinen, there is no rental housing and the average size of houses is over 120 m^2. Also, the floor space per person is remarkably high, even though the size of households was highest in the same area. From this perspective, it seems quite interesting that housing prices per square meter in Kilpiäinen are not that high when compared to other case areas in Lahti. Its' less central location explains this partly, but also different scales of the data affect the outcome: the socioeconomic indicators are mainly from the area of single-family houses that is inside the water catchment area, whereas the statistical district contains also the housing blocks close by. This highlights the need of data at detailed level for making reliable conclusions. Taapelipolku and Paavola are quite at the same level in respect of social status indicators, but when taking into consideration the varied housing stock in Paavola, the more detailed level of data will probably bring about differences between these two case areas. For this, however, a building level data is needed, as the statistical squares do not coincide with the division of housing types in Paavola.

When comparing the case areas of the two cities, we can see that even the most affluent area of Kilpiäinen still falls behind Veräjämäki, the detached, mainly single-family housing area in Helsinki. Here, almost half of the adult population has a university degree and unemployment rate is well below 10 %, although it should be noted that education and employment levels are in general higher in the capital than in the smaller cities of the Helsinki Metropolitan Area. Differences between Helsinki and Lahti are not that remarkable when the medium- and high-density areas are compared. The greater population density and higher housing price level in Helsinki can be seen in the figures describing housing stock and living space: the average size of houses in Veräjämäki is almost 40 m^2 smaller than in Kilpiäinen. It would be interesting to see, how this trend is visible in the plot sizes. Tenure choice is affected by the relative cost of owning and renting, and the availability of both tenure types. Housing prices are naturally much higher in Helsinki than elsewhere, but the same is true for rents, although we do not have information on the latter by area. Here, we just note that the highest share of rental apartments can be found in Taapelipolku, where two-thirds of apartments are rented even at the scale of statistical districts – inside the water catchment area, only a quarter of apartments are owner-occupied here.

Housing prices (and rents) reflect the existence and willingness to pay for internal and external characteristics of dwellings and related buildings as well as the "environments", where they are located. The "environment" consists of various location factors like distances and access to nearby private and public service facilities and the city centre. Moreover, nature-related issues, such as the access to green areas, waterfronts, etc., impact on the willingness to pay for housing. However, the market prices also reflect supply side, since the scarcity of desired characteristics increase their "prices". Although there is a single price (rent) for a dwelling bought (or rented), the implicit (so called hedonic) prices for characteristics can be derived by regression techniques from data on housing prices and their characteristics. They tell for instance that prices are higher in city centers and close (but not too close) to traffic networks, seaside locations or green areas.

In Tables 3 and 4 we also have some information on housing prices in the selected six locations. The source for this information is the housing price register of Ministry of Environment from which we could get the prices of sold dwellings in multi-storey and detached buildings by postal area code during the last month (December 2009 - January 2010). The advantage of this source is that there is also the name of subarea (but no address) in the information concerning each sale in addition to price and a few other characteristics. Thus sales of dwellings in our six areas can be detected. One of the disadvantages of this source is that the number of observations (transactions) is fairly low and excludes single-family houses. Because of this especially Kilpiäinen in Lahti and Veräjänmäki in Helsinki are not properly represented. The purpose here is simply to give a rough estimate of the market value and price per unit level of dwellings in the six areas.

The average market value (total price) of dwellings in the three areas of Lahti are very similar, all within 113 000 – 119 000 euro interval (see variables 18-20 in Table 3). In Helsinki the average market values in Pihlajamäki and Itä-Pasila are somewhat higher than the values in Lahti, but only a half of the average value in Veräjänmäki (Table 4). Looking at price per square meter is a first step in achieving a quality adjusted "price" for housing, although it controls for size differences and nothing else. Consequently, the areas in Lahti differ as Kilpiäinen (far from centre) is cheaper than the more centrally located Paavola and Taapelipolku. In Helsinki, Veräjänmäki and Itä-Pasila are much more expensive than Pihlajamäki, where the price per square meter level is about the same as in central Lahti sites (Paavola and Taapelipolku). To increase comparability slightly, the prices per square meter of dwellings with two rooms were considered separately. The price levels and the price structures in the six areas are very similar to what was described for all dwellings.

