Urban Metabolism and Quality of Life in Informal Areas

SaharAttia, Heba Allah E. Khalil

(Professor Dr. Sahar Attia, Cairo University, Faculty of Engineering, Department of Architecture, GametAlQahera Street , Giza, Cairo, Egypt, sahar.attia@gmail.com)
(Associate Professor Dr. Heba Allah E. Khalil, Cairo University, Faculty of Engineering, Department of Architecture, GametAlQahera Street , Giza, Cairo, Egypt, hebatallah.khalil@gmail.com)

1 ABSTRACT

The 21st century is known as the century of urbanization. Numerous debates are currently taking place to definecities and what they should aspire to be. A number of terms have appeared in this arena,such as sustainable city, eco-city and green city to name a few. However, the main question remains how to measure the performance of a city in regards tothese aims. In addition, it is vital to note that major urbanization activities take part in cities of the developing world, where informalization is synonym to urbanization, thus necessitating a profound study of informal areas and their potential role in achieving sustainable cities. This paper studies how acity performs in terms of consuming and producing resources and how they flow through its various systems, described as urban metabolism. The paper particularly discusses how informal areas perform regarding their metabolism, focusing on water flow through these areas as a priority identified by the residents. Imbaba district, one of the largest informal areas in Cairo, is investigated as a case study to determine the actual quality of life of local residents and their ecological footprint and to providepractical insights. The whole process depends on a multidisciplinary participatory research where the citizens and local community based organization are the focal point. In addition, the process depends on open source data and data sharing as a way to empower local communities to identify their needs and issues and hence their appropriate interventions. This is conducted through questionnaires and interviews to identify what the current conditions and processes in informal areas provide for the residents. The paper concludes with identifying points of leakages in the resources flows and the possible interventions to improve the quality of life in the area while maintaining an efficient use of local resources and minimizing the impact of urbanization of the ecological footprint of cities. This will assist cities to become more resilient in the face of water scarcity, and provide a more vibrant life for its residents.

2 INTRODUCTION

Since 2007, more people are living in cities than in the countryside. (GlobeScan and MRC Mclean Hazel, 2007) Some studies estimate that by the middle of the century 70% of world's population will reside in cities. This current process of urbanization is seen by many scientists to be one of the reasons for climate change, where most of the CO2 emissions from the built environment come and where the highest consumers live resulting in very high ecological footprints. The recent report by Working Group I Contribution to the IPCC Fifth Assessment Report: Climate Change 2013 states that "it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century. (IPCC WGI AR5, 2013)This rapid urbanization is mainly taking place in the developing countries where more than 70 % of the world's urban population currently live and is lead by Asian cities then African ones. (UN- HABITAT, 2012)

Over the past 50 years, cities have rapidly expanded onto their surrounding land at a rapid rate. Highways and transport systems have been built in tandem to support this physical growth. Valuable farmland has been eaten up and car dependency has increased. There are numerous theories and debates to how to manage such growth both to provide an adequate quality of life for the city dwellers and to efficiently use the limited resources within a global economic and environmental crisis. These include the terms eco-city, sustainable city, green city and the most recent addition the resilient city. However, it is vital to note that most of the urbanization that is taking place in developing countries cities is takes the form of informal development. Most of the added areas to the city are basically built with no prior planning by professionals.

This paper aims addressing the issue of urban metabolism; cities consumption and production of resources and how the various resources flow through urban districts. It studies how particularly informal areas perform regarding their metabolism, focusing on water flow through these areas as a priority identified by the residents. Through the use of different methods including GIS, Urban Metabolism Information System

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UMIS and crowdsourcing data, the paper calculates water flow and its consequential interventions to improve metabolism and respond to resource scarcity increasing the resilience of the city.

3 QUALITY OF LIFE AND ECO-RESPONSIVE CITIES

Quality of life has been the domain of development discourse for the past decade. It has been widely recognized that measuring progress in terms of GDP is not sufficient. There have been many attempts to address the issue. However, diverse "objective" and "subjective" indicators across a range of disciplines and scales, and recent work on subjective well-being (SWB) surveys and the psychology of happiness have spurred renewed interest.(Costanza, et al., 2008). In addition, developing eco-responsive cities has dominated the study and practice of urban development as a response to climate change and resources limitations.

3.1 Quality of life indicators

It is widely accepted now that seeking better quality of life should be the ultimate goal of development plans and not just economic progress. According to the Economist Intelligence Unit (2005), it has been accepted that material wellbeing, as measured by GDP per person, cannot alone explain the broader quality of life in a country. One strand of the literature has tried to adjust GDP by quantifying facets that are omitted by the GDP measure—various non-market activities and social ills such as environmental pollution. However, the approach has faced insurmountable difficulties in assigning monetary values to the various factors and intangibles that comprise a wider measure of socio-economic wellbeing.(The Economist Intelligence Unit EIU, 2007) Currently, there are a number of indices proposed and used by different organizations to score and rate cities and countries according to their quality of life. These organizations vary in nature and interests and thus in focus and methodology. (Khalil H. E., 2012) The most important indices are Quality of Living by Mercer consultants[1] (Mercer, 2011), Quality of Life index by The Economist Intelligence Unit (The Economist Intelligence Unit EIU[2], 2007), and YOUR BETTER LIFE INDEX by The Organization for Economic Cooperation and Development (OECD). (Organization for Economic Cooperation and Development OECD, 2011) It is apparent that these different indices focus on a number of common aspects as the main core of quality of life, namely: Housing, Income, Jobs, Community, Education, Environment, Governance, Health, Life Satisfaction, Safety and Work-life balance.

