MEASURING CONTRIBUTION OF ECOSYSTEM SERVICES TO URBAN QUALITY OF LIFE

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Cities around the world are becoming more and more urbanized. The expected increase in the number of urban residents has a striking influence on their quality of life (QOL), thus it is imperative to understand the spectrums contributing to it. Urban life depends largely on the goods and services that come from nature. These are what are known as ecosystem services (ES), which refer to the benefits from ecosystems that human populations directly enjoy, consume, or use to yield QOL. The links between ES and QOL are very complex and diverse, but it is important to explicitly recognize them to aid policy makers to make informed decisions. There are a number of studies done to measure the contribution of ES to QOL, however, how ES contribute specifically to urban QOL at basin-wide scale is not well explored yet. The aim of this paper is thus to review the existing methods used to identify the link between ES and QOL, and to propose a new framework that may be useful in recognizing the link between ES and urban QOL. The paper is divided into three parts: 1) ES that contribute to urban QOL were identified, 2) methods commonly used were reviewed, and 3) a new framework was proposed. Some of the commonly used methods in measuring the contribution of ES to QOL (objective and subjective) are: use of indicators, economic valuation techniques and use of surveys. The proposed method aimed to capture the total contribution of ES to urban QOL by integrating the three methods namely: ecological valuation, economic valuation and social valuation. The framework is not yet validated, thus pilot studies should be done to check its applicability and reliability.

Key Words: *Ecosystem Service, Urban QOL, basin-wide scale*

1. INTRODUCTION

Cities around the world are becoming more and more urbanized. According to United Nations report (UN, 2004)[1)], the world is expected to reach 50% urban for the first time in history in 2007. By 2030, projection shows that 61% of the world's population will be living in cities. As long as people continue to live in urban areas, it is important for their well-being that the urban air be healthy to breathe, that there be sufficient water of adequate quality to meet domestic needs, that the urban landscape be pleasing to the eye, that the urban climate be comfortable, and generally that the urban environment be healthy and pleasant for people to live in.

The expected increase in the number of urban inhabitants has a striking influence on their quality of life or QOL (Rees, 1992)[2)]. Urbanization is inevitable, that is why the goal of many cities is to ensure that the QOL of its citizens is not diminished but instead maintained or better yet improved. The desire to experience a good life is realized when the QOL is high. To achieve this, it is thus imperative to understand the spectrums contributing to the quality of urban life (Sufian, 1993 as cited by Turksever and Atalik, 2000)[3)].

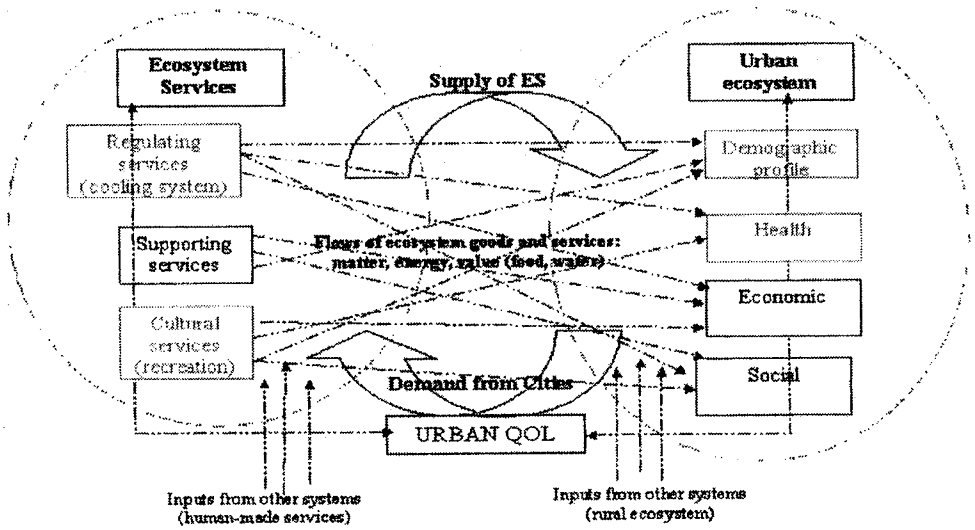

Figure 1. Conceptual Framework

Life in cities depends largely on the benefits derived from the natural environment. These are what are known as ecosystem services (ES), which can be defined as components of nature directly enjoyed, consumed, or used to yield human well-being (Boyd and Banzhaf, 2006)[4]. Based on the Millennium Ecosystem Assessment or MA (Ecosystems and Human Well-being: Framework for Assessment, 2003)[5], ES can be categorized into four functional groups namely:

1) provisioning services such as food, water, timber, fiber, and genetic resources;
2) regulating services such as the regulation of climate, floods, disease, and water quality;
3) cultural services such as recreational, aesthetic, and spiritual benefits; and
4) supporting services such as soil formation, pollination, and nutrient cycling.