Above we have only given some basic information about population, buildings and especially housing at the study sites. This information indicates to what extent the three areas in Helsinki and Lahti differ. Also, it makes possible, to some extent, to evaluate whether the counterpart sites of Lahti are similar to those in Helsinki. It is a future challenge to explore connections between ecological and socio-economic phenomena and find out what kind of information is needed for such purposes.

As already mentioned in the beginning of this chapter, the next step is to get a closer look at the statistical districts. The 250 x 250 meter squares seem to offer quite a good scale especially in Kilpiäinen, but for Paavola even a more detailed scale is needed. Some data are available at the level of each building, which can later be used to aggregate data on the exactly same area as the water catchment area. These data consist mainly of information on buildings themselves and less on population. For this and for comparability of the two cities the square data are still needed, and a new update of the data has just come in at the moment of writing. Economic data on housing prices can be obtained at the accuracy of a street address, but it needs further work to be useful.

3. Conclusions

In this report we have presented data collected during the first year of VACCIA Action 6 (Urban Environments) project. The collected biophysical data consists of data on urban runoff, proportion of pervious and impervious surfaces and soil samples in three different catchment areas in the City of Lahti. Similar data on runoff and surfaces from three catchment areas in the City of Helsinki will be available by the end of the second year of the project. The collected socioeconomic data so far consists of indicators of socioeconomic structures, housing, and the prices of housing from the same catchment areas of both cities.

The studied catchment areas in both cities differ in their population density and the amount of pervious and impervious surfaces, and are thus called low-density, medium-density and high-density catchment areas accordingly. Based on the data on pervious and impervious surfaces from the catchment areas in Lahti, it is evident that the high population density correlates with the amount of impervious surface. Although this is not surprising, it would perhaps be possible to increase the relative amount of pervious surfaces while maintaining the same population density if the high-density area was designed differently. During the project, we will also monitor how the different types or qualities of pervious surfaces vary in the different catchment areas.

Based on the soil sample data from the catchment areas in Lahti, it appears that the more urban (high-density) the catchment area is, the higher is the pH and the lower is the soil respiration rate (microbial activity). Also the ratios of moisture at field capacity, organic matter in soil and soil moisture decrease with urbanization. These observations illustrate that sealing the surface by impervious materials is not the only way through which urbanisation ameliorates soils; the lowered quality of the remnant pervious soils further lowers the functionality of these soils. It is therefore not surprising that the various ecosystem services provided by soils are virtually non-existent in heavily-built urban settings.

The amount of runoff differed clearly between the three study catchments in Lahti. Regardless of the season, the high- and medium-density sites leaked substantially more of the rain water out of the system as compared to the low-density area. Most of the stormwater, often contaminated by urban-derived pollutants (see below), end up in surface waters in adjacent aquatic ecosystems. This illustrates how intensive land use in urban settings can lower the quality of e.g. lakes and other ecosystems far away from the urban site. This can be taken as “cryptic urban sprawl” with obvious changes in the environment, yet causing little visible change in the structural milieu. In cold climate natural ecosystems with pervious soils the outflow maximum occurs during the spring snowmelt period. This was visible in the low-density catchment and the yearly pattern in the stormwater runoff indicates that the site was still in a relatively natural state.

Only a limited set of runoff quality data was available at this stage of the project. As with the quantity of the urban runoff, conductivity of the stormwater was clearly reduced in the low-density area as compared to the more urban sites. The low conductivity of stormwater runoff at the low-density urban site was likely due to a lower deposition of urban-borne pollutants and the much higher proportion of pervious, living soils that purify the stormwater. These findings support the hypothesis that, as with quantity the quality of stormwater is directly controlled by the intensity of land use.

Stormwater temperatures followed roughly the air temperatures. Stormwater and air temperature was always warmer at the two urban sites than in the rural site, the difference varying between 1-2 °C. The difference may be due to the higher average air temperature at the urban sites. Moreover, it is possible that the sealed surfaces (roads and roofs), absorbing large amount of solar radiation, warmed up the rainwater before entering the stormwater drainage system. This observation refers to a possibility that not only material but also energy is conveyed out of the catchment area via the underground sewer system.

