Urban Forestry in Hanoi, Vietnam
Applying the Framework of Social Ecological Systems to the Urban Forestry Management in Vietnam

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# Table of Contents

Abstract 3  
Chapter 1: Introduction 5  
Chapter 2: Literature Review 8  
  2.1 Defining an Urban Forest 8  
  a) What are “Urban Forest” 8  
  b) History of Urban Forestry as a Profession 8  
  2.2 Urban Forest Benefits 9  
  2.3 Social-ecological Systems 11  
  2.4 Common Pool Resources 13  
  2.5 Sustainable Urban Forest Management 15  
  2.6 Clark’s Sustainable Urban Forest Management Model 16  
  2.7 Urban Forest Management in Hanoi, Vietnam 17  
Chapter 3: Methods 18  
  3.1 Study Area 18  
  3.2 Environmental Pollution in Hanoi 22  
  3.3 Analytical Methods 23  
    a) Framework and Theory 23  
    b) Document Analysis 25  
    c) Interviewing 26  
    d) Personal Experience 27  
Chapter 4: Results Discussion 27  
  4.1 Identifying SES Variables 28  
    4.2) Users 28  
    4.3) Resource Units 31  
    4.4) Resource System 32  
    4.5) Governance System 34  
  4.6 Related Variables 35  
  4.7 Design Principles 40  
  4.8 Achieving Sustainability 43  
Chapter 5: Conclusion 46  
Appendix 47
Abstract

The urban forest, a social-ecological system (SES), is a significant resource and sustainability of it is critical for maintaining livable cities and for contributing to global carbon storage. Sustaining an urban forest means managing this resource to meet the needs of the present without compromising the needs of future generations by managing the system to maintain the production of ecosystem services over space and time (Dwyer et al. 2003).

Analyzing any SES’s sustainability requires consideration of not only the biophysical resource, but the community of its users and its governance system. These major variables are considerably intertwined in an urban forest with densely-settled human populations, complex governance systems, and competition for land use. This is particularly the case in Hanoi, Vietnam, the study site for the research.

This thesis has two main objectives: diagnosing the factors that influence Hanoi, Vietnam’s urban forest management and examining ways in which the city could adapt UF management practices from developed theory. A review of the model of urban forest sustainability (Clark, 1997) and Elinor Ostrom’s (2009) framework for examining the sustainability of SESs are assessed for Hanoi, Vietnam. In addition, the characteristics and sustainability criteria of urban forest are defined. Ostrom’s design principles for common pool resources and the SES framework are utilized to identify long-enduring urban forest management practices already in existence in
Hanoi, and to begin to understand what SES characteristics impede sustainable urban forest management there.

Lien Thi Hoang NGUYEN thesis of “The Greening of Hanoi” (2008) is used to identify historical and present open space planning. We have identified ways in which Hanoi can improve their urban forestry management with consideration on eastern views of greenspace planning on management. A dynamic planning and management model is present that could encourage sustainable urban forest management in Hanoi, Vietnam.
Chapter 1: Introduction

Many developed nations have adapted environmental policies after there has been considerable damage to natural resources. Although it is important to help prevent future environmental degradation, it is essential to prevent environmental pollution at the beginning of industrialization, and for reducing its consequences. This can be accomplished by focusing on third-world, or developing nations that have not experienced the consequences of rapid development.

Developing nations have the opportunity to be proactive and adapt pro-environmental policy to reduce their environmental impact. Vietnam is a developing country and in 2008 Hanoi was one of the fastest growing cities in the world. Their increased capita and GDP allows them to reform the city in terms of infrastructure, education and industry. It also has allowed Hanoi to allocate their resources and time to focus on some major environmental problems the city is facing due to their rapid urbanization.

Major environmental problems that Hanoi is facing are mass stormwater runoff and air pollution; Hanoi is creating goals to try and reduce those problems. Not only is the government identifying these objectives in their Master Plan, they are also collaborating internationally to create future plans that could reduce the impact of these environmental problems. Some of the objectives listed in the Master plan have targeted greenspace as an important resource that has the potential to solve these major environmental problems.
Hanoi’s greenspace or urban forest (UF), has the potential to mitigate air pollution and reduce stormwater runoff concerns. In order for the benefits of an urban forest to be noticeable and effective, it is imperative that these systems be managed in a sustainable fashion. The urban forest that will provide benefits for current issues can be defined as a social-ecological system (SES).

Elinor Ostrom defined a SES as an ecological system that has a relationship with human systems including the rules we establish for their use. Appropriators, or users, and its governance system ultimately affect the resource system’s sustainability. By applying this definition that Ostrom has described, it can be assumed that human populations, governance systems, and competition of land use are interrelated. Therefore, all of these aspects are essential for the sustainability and longevity of an urban forest to flourish and be effective.