With urbanization, the ability of local ecosystems to provide these services tends to decline, even as the number of people per unit of area, and hence the need for these services, increases.

The link between ES and QOL is very diverse and very complex. Even though it is quite a challenging task, explicit recognition of these links will help policy makers and other stakeholders to make informed decisions (MA: Framework for Assessment, 2003).

While there are a number of studies attempted to measure the contribution of ES to QOL, the problem is that most of them focuses on the rural area. For instance, Pereira et al. (2005)[6] studied the mountain area in Northern Portugal; Oliveira et al. (2003)[7] studied the global drylands; and Almenteras et al. (2004)[8] investigated the coffee-growing region in Columbia. Moreover, another problem in doing QOL studies is the aspect of categorization. There is no general agreement on how to define what contributes to QOL. As many as there are studies on QOL, there as many things that can be taken into consideration. Terms do not have an unequivocal meaning. For example, even if the environment is commonly used as one of the domains in the evaluation, the attention is more on the quality of the environment and not on the effect of ES alone. Therefore, it is important to overtly state how ES contributes to *urban* QOL at basin-wide scale, which is not well explored yet. The aim of this paper is thus to review the existing methods used to identify the link between ES and QOL and to propose a new framework that may be useful in recognizing the link between ES and urban QOL.

Tracing the link between ES and QOL commonly involves answering the following questions:

1) What are the specific benefits from ES that contributes to urban QOL in basin-wide scale?
2) What are the existing methods commonly used to measure the contribution of ES to QOL?
3) What is the new framework that may be useful for identifying the link between ES and urban QOL?

2. CONTRIBUTION OF ECOSYSTEM SERVICE TO URBAN QUALITY OF LIFE

To be able to analyze the contribution of ES to urban QOL concretely, it is important to first define what the urban ecosystem is.

Urban ecosystem can be viewed in three ways: 1) as built-up areas that are the habitat of urban people, animals and plants; 2) as peri-urban areas that provide natural services like water supplies, recreation zone, greenhouse gas uptake, and biodiversity; and 3) as the areas affected by urban activities as a driving force (Piracha and Marcotullio, 2003)[9]. In this study, the urban ecosystem will refer to both the built area and the peri-urban areas.

From a systems' point of view, the framework for measuring contribution of ES to urban QOL was developed and this was shown in **Figure 1**.

As indicated in **Figure 1**, ES can be viewed as an open system. ES includes the stocks: the regulating, supporting and cultural services. These services interact and form certain functional relationships that affect the flows of ES. Moreover, the stability of the whole system could be affected by other external factors, like the availability of substitutes. The degree of influence depends on the level of the interaction between them.

In similar fashion, several domains characterize the urban ecosystem: demographic profile, health, economic, and social aspects. It is also affected by external inputs from other ecosystems such as the rural ecosystem.

When taken together, both ES and urban ecosystem are forming complex functional relationships where one is closely inter-related and interdependent to the other. The formation of these relationships is facilitated by the flow of materials, energy, and value across system boundaries. It is this interaction where the urban QOL must be defined. The linkage between them would change over time in response to the level of inputs they received by them and outputs taken away from them.

Furthermore, the individual components of both systems mediate these systemic interactions. It means that the individual components of each system are the ones affected and affecting the entities of the other system, not the system as a whole. For example, recreation can affect the health of the inhabitants in the urban ecosystem, and not the urban ecosystem itself. There are some elements in one system that could not affect or be affected by some elements in the other system.

In order to achieve better urban QOL, focus should be in the linkage between both in the stock and flow of ES into the urban ecosystem.

In view of the above, evaluation of the urban QOL should consider the interactions among individual constituents in both ES and urban ecosystems, and not the system as a whole. Analysis should, therefore, focus primarily on with the relationships between or among individual elements that influence ES and urban QOL. Since the relationships are analyzed at the individual system component level, ES that significantly affect urban QOL could easily be identified. In the same manner, the domains characterizing urban ecosystem could also be easily analyzed. Results of these analyses could serve as basis for developing the framework for the evaluation of ES to urban QOL.