Despite these various efforts, an important aspect is still missing in most indices. It is sustainability, which could identify whether this level of quality of life can be sustained or not, whether it is affecting the ability of future generations to attain such levels or not and how this quality of life uses various resources. This notion is still underscored, as it is complex to assess.(Khalil H. E., 2012)

3.2 Green rating indices

One of the most common indices to assess sustainability is the ecological footprint EF. (Wackernagel & Rees, 1996) It requires quantitative procedures for assessing total flows in an area and compares it to the faced constraints imposed by the planetary ecosystem (carrying capacity). EF converts flows into the area ofproductive ecosystems required to sustain such flows. However, the limitation of this index lies in its dependency on standardized and rigorous methods for environmentalaccounting, especially when comparing locations or over time or formulating backcast and forecasting scenarios. (Moffatt & Kohler, 2008)

Worldwide, tools for evaluating cities are not as widely available as they are for buildings. There is a growing demand for tools to evaluate measures and activities on the scale of a city or society as a whole. Currently there are a number of indices to rate urban agglomerations varying in scale and thus the criteria or indicators they monitor or rate. Among these indices related to the urban scale are CASBEE for urban development and CASBEE for cities in Japan, LEED for neighbourhoods in the U.S. and Green City Index developed by The Economist Intelligence Unit and Siemens. This Index measures the current environmental performance of major cities in different continents, as well as their commitment to reducing their future environmental impact by way of ongoing initiatives and objectives. The Economist Intelligence Unit in cooperation with Siemens developed the methodology. (The Economist Intelligence Unit, 2009) It scores cities across eight categories: CO2 emissions, energy, buildings, transport, water, waste and land use, air

[1] Global leaders for trusted HR and related financial advice, products and services
[2] The business information arm of The Economist Group, publisher of The Economist

quality and environmental governance and 30 individual indicators. Sixteen of the index's 30 indicators are derived from quantitative data and aim to measure how a city is currently performing while the other 14 indicators are qualitative assessments of cities' aspirations or ambitions. Currently this index covers areas: Europe, Latin America, Asia, US and Canada, Germany and Africa.(Green City Index, 2012)

Other indices related to assessing the sustainability of settlements tailored local circumstances include: megacity sustainability indicators in Brazil (Leite & Tello, 2011), The Sustainability Cities Index rating the biggest 20 cities in the United Kingdom(Forum for The Future; General Electric GE, 2010) and The Freiburg Charter for Sustainable Urbanism (The Academy of Urbanism, 2010).

City prosperity index CPI has attempted to fill the gap in assessment indices. It comprises five different dimensions: productivity, infrastructure development, quality of life, equity and social inclusion and environmental sustainability. (UN- HABITAT, 2012) It addresses both issues of quality of life and sustainability. However, the indicators that constitute quality of life in CPI is just a part of the overall indicators comprising the notion of quality of life as viewed by other indices. Table 1 shows a comparison between indicators of different indices.

Sector	Quality of Life Indices			City Prosperity Index
	Mercer	EIU	OECD	
Political	Political & Social Environment	Political stability & security	Safety	laws, regulations & institutions, urban planning,
		Political freedom		Civil society, trade associations, special agencies
Governance			Governance	
Economic	Economic Environment	Material wellbeing	Income	Productivity
	Consumer Goods	Job security	Jobs	Capital investment, formal/informal employment, inflation, trade, savings, export/import & household income/ consumption.
				city product
Infrastructure	Public Services & Transport			Infrastructure Infrastructure proper
House	Housing		Housing	Housing
Social Serv.	Medical & Health Considerations	Health	Health	Quality of life
	Schools & Education		Education	Education, health sub-index.
Socio-Cultural	Socio-Cultural Environment	Family life	Community	Public space
	Recreation	Community life	Work-life balance	
			Life Satisfaction	
Environment	Natural Environment	Climate & geography	Environment	Environmental Sustainability: protection of urban environment and natural assets, energy efficiency, minimize pressure on surrounding land & natural resources, minimize environmental losses
Equity		Gender equality		Equity: reduces poverty & the incidence of slums, rights of minority & vulnerable groups, gender equality, civic participation

Table 1: Comparing Quality of Life Indices and City Prosperity Index, (Khalil H. , 2014)

A recent addition to the list is the International EcocityFramework and Standards developed by the ECOCITY builders and the BCIT, Canada. (International Ecocity Framework and Standards, 2011)It is still

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under development but has some similar categories and indicators as the Green City Index. It is comprised of 15 universal conditions for healthy cities and a civilization in balance with earth systems organized through 4 fundamental urban arenas: urban design (access by Proximity, safe housing and green building, affordable housing, environmentally friendly transport), bio-geo-physical conditions (clean air, healthy soil, clean and safe water, responsible resources/materials, clean and renewable energy, healthy and accessible food), ecological imperatives (healthy biodiversity, live within earth's carrying capacityand ecological linkages) and socio-cultural conditions (eco-friendly culture, community capacity and governance, healthy and equitable economy, lifelong education, well being – quality of life). Moreover, it depends on more qualitative assessment rather than quantitative assessment, which can serve better when using participatory evaluation of environmental performance of districts and cities. This framework is the base for the quality of life questionnaire used in this research.