Ostrom (2009) developed the SES framework that is useful in diagnosing factors that influence specific outcomes in a resource system. In Hanoi, this framework will be used to identify what SES variables influence the sustainability of urban forest management to mitigate stormwater runoff and air pollution. Using Clark’s (1997) model of sustainable UF, this paper will examine ways in which the city could adapt sustainable urban forest management (UFM) practices.

Although in the last decade, there has been increasing awareness of natural resources in Hanoi, there is a lack of policy to maintain and preserve resource areas. An area that has experienced tremendous environmental degradation is the urban
forest in the city. The SES framework will be used as a diagnostic tool to analyze research on Hanoi’s UFM. Identifying SES variables that influence the sustainability of Hanoi’s urban forest, along with other supporting theories such as UF sustainability model and the design principles, will help accumulate more knowledge needed to enhance the sustainability of complex social-ecological systems.
Chapter 2: Literature Review

2.1 Defining an Urban Forest

a) What are “urban forests?”

Urban forests include all publicly and privately owned trees within an urban or community area. This includes trees along streets, in private backyards, and stands of remnant forest. Urban forest, green space and community forest all have similar meanings, referring to trees, vegetation and open green areas within urban lands.

Urban land can be broadly defined as “developed land.” The US Census Bureau defines urban areas as 1) urbanized areas with populations of more than 50,000, 2) places that contain some urbanized areas within their boundaries, or 3) places with at least 2,500 people and located outside of urbanized areas (U.S. Census, 1995).

Urban forestry, also known as urban forest management, is the planning and management of trees, forests, and related vegetation within communities to create and add value (Bratkovich et al. 2010). The concept of urban forestry is the management of a total urban forest system, compared to arboriculture, which focuses on individual trees. Urban forestry has emerged as a combination of arboriculture, landscape architecture, horticulture, pathology and forestry.

b) History of urban forestry as a profession

Although “urban forestry” did not become a common term until the 1960s, urban tree management was first identified in the 16th and 17th centuries in Europe. In Our heritage
of Community Trees, by Gerhold and Frank (date?), describes how street trees became an important part of urban landscapes in Europe. In the late 1800’s, Ebenezer Howard conceptualized the idea of the garden city to address the common problems across European cities of overcrowding, health and environmental problems that were a result of the industrial revolution. As the concept was accepted, it increased development of public parks across Europe where urban trees were in need of management.

Thus, it was not until the 1800s that the concept of planting, propagating, and managing indigenous tree species in cities became common. In 1910 a forester in New York City listed his main duties as tree planting and maintenance (Dovetail, 2010).

The term “urban forest management” was first coined in 1965 by Professor Erik Jorgensen as “a specialized branch of forestry (that) has as its objective the cultivation and management of trees for their present and potential contributions to the physiological, sociological and economic well-being of urban society.” Thus, Jorgensen introduced the important benefits that urban trees can provide city dwellers.

2.2 Urban Forest Benefits
An urban forest provides many benefits in the form of ecosystem services. Urban trees provide these services through climate control, energy savings, rainfall interception/storage, improved water quality, and improved air quality (Burden, 2006). The social benefits of trees include increased recreation opportunities, increased property values, and aesthetic benefits (Burden, 2006).
Trees in cities can mitigate urban heat islands. Asphalt and concrete can increase urban temperatures 3-7 degrees, creating heat islands within the city (Burde, 2006). Urban trees influence a city’s thermal temperatures, energy use and air quality by providing shade, transpiring moisture and reducing wind speeds. Tree canopies also dramatically influence solar radiation by absorbing as much as 90 percent of it (FSRN, 2005). Trees reduce heating and cooling needs by reducing the amount of radiant energy absorbed and stored by impervious surfaces.

Urban trees also mitigate stormwater management problems in cities caused by high amounts of impervious surfaces. Trees slow the flow of stormwater runoff by absorbing the first 30% of precipitation through their leaf system, and another 30% of precipitation through their root systems (Burden, 2006). Tree leaves catch and delay rain from hitting impervious surfaces and the tree’s bark, roots and branches intercept or take up the rain, slowing the rate at which water is filtered to surface runoff. This same process also reduces the concentration of pollutants that flow into a municipality’s water supply.