Based on the characteristics of the urban ecosystem as well as issues facing it, the following ES are identified as having an impact on the urban QOL: noise, heat island effect, high noise levels, high carbon dioxide emission, air and water pollution, solid waste accumulation, occurrence of floods, food and water shortage, and recreation. Related studies showing the contribution of ES to the urban area was compiled (Bolund and Hunhammar, 1999[10]; Piracha and Morcotullio, 2003; MA Global and Sub global Assessments, 2004[11]; City Green, 2004[12]; Jian et al., 2005[13] and Moyer's report)[14] and shown in **Table 1**. The ES are chosen based on the frequency of their incidence (three or more checks as seen in **Table 1**).

(1) Noise reduction

In residential neighborhoods intersecting with roads and highways, noise is one of the biggest problems. Noise, being an unwanted sound, adversely impacts an individual's quality of life. Among the detrimental effects are sleep disturbance, physiological effects, health and welfare, (Harris et al., 1997)[15].

Vegetation can reduce the impacts of noise in rural as well as in urban environments. At a larger scale, masses of trees and vegetation are planted as noise barriers i.e., to mitigate traffic noise along highways. This was observed in the U.S. as well as in Europe (Bolund and Hunhammar, 1999). This was also being implemented in Japan (Ministry of Environment, 2002)[16].

In an urban park (Natinal Garden of Athens), it was found that the vegetation composition determined noise levels. For instance, more open landscape like lawns, planting beds, and paths provided less noise protection than taller vegetation (Kane, 2004)[17].

(2) Heat island mitigation

The building, concrete, asphalt, and the human and industrial activity of urban areas have caused cities to maintain higher temperatures than their surrounding countryside. This phenomenon is known as an urban heat island.

Table 1. Ecosystem Services in the Urban Areas

Typology of Ecosystem Services (de Groot et al., 2002)*	Bolund and Hunhammar (1999)	Piracha and Morcotullio (2003)		Millennium Ecosystem Assessment (MA)		City Green (2004)	Jian et al., 2005	Moyer's Reports
		Built-up areas	Peri-urban areas	Sub-global (Sweden, 2003)	Global (2004)			
Regulating functions								
Gas regulation (Air filtration)	√			√	√	√		√
Climate regulation								
Heat island modification	√	√		√	√	√	√	√
Carbon sequestration			√			√	√	
Disturbance prevention								
Storm/ floodwater protection		√	√			√		√
Water regulation				√	√		√	
Water supply (Groundwater supply)	√		√	√				
Soil retention							√	
Nutrient regulation				√	√			
Waste treatment (sewage, waste assimilation)	√		√				√	
Water pollution control			√			√	√	
Noise pollution reduction	√		√	√	√		√	
Pollination				√	√			
Biological control				√	√			
Habitat functions (Refugium)				√	√			√
Production functions (Food)	√	√		√	√			√
Timber production			√	√				
Information functions (Recreation)	√	√	√					√

* The italicized words are the 4 categories of functions that provides ES as classified by de Groot et al., 2002. The underlined words are the functions under each category while the rest are the ES in the urban area.

In Tokyo, on one night in winter, a field observation was made on the Earth's surface temperature using automobiles. From the traverse observations, it was found that the atmospheric temperature is as high as 12.6°C in Otemachi, the center of Tokyo, and 4.5°C in Hachioji, a suburb of Tokyo. The heat island intensity amounts to 8.1°C (Saitoh et al., 1996)[18].

Trees help mitigate the effects of heat islands. Planting trees not only helps to shade cities from incoming solar radiation, they also increase evapotranspiration, which decreases the air temperature. A single large tree can transpire 450 l of water per day. This consumes 1000 MJ of heat energy to drive the evaporation process. City trees can lower summer temperatures of the city markedly.

Plants can also modify wind speed in urbanized areas. Natural ventilation is one of the most effective energy-saving methods to cope with high temperature and humidity in summer in Japan and to improve the QOL not only in outdoor spaces but also in interior spaces in buildings (Kubota and Miura, 2000)[19].

In Japan, the "Outline of the Policy Framework to Reduce Urban Heat Island Effects", which was laid down in March 2004 focuses on the following: (i) Reduction of anthropogenic heat release through urban activities, (ii) improvement of artificial urban surface covers, (iii) improvement of urban structure such as the placement and orientation of buildings, and (iv) enhancement of lifestyles. For first three policies, the range of mitigation measures that are considered most effective includes greening of building rooftops and walls, streets, and dwellings; maintenance and improvement of parks and green spaces; and construction of large-scale greenbelts (Yamamoto, 2006)[20].