Despite all these studies, informalization as the currently most prominent feature of urbanization remains a surmountable challenge. As major urbanization, activities are taking place in the developing world and mostly outside the legal and formal regulations. It is estimated that more than 60 % of Cairo is informal areas with more areas added daily. Thus, the issue of creating and sustaining prosperous cities becomes crucial. The city might be productive but not equitable and with low quality of life. Therefore, it is vital to highlight the debate between fulfilling needs and achieving overall prosperity and using resources in an ever-growing resource scarcity.

4 URBAN METABOLISM

Wolman (1965) first developed urban metabolism where, according to White (2002), he used national data on water, food and fuel use, production rates of sewage, waste and air pollutants to determine per capita inflow and outflow rates for a hypothetical American city of one million people. Through this study, he helped focus attention on system-wide impacts of goods consumption and waste generation within urban areas. (Decker, Elliott, Smith, Blake, & Sherwood Rowland, 2000). It can be defined as "the sum total of the technical and socio-economic processes that occur in cities, resulting in growth, production of energy, and elimination of waste" (Kennedy, Cuddihy, & Engel Yan, The changing metabolism of cities, 2007). Urban metabolism is based on an analogy with organisms' metabolism and as resembling ecosystems. However, cities are more complex than single organism that consume resources from its surroundings and excrete wastes. Thus, it can be more congruent with ecosystems, where achieving a natural ecosystem is the ultimate goal of developing sustainable cities. (Kennedy, Pincetl, & Bunje, 2011) However, current urban practices have resulted in much less sustainable development that follows a linear metabolism with high through flows of energy and materials and few loops and recycling of resources. There is a growing need to convert existing cites and urban development into more cyclical metabolism where resources are conserved and efficiently deployed, a similar process as natural ecosystems. (Gerardet, 2008; Newman & Jennings, 2008)

Study of Urban Metabolism, although started in 1965, has seen a period of low interest during the 1980s and then remerged to attract significant interest in the past decade. Two main approaches guiding the study of urban metabolism can be identified. The first is based on the work of Odum (Odum, 1983) that aims to describe urban metabolism in terms of energy equivalents and mainly solar energy equivalent or emergy. A number of studies followed this approach to calculate the urban metabolism for cities as Miami (Zucchetto, 1975), 1850s Paris (Odum, 1983), Taipei (Huang S. , 1998; Huang & Hsu, 2003) and Beijing (Zhang, Yang, & Yu, 2009).

The otherapproach follows a broader approach expressing the different resources flows through the city: water, materials and nutrients, in terms of mass fluxes. It follows the progress done in the 1990s in the development of the method of material flow analysis (MFA), where MFA reports stocks and flows of resources in terms of mass. In essence, the two approaches are not that far apart; they quantify the same items, but just use different units. (Kennedy, Pincetl, & Bunje, 2011)

One of the first researchers to identify the key link between urban metabolism and the sustainable development of cities was Girardet (1992). This paper follows the second approach regarding the study of urban metabolism and although there are many uses for it, this research uses urban metabolism as a tool for sustainable urban design and planning.

4.1 Resource flows through the city

Few studies seriously attempt to move beyond analysis into re/designing the city to be more sustainable/ resource efficient. Oswald and Baccini (2003) demonstrated in their work in Netzstadt how a combination of morphological and physiological tools can be used in the "long process of reconstructing the city". John Fernandez and students in MIT's School of Architecture have used the perspective of urban metabolism regarding material flow analysis in considering redesign of New Orleans after Hurricane Katrina. (Quinn & Fernandez, 2007)

In University of Toronto, Civil Engineering students studied the urban metabolism in order to design infrastructure for sustainable cities. They faced many challenges regarding the integration of various infrastructure. (Codoban & Kennedy, 2008; Engel Yan, Kennedy, Saiz, & Pressnail, 2005; Kennedy C. , 2007). However, they traced the flows of water, energy, nutrients and materials and attempted to design the city/ neighbourhood to close loops and reduce resource consumption. They have proposed ideas such as the use of grey water for toilets and outdoor use; using sludge from wastewater on community gardens for food production. Powering buildings and providing light rail systems with energy from municipal waste and recycling fly-ash from the waste gasification plant as building material were also proposed. These measures have significantly reduced the input of energy, water, materials, and nutrients. (Kennedy, Pincetl, & Bunje, 2011)

Resources that were investigated as part of the urban metabolism process in cities included: nutrients (nitrogen and phosphorus) with a focus on individual substances (Færge, Magid, & Penning de Vries, 2001; Burstrom, Frostell, & Mohlander, 2003), water issues (Hermanowicz & Asano, 1999; Gandy, 2004; Thériault & Laroche, 2009; Sahely & Kennedy, 2007; Baker, 2009), urban material stocks and flows (Niza, Rosado, & Ferrão, 2009; Schulz, 2007; Barrett, Vallack, Jones, & Haq, 2002) and specific metals in relation to their environmental burden and potential future resource (Sörme, Bergbäck, & Lohm, 2001; Svidén & Jonsson, 2001; Obernosterer, 2002; Obernosterer & Brunner, 2001).