In cities with high levels of air pollution, urban trees are key in reducing significant pollutants such as carbon monoxide, volatile organic compounds (VOC), nitrogen oxides, and particulate matter. Automobile exhaust is a major public health concern and tailpipe emissions are adding to asthma, and ozone. Urban trees can significantly reduce these impacts by absorbing nine times more pollutants than more distant trees by converting harmful gases back into oxygen. Through carbon sequestration, trees remove carbon dioxide from the air through photosynthesis (FSRN, 2005). Large trees can store about three tons of carbon (Nowak, 2005).
While clean air and water are the primary ecological benefits trees generate, trees in cities also have a high social value. Using i-tree software, researchers at the Minnesota Urban Forestry Program calculated that planting 100 trees offer a 40-year net benefit of $272,000. Trees add to the sale appeal of commercial and residential property, by increasing property value between 5-20 percent (Louks, 2009). Trees reduce the amount of car crashes by constructing vertical walls framing streets, which help guide driver’s movement and assess their speed (leading to overall speed reductions) (Burden, 2006). By forming visual walls and providing distinct edges to sidewalks (by separating pedestrians from vehicles), trees also created safer walking environments. Finally, urban forests create more aesthetically pleasing environments. They soften wide, grey atmospheres that buildings, streets and parking lots create, and in doing so, they reduce blood pressure and improve overall emotional and psychological health (Burden, 2006).

2.3 Social-ecological-systems

Because of the social and ecological nature of urban forests, it is important to recognize them as social-ecological systems. A social-ecological-system includes ecological systems (interdependent system of organisms and biological units) that have a relationship with human systems, in terms of their management and the rules we establish about them. SESs are composed of multiple subsystems and internal variables within those subsystems at multiple levels. When social and ecological systems are linked the SES becomes complex and has multiple layers. Namely, in here SES Framework, Ostrom (2009) identifies the following subsystems of a SES: resource system (RS), resource units (RU), users (U), and governance system (GS).
Ostrom distinguishes between the resource system and the flow of resource units produced in a system. Resource systems are the stock variables, capable of producing a maximum quantity of a flow variable (Ostrom, 1990). Examples are fishing grounds, aquifers, grazing lands, lakes, and irrigation systems. Resource units are what individuals appropriate from resource systems. For example: the types of fish harvested from a fishing ground, the amount of water drawn from an aquifer, the parking spaces filled in a parking lot, and trees from a forest. It is important to distinguish resource units as a flow because its connection with renewable resources, in which it is possible to sustain a resource.

Anyone that uses resource units in a resource system is referred to appropriators or users. Users of a system could be the fishers in a coastal fishery, or farmers that use an irrigation system. Governance systems are the organizations and rules that govern the resource system. A city council, neighborhood associations, and non-for-profits are examples of types of governance systems that could influence a resource system.

These subsystems can be looked at individually, but collectively these variables interact to produce outcomes at the SES level. RU, RS, GS and U are linked in a SES (figure 3.1). Each core subsystem is made up of multiple second-level variables. These second-level variables positively or negatively affect the outcome of interest (Ostrom, 2009). Ostrom’s framework was largely created for diagnosing the sustainability, the outcome of interest, of a single SES. This multilevel framework is used to analyze outcomes achieved in an SES and the variables that influence the relationships between the
subsystems. This serves the purpose of a general framework created to utilize along with theory developed regarding the second-level variables and the outcome of interest.

Figure 3.1 The subsystems in a framework for analyzing SES

2.4 Common Pool Resources

Important theory that can be utilized within the SES framework is the concept of Common Pool Resources (CPRs). In 1968, Garrett Hardin coined the term “Common Pool Resource.” CPRs are characterized by the difficulty of excluding others and the rivalry of use (one group or individual means that there is less available resource for use by others). Hardin’s conclusion regarding CPRs was that all CPRs would be eventually destroyed because too many people could freely use them and they are finite in nature (subtractable or rivalrous). According to Harding, this dilemma arises from the situation in which multiple individuals act independently and in their own self-interest.
Ostrom (1990) argued that individuals do not always act in their own self-interest and can actually sustainably manage CPRs. In fact, after studying multiple communities where CPRs have persisted over time, Ostrom concluded that there are at least 8 characteristics of communities that can sustain CPRs; she called these characteristics the “Design Principles” and they include: Clearly defined boundaries, Congruence between appropriation and provision rules and local conditions, Collective-choice arrangements, Monitoring, Graduated sanctions, Conflict-resolution mechanisms, Minimal recognition of rights to organize and Nested enterprises. Such theory can be tested in urban forest systems because components of urban forests have been called CPRs.

Street trees, a component of the urban forest, have been called CPRs. The benefits of street trees are nonexcludable. For example, the carbon that trees store benefits everyone in the city, not just the person living on the property the tree is planted on. Other benefits that trees provide, such as reducing stormwater runoff, increased property values and reducing air pollutants can all be considered non-excludable goods. The location of street trees (in the public right-of-way) also makes them difficult to be considered an excludable resource. What specifically makes a urban forest a CPR is that they are also a rivalrous good. Tree rivalry in urban setting results from competing uses of tree spaces and competing preferences regarding the street trees themselves. The increase use of pavement or development in urban areas competes with the space that trees need to grow. “Street Trees- A Misunderstood Common Pool Resource” noted that “extraction of street trees occurs frequently due to competing incentives and public values that lead to the removal of street trees” (Fischer and Steed, 2007, 8). Trees are also removed in response to public safety concerns or when they interfere with public utilities.
2.5 Sustainable urban forest management

Sustaining an urban forest means managing this resource to meet the needs of the present without comprising the needs of future generations by managing the system to maintain the production of ecosystem services over space and time (Dwyer et al. 2003). In an urban forest, sustainability is focused on the net benefits of trees at the broadest level and requires a broad set of management activities that range from single trees to tree stands in an urban area (Clark 1997). Managing an urban forest is a complex process and requires efforts between many users. Although a “one-size-fits-all” approach may not be appropriate, effective management models presented by Dwyer (2010) and Clark (1997) parallel many variables identified in the SES framework as affecting the sustainability of an SES.