(3) Carbon dioxide sequestration

The direct and indirect benefits of trees for urban quality of life vastly outweigh their contribution to offset carbon emissions from industrial and urban processes. American Forests estimates that in the Portland metropolitan area, trees store 12,516 tons of carbon annually and remove over 2 million pounds of airborne pollutants every year (Kane, 2003). In the Chicago area, the U.S. Department of Forestry calculated that a single tree having a trunk circumference of 30 inches removes 200 pounds of carbon dioxide (CO_2), with the greatest removal taking place during the summer months (GHASP, 1999)[21].

(4) Air pollution reduction

Air pollution caused by transportation and heating of buildings, among other things, is a major environmental and public health problem in cities. It is clear that vegetation reduces air pollution. In urban areas with 100% tree cover (i.e., contiguous forest stands), short-term improvements in air quality (1 hour) from pollution removal by trees were as high as 15% for ozone, 14% for sulfur dioxide, 13% for particulate matter, 8% for nitrogen dioxide, and 0.05% for carbon monoxide (Nowak and Crane, 2002)[22].

(5) Rainwater drainage

In cities, with built-up infrastructures with concrete and tarmac covering the ground, about 60% of rainfall that becomes surface-water run-off results in increased peak flood discharges and degraded water quality through the pick-up of urban street pollutants. In vegetated areas only 5–15% of the rainwater runs off the ground, with the rest evaporating or infiltrating the ground (Bolund and Hunhammar, 1999). A single mature Live oak can consume up to 1,135 liters of water each day, and its canopy can intercept up to 28% of a major rain (GHASP, 1999).

(6) Recreational values

A city is a stressful environment for its residents. The recreational aspects of all urban ecosystems, with possibilities to play and rest, are perhaps the highest valued ecosystem service in cities (Bolund and Hunhammar, 1999). Outdoor recreation provides an opportunity to increase quality of life and heighten social interaction and thus helps to enhance community spirit and foster a more socially inclusive society (Scottish Natural Heritage, 2002 as mentioned by Morris, 2003)[23].

Green spaces are also psychologically very important. Urban green spaces are now widely recognized as major contributors both to the quality of the environment, and to human health and well-being in inner city and suburban areas (Ulrich, 1984; Grahn, 1989; Kaplan and Kaplan, 1989 as referred to by Morris, 2003).

On the basis of the Natural Parks Law in Japan, areas of outstanding scenic beauty and other areas of similar beauty are designated as National Parks and Quasi-National Parks. Natural Parks are designated to provide opportunities for people to experience nature, as well as to protect natural landscapes. Enjoyable and appropriate use of the parks by visitors is being encouraged through the planned development of walkways and visitor centers. Parks are expected to increase their role, among others, in high quality, on-site environmental education (Ministry of the Environment, 2006)[24].

(7) Urban food production

In cities, agriculture occurs in or near urban metropolitan counties. As the population in the urban area increases, so is the demand for food. Thus the primary purpose is to utilize urban agriculture as a means for the food insecure to gain access to fresh, affordable, and nutritious food. Food insecurity affects the QOL of urban residents in far reaching ways.

As the world food supply/demand situation could be tight in the mid- and long- term, Japanese people are now showing great concern over the future food supply in Japan characterized by very low food self-sufficiency. The national government assumes great responsibility in assuring the availability of the food supply to its people. Since there are certain limitations on stockpiling and importing, it is important to increase domestic agricultural production as much as possible in order to secure a stable food supply. This is stipulated in the "Basic Law on Food, Agriculture and Rural Areas" (Ministry of Agriculture, Forestry and Fisheries Japan, 1999)[25].

"The United Nations Development Programme estimates that while 15 percent of food worldwide is grown in cities, the opportunity exists to significantly increase this percentage. One-half of the vegetables consumed in Havana, Cuba are grown in the city's farms and gardens. Singapore has 10,000 urban farmers who produce 80% of the poultry and 25% of the vegetables consumed. Currently, 14% of London's and 44% of Vancouver's residents already grow some food in their gardens. It is estimated that Londoners could produce up to 232,000 tons of fruits and vegetables or 18 percent of the population's nutritional needs." (Brown and Carter, 2003)[26].

In spite of all ongoing research on urban agriculture, little is known, in most of the world's cities, about the actual extent of urban agriculture in terms of inner city areas used for agricultural purposes. Also, little is known about the spatial distribution of urban agriculture in the cities. That is why it is important to map its extent using the Geographic Information System (GIS).

(8) Provision of freshwater

The importance of water to human lives cannot be overemphasized. Without water no life forms would exist on the surface of the earth. While about 75% of the earth is covered with water, only 1% of the world's water can be useful for human needs, i.e., freshwater.