Other related methods to quantify the flow of materials include Life Cycle Assessment LCA, which provide a cradle-to-grave assessment of a process or larger system including direct, indirect, and supply chain effects, and analyse the associated environmental impacts from extraction to final disposal. (Solli, Reenaas, Stromman, & Hertwich, 2009; Chester, et al., 2010) The International Standards Organization (ISO) defines LCA as the complication and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle. (International Standards Organization (ISO), 1997) It is widely applied in industry to measure and compare the lifetime environmental impacts of materials and processes from the product design/development, followed by resource extraction, production, use/consumption and end of life activities. (Holmes & Pincetl, 2012). According to (Moffatt & Kohler, 2008), LCA differs from most other environmental costing and assessment by extending time scales both forward and backwards as product's life cycle starts when raw materials are extracted from Earth, and ends with waste management including recycling and final disposal.Moreover, life-cycle analysis (LCA) and materialflow analysis (MFA) have been refined and standardizedand a common framework of sorts has beeninitiated through building information models (BIM)and stock aggregation methods. However, LCA widespread application in the built environment has faced a challenge of intensive data requirements and the risk of beingincomplete. In addition, this method assumes a frozen future with no change in technology, no new environmental constraints or new demand on building materials and landuse. (Moffatt & Kohler, 2008)

There is aneed for a complementary information structure based upon parcels and flows, where a parcel may consist of a residential building, or a park, a road, a shopping mall, or even a sewage treatment plant. Each parcel can be treated the same way regarding information structure as each has the possibility of resource demand and supply. At any time it can become a source of surplus water, energy, peak power, organic material, …etc.

Moffat & Kohler (2008) propose a combination of methods based on system-ecological and thermodynamic modelling encompassing various flows of mass, energy, financial and information to be able to successfully calculate Urban Metabolism. They stress on the importance of aggregation for MFA, where information is collected on the local scale of a parcel then aggregated to bigger scales. Similar approaches have been successful with bottom up LCA where products can be aggregated into assemblies, and assemblies into buildings, and buildings into stock at various urban scales. (Kohler, 2006)

4.2 Linking the flow to the QOL indicators

It is vital to note that most of the studies of urban metabolism have focused on the materials flow with few or no integration of social metabolism. Among the few scholars was Newman's work on Sydney, where he included liveability measures: indicators of health, employment, income, education, housing, leisure and community activities. (Newman P. , 1999; Newman, et al., 1996) Other scholars have attempted to link urban metabolism and Quality of Life. (Stimson, Western, Mullins, & Simpson, 1999; Lennox & Turner, 2004)There is a growing awareness for the need for extending Urban Metabolism to cover socio- ecological systems. This perspective considers the built environment and the ecosphere as complex, dynamic self-producing systems, where the built environment should be defined not as an object but rather as social-ecological system. (Moffatt & Kohler, 2008; Rees, 2002; Walker, et al., 2006)

It is vital to consider a closed material realm, where all flows from nature and built environment must be balanced over long-term. This can be tracked by environmental accounting, where the question is how to live within fixed rates of flows either by reducing demands or by achieving greater service value from any resource inputs. (Moffatt & Kohler, 2008)An advantage of MFA in this aspect is that it helps to focus on the most significant flows, and on the most obvious opportunities for ecological design (looping and cascading).

In addition, different economies have different flow pattern. In pre-industrial economies there are a variety of inputs but with a low level of flow. While there are fewer inputs in industrial economies, larger flow quantities, with greater use of import/export and storage to balance the flows. It is interesting to note that in resource-efficient economies, there is a diversity of inputs, but there is extensive looping and cascading in the flow pathways to extract added value from the inputs. (Moffatt & Kohler, 2008)

This case study developed in this paper adopted the MFA as a tool to calculate the urban metabolism for urban areas. It has followed a methodology combining the calculation of resource flows and a questionnaire to determine the Quality of Life of local residents in addition to their ecological footprint based on their personal consumption. Thus, the net performance can be measured in terms of combined natural, social and cultural capital.

In the same sense, ecological footprint can be used on the national and regional level to direct policies and development strategies. While collecting information on the parcel level help design tailored solutions that address specific situations and are more resource efficient and better relate to local actors. What will be passed on to the bigger scale/ level would be the services that cannot be successfully satisfied on the local scale (due to economic, technical or other practical reasons). This would help create a self-organizing and self- reliant properties to the built environment similar to natural ecologies (which can be found to a great extent in the informal/ self built urban areas)

5 INFORMAL GROWTH AS A REACTION TO UNAVAILABILITY OF AFFORDABLE FORMAL OPTIONS

Informal growth is the dominating pattern in the urbanization process all over the developing world. It is the way how people supply their needs where their governments fail to do. Informalizationcan be defined as "a process which is unregulated by the institutions of society in a legal and social environment in which similar activities are regulated".(Oldham, Shorter, & Tekce, 1994, p. 10)There are mainly two types of informal areas: squatter areas and informal subdivisions. Squatter areas are mainly chaotic, unplanned and marginal, while informal subdivisions are subdivided land with legal ownership but lack infrastructure and areas for public services and uses. (Imperato & Ruster, 2003)

A study in 2007 defined informal areas in Egypt as "all what is self-built, whether single or multi storey buildings or shacks, in the absence of law and urban regulations enforcement. They are areas built on land not allocated for construction as specified in the city urban plan. Despite the buildings' conditions may be good, they might be unsafe environmentally and socially, and or lacking basic infrastructure and services." (GOPP & UNDP, 2007) However, in Egypt, the term used for these areas since 2008 is either unsafe areas developed by the Informal Settlement Development Facility ISDF (ISDF, 2011)which are similar to slums as defined by the UN-Habitat indicators and unplanned areas defined by the unified building law 119 for the year 2008.