The socioeconomic data gathered so far aims at profiling the chosen areas with key indicators of their social and economic structure. The focus is on residential aspects, as most of the case areas are mainly in residential use. By using the set of variables, such as number of buildings, share of residential buildings, total floor space, share of floor space and number of jobs, we addressed the variability of building stock and their use in the case areas. The demographic structure of the case areas was determined using the shares of different age groups and average size of households as variables. The social status and affluence of the residents were addressed using variables such as unemployment rate, annual income level, shares of university degree and rental apartments etc. The housing prices were addressed using different price variables available.

This basic socioeconomic information gathered so far in the study areas indicates to what extent the three catchment areas in Helsinki and Lahti differ. Furthermore, it enables us to evaluate to some extent whether the counterpart sites of Lahti are similar to those in Helsinki. We have also presented some preliminary observations emerging from the data. As the project proceeds and we gather more data, we aim at creating connections between ecological and socio-economic phenomena and testing the hypothesis presented earlier. A proper integrated analysis of the data will follow at the later stage of the project.

The collection of biophysical data continues during the second year of the project and we are looking forward to receiving and analyzing more detailed and longer-term data on urban runoff quantity and quality from the Lahti catchments. We are also anticipating getting similar and comparable data from the catchments in Helsinki. Overall, the analyses of the biophysical data will be taken further during the second year of the project.

The next phase of the socioeconomic data collection is to look at the inner divisions of the statistical districts and to get better areal correspondence with the catchment areas. The 250 x 250 meter squares seem to offer quite a good scale especially in the low-density areas such as Kilpiäinen in Lahti, but for medium- and high-density areas more detailed scale is needed. It is very promising that some data (mainly information on buildings) are available at the level of each building, which can later be used to aggregate data on the exactly same area as the catchment area. For this and for comparability of the two cities the square data is still needed, and a new update of the data has just come in at the moment of writing. Economic data on housing prices can be obtained at the accuracy level of a street address, but it needs further work to be useful. The set of indicators presented here will also be developed further, when more data comes available and the connections to ecological aspects come clearer.

VACCIA/Action 6 working group members and their contributions to this report

- Prof. **Heikki Setälä** (University of Helsinki, Department of Environmental Sciences): ecological issues, runoff data
- Prof. **Jari Niemelä** (University of Helsinki, Department of Environmental Sciences): ecological issues
- Prof. **Heikki A. Loikkanen** (University of Helsinki, Department of Political and Economic Studies): socioeconomic issues
- Prof. **Matti Kortteinen** (University of Helsinki, Department of Sociology): socio-economic issues
- Prof. **Mari Vaattovaara** (University of Helsinki, Department of Geography): socio-economic issues
- Dr. **Vesa Yli-Pelkonen** (University of Helsinki, Department of Environmental Sciences): social-ecological linkages, compiling and editing the report
- Dr. **Kimmo Kurunmäki** (Joint Authority of Tampere Central Region): socio-political outlines, coordination of the work group in 2009
- MSc **Hanna Ristisuo** (University of Helsinki, Department of Geography): socioeconomic patterns
- Dr. **Olli Ruth** (University of Helsinki, Department of Geography): ecological/runoff issues
- MSc **Marjo Valtanen** (University of Helsinki, Department of Environmental Sciences): ecological issues, runoff data
- MSc (Tech.) **Nora Sillanpää** (University of Helsinki, Department of Environmental Sciences): ecological issues, runoff data

Tiivistelmä

Ensimmäisenä vuonna kerätty ja dokumentoitu aineisto

Heikki Setälä, Jari Niemelä, Heikki A. Loikkanen, Matti Kortteinen, Mari Vaattovaara, Vesa Yli-Pelkonen, Kimmo Kurunmäki, Hanna Ristisuo, Olli Ruth, Marjo Valtanen, Nora Sillanpää

Olemme tässä raportissa esittäneet VACCIA Action 6 (Urban Environments) -hankkeen ensimmäisenä vuonna kerätyn aineiston. Kerätty biofysikaalinen aineisto koostuu hulevesiaineistosta, vettä läpäisevien ja läpäisemättömien pintojen suhteista ja maaperänäytteistä kolmelta eri valuma-alueelta Lahden kaupungista. Samanlainen aineisto tuotetaan kolmelta valuma-alueelta Helsingin kaupungista hankkeen toisen vuoden aikana. Tähän mennessä kerätty sosioekonominen aineisto koostuu sosioekonomisten rakenteiden indikaattoreista sekä asumiseen ja asuntojen hintoihin liittyvästä aineistosta samoilta valuma-alueilta molemmista kaupungeista.