Groundwater plays an important role in water supply. It has been estimated that between 1.5 billion (UNEP, 1996) and 3 billion people (UN/WWAP, 2003) depend on groundwater supplies for drinking (as cited in MA: Current State and Trends, 2004).

Water shortages are occurring in country after country due to the rapid growth of populations and the development of the society. In Japan, the quantity of water that is necessary for the production of the food that it imports is said to be the equivalent of tens of billions of cubic meters of water per year. Japan will be affected by any intensification of world water problems.

3. REVIEW OF EXISTING METHODS FOR MEASURING THE CONTRIBUTION OF ES TO URBAN QOL

Ecosystem services consist of flows form materials, energy and information from natural capital stocks that combine manufactured and human capital services to produce human welfare (Costanza et al., 1997)[27].

ES directly or indirectly contributes to urban QOL. For the provisioning services, the level of contribution is usually determined by the magnitude and rate of the goods harvested (the flow) from the natural ecosystem. On the other hand, for the regulating, supporting services and cultural services, the level of contribution is normally determined by the size and quality (the stock) of the natural ecosystem (Duraiappah, 2004)[28].

In evaluating the contribution of ES to urban QOL, it is important to do identify the possible methods from the viewpoint of the stock and flow analysis.

(1) Measuring flows

Measuring the input and output flows are rather straightforward because data on the ES supplied and ES that are actually utilized are almost always available. The contribution of ES to urban QOL can be measured directly.

a) Use of indicators

An indicator is a scientific construct that uses quantitative data to measure ecosystem condition and services, drivers of changes, and QOL. Indicators serve several purposes: to evaluate the state of things, to evaluate public policies more directly, to find a simplifying abstraction for ecological models, and to communicate simplified ideas to policy makers or to the public (Banzhaf and Boyd, 2006). It is very important therefore to choose indicators that are suitable for the desired study and output. Indicators for measuring the flows of ES generally relate to commodity outputs from the system (for example crop yields or fish catch), which are readily communicable to policy-makers.

Example of flow indicators for food production is yield (measured in kilograms per hectare) while the indicator for water use is cubic kilometer per year.

b) Economic valuation techniques

Direct use values of ES are those that are directly used by human beings. They include the value of consumptive uses such as harvesting food products for consumption and the value of non-consumptive uses such are enjoyment of recreation. Direct use value is the easiest economic valuation technique because it involves observable quantities of products whose prices can usually be observed in the market. With regards to recreation, it is relatively easy to value because the number of visits is directly observable (IDB, 2004)[29].

(2) Measuring stocks

The data for measuring the stock of ES is rarely available, that is why this poses a greater challenge

Table 2. Commonly Used Indicators in Ecological Valuation of ES
Adapted from Pagiola et al. cited in MA: Current State and Trends, 2005 and City Green, 2004

Ecosystem service	Example of Indicator	Availability of Data for Indicator	Units
Production service	Food production	High	Yield (kilograms per hectare per year)[a]
Fresh water provision service	Water use	High	Water use (cubic kilometer per year)[a]
Capacity to mitigate floods	Change in stream flow per unit precipitation	Low	Discharge (cubic meters per second)[a]
Capacity to provide biological products	Biological products of potential value	Low	Number of products or economic value[a]
Capacity for cultural services	Recreational value	Medium	Number of persons visiting the park per year[a]
Capacity to purify water	Total Nitrogen and Total Phosphorous emission level reduction	Medium	Parts per minute removed[b]
Capacity to purify air	Air pollutants removed	Medium	Pound removed per year[b]
Capacity to store carbon	Amount of carbon stored in the tree	Medium	Tons of carbon sequestered per year[b]
Capacity to mitigate heat island	Effect of natural ventilation to lower temperature	Low	Wind velocity ratio[c]

Sources: a. City Green, 2004; b. Kubota, 1994 and c. MA: Current State and Trends, 2004 to researchers. Measuring the contribution of ES to urban QOL is done indirectly.

a) Use of indicators

Data on other services like the regulating, supporting, and cultural services, are seldom available that is why it is necessary to use indicators (MA: Current State and Trends, 2004). The ecological value of each ES will be measured using indicators. The indicators will determine or report the quantity, quality, accessibility and/or spatial distribution of the ES. These values will then be mapped using GIS and the City Green software for ArcGIS 8.3.

a-1) Ecosystem Service Indicators

Indicators related to the supporting and regulating services are rarely available, or even if available, are difficult to interpret. That is why they are a greater challenge (MA: Current State and Trends, 2004). Examples of specific indicators are shown in **Table 2.**

a-2) Quality of life indicators

Quality of life (QOL) has been the focus of many studies and researches (Marans, 2003[30]; Yuan, 2001[31]; Rogerson, 1999[32]; Pelce and Perry, 1995[33]; Gyourko, 1997)[34]. Even though there is no general agreement regarding its definition, QOL is often associated with human well-being, welfare, standards of living, happiness, and health (Veenhoven, 2000)[35]. In this research, QOL will be used interchangeably with human well-being.