Moreover, the general classification of informal areas, in Egypt, includes informal areas built on agricultural land (comprising the majority of informal development in Egyptian urban areas). They are illegal as they are built on agricultural land, not allocated for construction, and they defy the banning of mixed uses as specified by law. Their general characteristics are: (a) narrow long streets with width no more than 4-5 meters, some even with dead ends; (b) regular block shapes according to agricultural basins subdivisions and; (c) housing units having constant depth but with different street frontage. Heights are according to owner's affordability. The other apparent type is areas built on desert land (which suffer more deteriorated living conditions), in addition to shacks and environmentally unsafe areas.They appear on vacant land on city fringes, where the land is publicly owned, making the buildings there illegal. Their general characteristics are: (a) curved, uneven streets; (b) temporary houses made of primitive materials such as tin, carton or straw and; (c) insecure tenure.

According to(Khalil H. E., 2010) informal areas do possess many aspects defined by sustainable urbanism theories. They have defined edges that separate them from their surrounding areas, a railroad, canal or ring road. They have a distinct urban pattern, especially those following agricultural basins subdivisions. Secondary streets act as recreational spaces where children play due to the prevailing sense of security. As for the quality of architecture, in some areas, it can be poor but can be upgraded to promote local character and sense of place. However, the prevailing visual image is homogeneous, due to buildingusingthe same materials, bricks and concrete, and following the same urban pattern. Informal areas are compact with high densities, e.g. 890 person/hectare in Boulaq Aldakrour district, Cairo exceeding other formal areas due to the privately development mechanism. Thus, providing a perfect setting for walkability and energy efficiency. The buildings are stacked together with usually only one free façade, which minimizes thermal loads, maximizes space use and enhances energy efficiency. They are characterized by narrow streets, which are mainly pedestrian. Services which are mainly community built are usually within less than 10 minutes walking distance. However, government provided services might not exist in close proximity. Streets are interconnected; however, they advocate pedestrians to vehicles, as they are narrow. Although there is a network of wider streets, due to increased traffic load, they are usually congested specially at market places and area entrance points. Moreover, streets can be too long without crossings, which decrease connectivity.

These areas have a variety of uses that make them complete and independent for daily needs. They can be considered as a separate identity and provide lifelong utilities for many residents. Residents can spend their life working, living in an informal area without having to go outside except for some higher educational and health services. Despite that mixed uses in informal areas is seen by the formal authorities as incorrect, it is the mixed uses that give the area its richness, liveliness and advantage of availability of needs within the area, an advantage sought by the new urban trends plans. These areas also offer uses and utilities for a diverse spectrum of groups, ages and incomes. There is a variety of housing opportunities in informal areas since they are community built and are driven by their needs. Different sizes are available and in some areas there is a variety of standards, especially in informal areas built on private lands. This diversity and community driven development pattern adds to the area's sense of place, as opposed to the identical blocks in publicly developed projects.

Informal areas have their own transportation network and modes that might be exclusive to them, which explainswhy entrances to these areas are always considered as transportation nodes. They rely on private transportation modes, ranging from microbuses, pickup trucks, and recently autorickshaws (toktok). These are usually in bad condition, and driven by unlicensed drivers, thus posing threat to passengers' lives and to the environment. However, sometimes these areas are built beside railways, underground metro or transportation stations and can benefit from such facilities. Despite this drawback in transportation in informal areas, people use bicycles a lot or walk, thus adding to the area's green advantages.

Land uses are distributed according to needs, where commercial uses and other services are distributed along the main streets, leaving the narrower streets for residential and recreational uses. Informal areas were self built by the community and its informal sector. Almost all development decisions are community directed. The community has succeeded in providing housing and basic services through collaborative efforts. Other services, such as child care facilities, medical centers, training centers, etc., are usually provided through community based organizations. Thus, these efforts provide a solid ground for further participation.

What these areas lack is an overall urban vision as they are built incrementally. Moreover, where the land is privately owned, open spaces are usually overlooked as they have little or no economic revenue. They do not provide access to nature. On the contrary they are a threat to nature. This can be overcome by preserving whatever vacant land that still exists inside the informal areas, and belting the whole area to prevent its further encroachment on green fields. Moreover, when there is an open space it is not taken care of unless there is a strong sense of community between residents. Although high density is favoured by sustainable urbanism theories, it is vital to note that existing high density does not pose a threat to human living conditions. The UN-HABITAT suggests a maximum crowdness indicator of 2persons/room.

The people's way of developing is "smart", however their settlements need a more comprehensive approach to insure the provision of needs; housing and services, in a more environmentally responsive pattern.