Tutkitut valuma-alueet molemmissa kaupungeissa eroavat väestöntiheydeltään sekä vettä läpäisevien ja läpäisemättömien pintojen määrältään, ja ovat siten tässä raportissa nimetty matalan tiheyden, keskitiheyden ja korkean tiheyden valuma-alueiksi. Lahden valuma-alueilta laskettujen läpäisevyysaineistojen perusteella on selvää, että korkea väestöntiheys korreloi vettä läpäisemättömien pintojen määrän kanssa. Vaikka tämä ei olekaan yllätys, niin toisenlaisen suunnittelun avulla saattaisi olla mahdollista nostaa vettä läpäisevien pintojen suhteellista määrää korkean väestöntiheyden alueella.

Lahden valuma-alueilta kerätyn maaperänäyteaineiston perusteella näyttää esimerkiksi siltä, että mitä kaupunkimaisempi (korkea tiheys) valuma-alue on, sitä korkeampi on maaperän pH ja sitä alhaisempi on maahengityksen aste (mikrobiaktiivisuus). Kaiken kaikkiaan monet maaperän normaalisti tuottamat ekosysteemipalvelut ovat hyvin vähissä raskaasti ja tiheästi rakennetuilla kaupunkialueilla.

Hulevesien määrä vaihteli selvästi kolmen tutkitun valuma-alueen kesken Lahdessa. Vuodenajasta riippumatta huomattavasti suurempi osa sadevedestä valui pois valuma-alueelta hulevetenä korkean ja keskitiheyden valuma-alueilla kuin matalan tiheyden valuma-alueella. Hulevesien laadun osalta vain rajoitettu määrä muuttujia oli kokonaan käytettävissä tässä vaiheessa hanketta. Kuten huleveden määräkin, myös huleveden sähköjohtavuus oli selvästi alhaisempi matalan tiheyden valuma-alueella kuin kaupunkimaisemmilla valuma-alueilla. Huleveden lämpötila seuraili karkeasti ilman lämpötilaa. Huleveden ja ilman lämpötila oli kahdella kaupungistuneemmalla valuma-alueella aina 1-2 astetta lämpimämpi kuin matalan tiheyden valuma-alueella.

Tähän mennessä kerätty sosioekonominen aineisto tähtää valittujen valuma-alueiden profilointiin niiden sosiaalisiin ja taloudellisiin rakenteisiin liittyvien indikaattorien avulla. Erilaisten muuttujien avulla tarkastelimme valuma-alueiden rakennuskannan ja rakennusten käytön vaihtelua, demografista rakennetta, asukkaiden sosiaalista statusta ja vaurautta sekä alueiden asuntojen hintoja. Kerätty sosioekonominen aineisto kertoo missä määrin tutkitut valuma-alueet eroavat toisistaan tai ovat samankaltaisia. Hankkeen ja aineiston keruun edistyessä tavoitteenamme on tarkastella valuma-alueiden ekologisten ja sosioekonomisten ilmiöiden välisiä yhteyksiä ja pyrkiä

testaamaan esittämiämme hypoteeseja. Varsinainen kaiken aineiston yhdistävä analyysi tapahtuu hankkeen myöhemmässä vaiheessa kun kaikki aineisto on kerätty.

Biofysikaalisen aineiston kerääminen jatkuu hankkeen toisen vuoden aikana Lahden valuma-alueiden osalta ja Helsingin valuma-alueilla aineiston keruu alkaa toisen vuoden aikana. Sosioekonomisen aineiston keruun osalta hankkeen toisena vuonna tavoitteena on pienipiirteisempi tarkastelu, jotta tuloksena olisi aineiston tarkempi vastaavuus valuma-aluerajoihin nähden.

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