The term "QOL" can be defined as a combination of life conditions and satisfaction with these conditions weighted by scale of importance, which is decided by the individual (Cummins as quoted by Pelce and Perry, 1995). Life conditions refer to objective QOL, which is about fulfilling the needs of individuals; while satisfaction with life conditions refers to subjective QOL, which is about feeling good and being satisfied. On the other hand, "well-being" seems to be used to refer to whatever is assessed in an evaluation of a person's situation that is focused on the person's "being". The term "welfare" can mean how well people live (Gasper, 2004)[36].

QOL studies tend to use key concepts and terms. These terms must be divided into categories, which are called domains and the elements underneath them are called indicators. Lanteigne (2005)[37] made a literature survey regarding what commonly comprises QOL. Her results showed that from the studies conducted from 1996 to 2004, 59% used economy, environment, and social; 53% used safety and education; 47% used health; 41% used housing; 35% used amenities and transportation; and 24% used infrastructure to refer to the various aspects or domains of what contributes to having a good life.

As QOL issues are quite wide in scope, many researches only focus on urban QOL.

b) Economic valuation techniques

Economic valuation offers a way to assess QOL as a whole by expressing the disparate components of well-being into a single unit. It typically attempts to measure all services in monetary terms, in order to provide an understandable term to express the benefits of the diverse variety of services provided by ecosystems (Pearce as quoted by Howarth and Farber, 2002)[38]. It is based on the fact that the value of ES is based on their benefits or utility or the amount of human satisfaction that they provide, i.e., people are willing to pay or trade something for maintaining these services, or they are willing to accept to forego them (Daily, 1997[39]; MA Current State and Trends, 2004; Howarth and Farber, 2002). The main economic valuation techniques and their application to different services are seen in **Table 3**.

c) Socio-cultural valuation: importance and satisfaction

Socio-cultural valuation is usually done through survey questionnaire, focus groups, or interviews. Socio-cultural valuation measures the subjective indicators of QOL. Being subjective and personal, demographic profiles of the respondents are usually correlated with the domains of QOL. Examples of studies that used this method are the following: 1) Public attitudes toward open space (Miller et al., 2003)[40]; 2) Attitudes towards green spaces (Balram and Dragicevic, 2004)[41]; 3) Syracuse Urban Forest Master Plan (Nowak and O'Connor, 2001)[42]; and 4) How Urban Residents Rate Tree Benefits and Problems (Lohr et al., 2004)[43].

4. PROPOSED METHODOLOGY TO MEASURE THE CONTRIBUTION OF ES TO URBAN QOL

The proposed framework is significantly different from existing QOL studies because it aims to integrate the three methods reviewed in this paper previously. **Figure 2** shows the research framework.

It is vital to know what basin-wide ES contribute to urban QOL. An initial list of ES was generated incorporating many studies. Please refer to **Table 1**. This list was reduced based on several discussions with the co-authors to come up with the focus or priority ES. The following ES are pointed out as extremely important for the urban area: food production, water supply, recreation and natural cooling system (heat island mitigation). These were chosen according to the focus of an on-going project in Arakawa River Basin entitled, "Strategic Scenario and Policy Planning for Sustainable

Management of Basin Regions" (Tanji et al., 2003[44], 2004[45]; Kato et al., 2004)[46].

(1) Ecological valuation

In valuing ES, it is important to determine specifically what is delivering the ES to where (QOLA, 2001)[47], so a systematic cataloguing of the sources and consumers will be done (Daily et al., 2003)[48]. The suppliers and users of ES at basin-wide scale were identified.

Ecological measurement to know the level of services supplied by an ecosystem and its aerial extent is important in ES characterization. The indicators in **Table 2** that will be used for measuring the ecological value of groundwater supply, food production, natural cooling system, and recreation to quantify each of the ES are: water use, yield, wind velocity ratio, number of persons visiting the park per year, respectively. The values of the indicators will be mapped using Geographic Information System (GIS) to see the distribution of each of the ES.