6 INVESTIGATING THE RESPONSIVENESS OF INFORMAL AREAS

As mentioned before, it is estimated that more than 60 % of Cairo built up area is informal ,and still increasing daily. Imbaba district as part of the north sector in Giza,(Greater Cairo Region) on the west bank of the Nile, as shown in Figure 1, is one of the largest districts that grew in an informal unplanned pattern. It was previously agricultural land that was subdivided illegally to accommodate housing needs of the ever growing urban population of Cairo. Currently it has more than one million inhabitants with a density ranging around 650 persons/ha. It is considered as a center for displaced people from the countryside to Cairo, especially people coming from Upper Egypt because of its proximity to services, low rents and affordability.

Figure 1 Location of Imbaba within the Northern Sector of Giza, Greater Cairo Region, Egypt.

6.1 Defining the district and pilot area

On the macro scale, urban prosperity in Imbaba scores low in a number of indicators as seen in Table 2. It is evident that the quality of life in such areas is not acceptable. This is mainly due to a number of factors. First, Imaba lacks adequate services including education and health facilities that can support a good quality of life. Second, the street network that resulted from the unplanned growth resulted in incompatibility with traffic especially when the area grows extensively as Imbaba. The dependence on microbuses, pickups and autorickshaws as the primary mode of transportation has made things worse, with their induced pollution and increased CO_2 emissions; especially given their usual bad conditions. Third, Imbaba lacks open spaces that promote civic activities, alternatively civic interaction takes place in streets as the major open spaces in the area. Informal areas consume less energy due to their compact design. However, this compactness and extensive use of bricks, concrete and asphalt increases the effect of urban heat island in the area, thus reducing comfort in outdoor spaces and increasing thermal loads on buildings. Regarding green spaces or vegetation, they are scarce in Imbaba, (except for the newly opened park on the site of a relocated airport) as they require land, which is privately owned and developed according to the maximum economic profit available. The area provides a prototype for informal areas that constitute most of Cairo.

Sector	City Prosperity Index	Imbaba
Governance	laws, regulations and institutions, urban planning,	Originally informal, illegal, unplanned but now is under the jurisdiction of Urban Law 119
	Civil society, trade associations, special agencies	Many civil societies are active
Economic	Productivity	Informal economic sectors strives in the area
	Capital investment, formal/informal employment, inflation, trade, savings, export/import and household income/ consumption.	
	city product	
Infrastructure	Infrastructure Infrastructure proper	There is adequate water network and sanitation Transportation is insufficient depending on privately operated microbuses and autorickshaws
Housing	Housing	There is a variety of housing units but all occupied

Social Serv.	Quality of life	Health services are not enough
	Education, health sub-index.	Overcrowdness of pupils in school classes
Socio- Cultural	Public space	There are no public spaces in the area
Environment	Environmental Sustainability: protection of urban environment and natural assets, energy efficiency, minimize pressure on surrounding land and natural resources, minimize environmental losses	There is continuous encroachment on agro land. Regarding energy efficiency buildings perform well, however the outdoor spaces suffer from the effects of urban heat island.
Equity	Equity: reduces poverty and the incidence of slums, rights of minority and vulnerable groups, gender equality, civic participation	There has been a project to plan the whole district ensuring equity and improving connectivity and quality of life but it is still in its first phase.

Table 2: Imbaba area performance according to the criteria of prosperity developed by UN-Habitat, source: (Khalil H. , 2014)

The study area as shown in Figure 2 is a typical mixed use area. It has both retail and residential uses along with some workshops. The prevailing building height is 4 storey high and the buildings are attached on 3 sides leaving only one façade free. The area is one of the oldest in the district with some buildings dating from the 1960s, which implies the consolidation state of both the built and the social environment.

Figure 2Imbaba district and the study area, Cairo

6.2 The methodology and process

The field study in this paper is part of the Ecocitizen World Map Project (EWMP), which is comprised of three distinct yet interwoven components: the Partnership, the Platform and the Pedagogy. (Khalil & Ron, 2015) The Partnership is led by US NGO Ecocity Builders and joined by Esri, the Association of American Geographers, Eye on Earth (a partnership of UNEP and ADGEDI Abu Dhabi Global Environmental Data Initiative), Cairo University, Mundiapolis University, University of California at Berkeley, local NGOs and community partners. This project uses new concepts of crowdsourcing and crowd mapping. It aims to calculate the ecological footprint and the urban metabolism of a typical neighbourhood (in Imbaba district) and encourages residents to participate in data gathering with the help of the team and local Community Based Organizations CBOs.

The Platform[3] of EWMP provides the incentive and understanding for communities to crowd-source urban data and holistically assess the condition of their neighbourhoods. This promotes more democratic and grassroots leadership in proposing and planning interventions that directly enhance the sustainability and equitability of cities. Geographic information systems (GIS) and urban metabolism information systems (UMIS) are the two primary methods employed for organizing and displaying data through the Platform. UMIS describes a system, along with all of its components, to account for and analyse resource flows as they move from the natural environment (i.e. a source) through the built environment (i.e. a city) back to the natural environment (i.e. a sink). Sankey diagrams are a means to represent this whereby the width of arrows in a linear flow is proportional to their quantity. The Platform displays data in visually accessible ways that communities can customize and interact with directly; specifically, spatially dynamic online maps with multiple dataset layers and Sankey diagrams.

[3] www.ecocitizenworldmap.org

The Pedagogy of EWMP is defined through a research justice framework, breaking down existing structural barriers between the researcher and the researched, and includes a training-of-trainers (TOT) methodology to support capacity-building among students and citizens. These trainers then engage in knowledge-transfer activities with citizens, facilitating bottom-up data collection, analysis and publication to the Platform.