For food production, "yield" of rice and other agricultural products indicator will measure how much food is produced in the urban area and how much it contributes to the total food production. For water supply, "water use" indicator will quantify the surface water and groundwater withdrawn for household consumption. Accurate information about the amount of water being used is helpful for making better decisions regarding use of water resources. For recreation, the "number of people visiting the park" will be used as an indicator to measure how the urban residents value the recreational benefits of ES. For natural cooling system, the "wind velocity ratio" indicator aims to know the quality of the ES. It is important to know this ratio in built-up areas and places with vegetation to see how much ES can contribute to the cooling down or lowering of temperature in the urban areas.

(2) Economic valuation

From the viewpoint of economists, ES are classified according to how they are used. The total economic value (TEV) of ES can be grouped into two: use values and non-use values. Use values can be broken down further into direct use values, indirect use values.

The values of each ES, the commonly used method from related studies, and the most appropriate method for valuations were shown in **Table 3**.

The avoided cost of natural cooling system with indirect use values will be calculated using the City Green for ArcGIS software. On the other hand, the direct market valuation of groundwater supply, food production and recreation will be estimated using the price of water per cubic meter, price of agricultural products and the total cost of visiting the park (entrance free and other costs), respectively.

To calculate the TEV of the ES, the quantity of each ES will be multiplied by its economic value. This is shown in Equation (1).

$$\mathbf{TEV} = \Sigma\, \mathbf{ES_q} \times \mathbf{\$ES} \qquad (1)$$

were: **TEV** = total economic value
$\mathbf{ES_q}$ = quantity of each ES
$ES = economic value of each ES

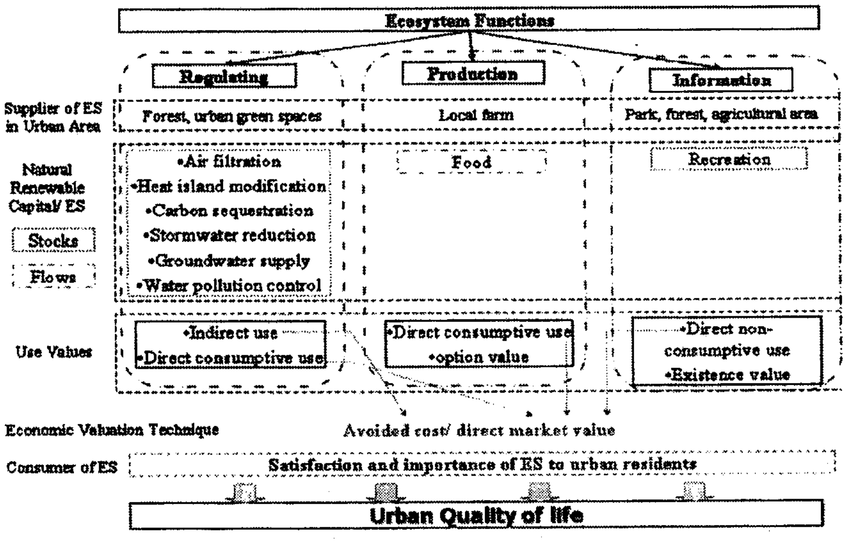

Figure 2. Research Framework for Measuring ES Contribution to Urban QOL

Table 3. Main Economic Valuation Techniques
Adapted from a. De Groot et al., 2002; b. Costanza et al., 2003

Ecosystem Services in the Urban Areas	Values	Commonly Used Economic Valuation Methods[a]	Most Appropriate Method for Valuation[b]	Method to be Used for my Research
1) Air filtration	Indirect use	**Avoided cost**	Contingent valuation **Avoided cost** Replacement cost	**Avoided cost** (The "externality" cost-that is a cost that society would have to pay in areas such as health care, if trees did not remove the air pollutants)[c]
2) Heat island modification	Indirect use	**Avoided cost**	Contingent valuation	**Avoided cost** (The cost of energy conservation benefits of trees from direct shading of buildings)[c]
3) Carbon sequestration	Indirect use	**Avoided cost** Replacement cost	Contingent valuation	**Avoided cost** (The cost of replacing the carbon storage function of trees)[c]
4) Storm/ floodwater protection	Indirect use	**Avoided cost** Replacement cost Contingent valuation	**Avoided cost**	**Avoided cost** (The cost of reducing the volume of water that a containment facility must store due to slowing of storm flow by trees)[c]
5) Groundwater supply	Indirect use, direct consumptive use	**Market pricing** Replacement cost	Avoided cost Replacement cost **Market pricing** Travel cost	**Market pricing** (Total market value of water abstracted from underground)[d]
6) Water pollution control	Indirect use	**Avoided cost** Replacement cost Contingent valuation	Replacement cost **Avoided cost** Contingent valuation	**Avoided cost** (The cost to remove water pollutants if not removed by vegetation)[c]
7) Food	Direct consumptive use, option value	**Market pricing** Factor income Contingent valuation	**Market pricing** Production approach	**Market pricing** (Total market value of food products)[d]
8) Recreation	Direct non-consumptive use, existence value	**Market pricing** Factor income Contingent valuation Travel cost Hedonic pricing	Travel cost Contingent valuation Ranking	**Market pricing** (The total cost of visiting the park)[d]