The Project's piloting in Cairo, established in early 2014, has been led in part by El-Balad and Household development organization, both local community-based organizations (CBO) in the neighbourhood of Imbaba. The CBOs mobilized citizens, through their existing networks,worked with the students at Cairo University who were trained on adapting and applying public participation techniques, GIS and UMIS, by academic faculty and the EWMP Partnership.

The students engaged in labs, lectures and group activities that touched on these topics. A community roundtable invited elders, youth and leadership from the selected study area to a presentation on the EWMP, where a discussion took place concerning refining the purpose, scope, preferred decision-making models, study area boundaries, data-reporting standards and ownership of research outcomes. At the Imbaba roundtable, the community prioritized concerns around access and quality of potable water supply.

The field work started withfield visits and transect walks to identify various issues, resources and potentials that ran in parallel with the community roundtable activities. A complete urban survey was conducted to the study area including: land use, building heights, building conditions, construction materials and building age producing GIS maps. This would be the base for choosing the samples for conducting the parcel audits based on identifying the existing archetypes. This way the data collected from these sample parcels could be entered into the UMIS to aggregate the results into a single Sankey diagram showing the water flow into the area.

An intensive training was held as a two-day TOT event where the CBOs and students facilitated workshops and initiated the citizen-led collection of data. Teams were arranged according tothree different collection methods. First, environmental assessments of air and water quality tests were conducted to sample units, including 10 components measuring the level of PH, copper, iron, nitrate, phosphate, chloride, chlorine, lead, chrome, ammonia, and coliform. Second, quality of life (based on the International Ecocity Framework and Standards IEFS) and ecological footprint questionnaires were asked to residents on street and in different shops.Third, parcel audits of resource management starting with water demand were conducted to sample units. At the designated workstations set up within the study area, one of the CBOs quarters, data was digitized, samples were tested against established baselines, and results were analysed. The data collected from parcels concerning water consumption was aggregated to the whole study area, in order to have a concrete idea about the water consumption in the area. If urban survey data is available for the whole Imbaba district, an aggregate for water consumption in the district is possible. A number of flyers and posters were designed by the students to inform local residents about the project and its aims and activities. In addition, a workshop and project presentation on street was conducted to engage local residents into the activities and reach out for their interest and participation. (Figure 3)

Figure 3 workshop and presentation on the street to engage local residents and youth, authors

In order to complete the water flow study, the students along with the CBOs have investigated water quality and flow from upstream, the potable water facility with its intake from the Nile, and the downstream where wastewater goes through the water treatment facility and, in most cases, back to the Nile. Acomplete Sankey diagram was developed based on the complete information collected. After finishing the data analysis, another workshop and presentation was conducted on the street to demonstrate the study findings to local residents and ensure project transparency.

7 DISCUSSION OF THE OUTCOMES

All produced data for Imbaba was published through the Platform[4] and has demonstrated quality, access and management issues. In terms of the former, the quality of life questionnaire results showed a lack in health care services; and when existing are inefficient. The Employment opportunities are always found in the commercial career. There are no entertainment facilities or green areas in the area. While regarding the ecological footprint questionnaire, the results revealed that 75 % of the citizens consume very high environmental resources due to behaviour where no garbage reuse/ recycling exists in the area, high usage of electricity and water based on personal conduct and consumption of large quantities of fossil fuels daily.

The water quality testing as shown in Figure 4 has revealed an increase in the percentage of coliform bacteria as a result of broken piping infrastructure mixing potable water and sanitary streams and the former existance of an irrigation canal that was filled up without proper treatment. Moreover, there was an increase in copper traces due to old piping infrastructure and minimal storage maintenance. In addition, traces of phosphate were detected in many samples due to the former history of the area as anagricultural land and the infiltration into the old pipes. The samples from the potable water facility and the Nile intake into the station were of good quality. This in turn has proven that the water quality problem is caused by local problems in Imbaba area due to the low quality of the piping system and the high infiltration of both sewage water and contaminated underground water in the area.

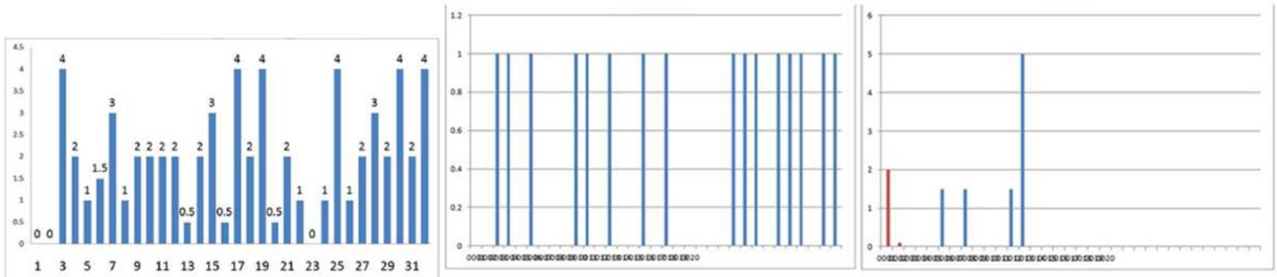

Figure 4 Water quality testing sample results for phosphates, coliform and copper; the red bars are WHO accepted ratios, zero for phosphates and coliform, authors

In terms of management, parcel audits have shown poor water flow from the main supply lines and the disproportionate use of water demand according to building archetypes. In addition, the existing low water pressure in the water network (due to old pipes that could not withstand higher pressures) necessitates the dependence on electric water pumps (with their contribution in increasing costs of electric bills) and high water consumption and consequently unaffordable water bills, which in part is due to behaviour but also due to leakages in the water pipes.The Sankey diagram produced for the water flow in the area (Figure 5) presented citizens with visual guides to suggest areas for conservation (e.g. minimizing use in cooking), efficiency (e.g. low-flow shower heads), cascading (e.g. grey water use for rooftop gardens), and advocating for municipal upgrades of infrastructure upstream (e.g. retrofitting crumbling concrete plumbing with more enduring materials to minimize water loss). A series of printed materials and awareness events, organized by El-Balad CBO and the students, disseminated the pilot study results and ensured transparent flow of data to the local community.

Therefore, a number of interventions have been proposed which are divided into three groups. First, on the neighbourhood level, changing the water network in the area, which is rather a governmental responsibility. Second, on the buildings and units' level, replacing deteriorated water pipes, adding water filter and installing grey water system. Third, on the individual level, promoting efficient use of water through behavioural awareness and education. A feasibility study was conducted based on low cost solutions to provide buildings with better water quality and reduce consumption through replacing deteriorated water pipes on the building level (to prevent water pollution resulting from these pipes as iron & copper and prevent leakages), adding water filter (to improve water quality and reduce deseases as liver & kidney failures and diarrhoea) and installing grey water treatment system for each apartment building (to be used in toilet flushing, cleaning surfaces, on street car washing ...etc.). In addition, if the treated grey water quality permits, it can be used in roof planting. This will need accurate testing of the treated water to ensure

4 http://ecocitizenworldmap.org/pilots/cairo

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adequacy. Moreover, participants formed an advocacy group to mobilize funds for household interventions and to push for governmental financing of upgrades to the area's water network.

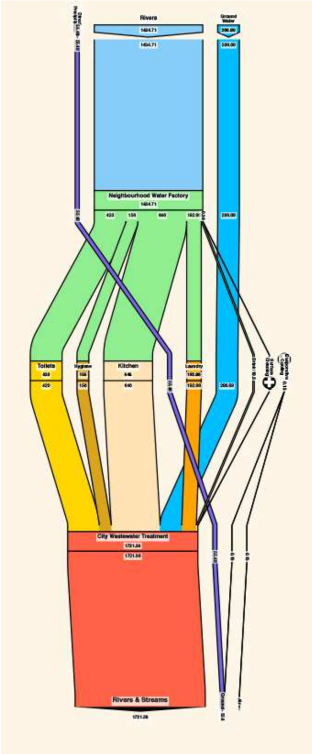

Figure 5 Sankey diagram showing the water flow into the study area from source (the Nile) to the potable water facility into the area and different uses in the parcels, downstream to the wastewater treatment facility and onto the sink (the Nile)

The team have also undertaken the same study for Energy flow through the area and is currently studying of material flow. This is essential to ensure the efficient use of local resources and the adequate intervention to reduce the residents' vulnerability to climate change.Moreover, the project continues to build the capacities of both the CBOs and local residents through conducting the same investigation but for other resources to enhance the awareness of the issue of resource efficiency and to enable them to contribute independently to the data gathering and assessing their needs and priorities. In addition, the technical capacities gained through the process has enabled the group to approach other informal and formal areas.

8 CONCLUSION

Urban metabolism is becoming not only a quantifying, or analyzing tool, it has the potential to influencethe sustainability of districts an neighborhoods. It can expand to reach multiple parameters such as mobility, employment,education,..and many other that could bring innovation in the field of urban systems.This would definitly imply new approaches, methodologies, and techniques while dealing with new factors that were not tackled in the current state of the art. The study in Imbaba demonstrated the moderate living conditions in informal areas which mainly suffer from lack of health services, entertainment opportunities and green spaces. There is big problem in consumption of resources, mainly water in the case of Imbaba. This necessitates a prompt response from various stakeholders on different levels. Water scarcity is a growing global problem, but it accentuated in Egypt given its limited water resources and diminishing share of the Nile water. If the results of the field study are aggregated to encompass informal areas in Cairo, the water consumption/depletion would be alarming. There is aneed to address this issue both on the policy level and on the local level of district plans. Personal behaviour is vital in this issue, where common practices of water over consumption and illegal encroachment on the water network should be reconsidered. The problem was easily communicated through the tools used including GIS, UMIS and the produced maps, charts and Sankey diagrams. Moreover, the partnership between different stakeholders can provide an adequate platform for promoting the methodology and the results onto tailoring locally appropriate solutions that are both affordable and require minimum technological capacities for maintenance and upkeeping. The study of other resources would also provide insights to minimize consumption and promote looping and cascading to maximise the value added of limited available resources, guiding autorities, NGos, and the citizens themselves since it does not rely on predictions, it reflects facts in daily life, behavioural patterns, and related societal norms that affect the form and function of the built environment. Studies in urban metabilism would also assist in providing design and planning guidelines for developing more responsive vibrant communities that address local needs and foster better quality of life.

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