c. Calculate using City Green for ArcGIS software; d. Calculate using available statistical data

The total economic value will then be compared to Gross Domestic Product (GDP) to estimate the importance of these ES to the society.

(3) Socio-cultural valuation

A survey will be conducted in Tokyo and Saitama (Arakawa river basin) to assess the social values of ES placed by the urban residents. The target population of at least 1,000 will consist of the government officials from each village, town, city and prefecture; the members of Non Profit Organizations (NPO); and the residents of Tokyo and Saitama.

Both focus group discussions and survey questionnaire will be used in gathering the data. In focus groups, the priority ES in their respective areas will be identified. They will also be asked regarding the importance of each ES and their satisfaction. Later on, they will be asked if they have any suggestions on how to develop ES to improve the QOL in their area.

On the other hand, the survey questionnaire will be composed of 3 parts: 1) knowledge and recognition of ES, 2) satisfaction with ES, and 3) socio-demographic background.

The first part seeks to know the perception and awareness of the residents regarding ES. They will be asked to review the list of ES and rank each of their importance using a Likert Scale of 1 -5 (1 being not important, 3 being unclear and 5 being very important). Other suggestions will also be solicited on why ES is important to them.

The second part aims to measure their satisfaction with the ES in the urban area. They will be asked to rate each of the ES with regards to their level of satisfaction also using Likert Scale of 1 - 5 (1 being not satisfied, 3 being undecided and 5 being very satisfied). If they are not satisfied with at least one ES, they will be asked for suggestions on how to improve them so that they will enjoy life in the city more.

The third part will be used to analyze the relationship between the first two parts and the socio-demographic background. The following variables will be used: age, gender, educational attainment, income and place of residence (Tokyo or Saitama) (Miller et al., 2003; Balram and Dragicevic, 2004; Lohr et al., 2004; IDNR, 2003[49]; DCAUL, 2003[50] and Swanwick et al., 2003)[51].

Data gathered from the interview will be encoded in MS Excel program and will be processed using SPSS software. Descriptive statistics such as frequency distributions, percentages, and means will be computed to generate a distribution of responses. Correlation test, chi-square test, t-test and ANOVA will be used to determine the relationship between the socio-demographic variables and the respondents' knowledge and satisfaction for each of the ES.

The proposed method is different from the existing methods because it aims to capture the total contribution of ES to urban QOL in terms of its flows and stocks using the indicators, economic valuation techniques like direct market valuation and avoided cost, and survey questionnaire to be able to achieve high QOL. The proposed method may be effective in capturing all the aspects of ES that contributes to urban QOL.

5. CONCLUSION AND FUTURE STUDIES

The paper attempted to measure the contribution of ES to urban QOL. It was basically divided into three parts: 1) specific ES that affects the inhabitants of the urban and peri-urban areas were identified; 2) existing methods for measuring the ES in the point of view of stock and flows approach; and 3) a methodology to measure the contribution of ES to urban QOL was proposed. The urban environment derives so many benefits from ES that is why it is crucial to identify and measure them to be able to know their contribution to QOL. ES have economic and social values that must incorporated in urban planning decisions to improve the quality of life in the city.

Although there is no agreement on the correct way or method of measuring urban QOL, the proposed framework in this paper anticipates that it can contribute to the field of QOL research. This framework is not yet validated, thus it is necessary that pilot studies be done to check its applicability and reliability.

The research aimed to recommend urban planning policies based on the current or short-term economic and social benefits of ES to improve QOL. In Japan, where earthquakes occur frequently, it is important to consider natural disasters in urban planning. In the future, when choosing the importance of ES to urban QOL, each of the ES may be prioritized using risk analysis. Easily measurable and available indicators may be evaluated. The importance of the ES may be ranked based on the level of risk, the higher the risk, the more important the ES becomes.

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