Social, political and biological concerns must be jointly addressed to sustain urban forest health (Dwyer et al, 2003). Dwyer’s framework for UF planning involves five factors: social context, management goals and objectives, means (specific programs that are necessary), management outcomes, and information (quantitative data). Since an urban forest is located in a constantly changing area, management approaches must be flexible and adaptive.

Clark identified important criteria and performance measures for UF sustainability. These models encompass a community framework, resource management, and vegetation resources (Clark, 1997). This criteria aligns with Ostrom’s framework for sustainable
SES. A sustainable UF must combine biodiversity, native species, different sizes and ages of trees. The community must have a common vision of a UF in order to identify specific goals. A comprehensive management plan and funding program is vital in order for goals to be accomplished.

2.6 Clark’s sustainable urban forest management model

The science behind urban forest management is relatively new. It examines the relationships between ecological characteristics of trees and forest and their impact on the environment and communities. Many cities have adaptive a dynamic, comprehensive UF management plan. Many of these plans draw from criteria based from Clark’s UF sustainability model (1997), and many variables are congruent to Ostrom’s (2009) framework for sustainable SES.

Through a written survey, Clark’s model of urban forest sustainability was evaluated. Sustainability in a city’s UF was highest in cities with awareness of trees as a community resource and through community action. A score of 80 represented a sustainable urban forest, and among the 45 cities, the average score was 48.8 (Clark et al, 1998). The survey reflected two concepts in the model: that human intervention in an urban forest is necessary and private property contains a majority of urban trees. A main challenge to communities is integration management of private forest and regional cooperation in urban forest management. Many cities have used Clark’s criteria and have developed a strong community action plan in order to implement city tree program goals. Clark’s survey shows that his criteria has been proven to be important, and is similar to Ostrom’s
common pool resource and design principal theories, as well as her framework. Using these theories will be key to analyzing the sustainability of Hanoi’s urban forest.

2.7 UF Management in Hanoi, Vietnam

Although there have been many successful programs in U.S. cities, there is a lack of Urban Forest Management in developing countries. Hanoi, Vietnam has a rich history that has been influenced by many different cultures, notably Chinese, French and the Russian soviet regime. There is also a lack of quantitative data in respect to tree inventory and tree canopy cover in Hanoi; although, there is a growing awareness about the benefits green spaces provide to a city. This is evident in the growing research done in the field of natural resources within Hanoi. Pham Duc Uy and Nobukazu Nakagoshi used GIS and FRAGSTATS to quantify greenspace landscape changes and concluded that greenspace in Hanoi is reducing in the inner city and overall much more fragmented. For example, in 1996 there were 357 green patches totaling in 8449 ha and 669 patches (7139 ha) in 2003. Lien Thi Hoang NGUYEN examined the influences and changes in open space in the city from its founding in 1010c.e. She concluded that open space planning in Hanoi has been influenced by three main cultures (Chinese, French and Soviet), and that future planning should involve evaluation criteria and an adaptive management approach to meet increased greenspace goals.

Given the conclusions of these researchers, these two studies are key in examining Hanoi’s Urban Forestry management in relation to Ostom’s framework for sustaining CPRs in SESs and Clarks’s model of urban forest management.
Chapter 3: Methods

3.1 Study Area

Vietnam is located on the eastern margin of the Indochinese peninsula and Hanoi is located in the northern portion of the country (Figure 2.1). The mainland has an area of 127,240 square miles. Its curved, J-shaped area widens to flat deltas in the north and south, while the central region is narrow, and has a width of about 30 miles. Vietnam’s mountainous areas lie in the country’s northern and central regions. Two main topographic features are the Red River Delta in the north and the Mekong Delta in the south. It is surrounded by the Red River to the east, the Lich River in the West and the Kim Nguu River in the South. Two major lakes in Hanoi are the West Lake and Hoan Kiem Lake.

Figure 2.1 Map of Vietnam (National Geographic, 2012)
Vietnam’s climate is variable from region to region. However, the general climate is associated with monsoons, which produce two main seasons: a dry, cool winter and a warm wet summer. Even in the northern tropical rainforest of Vietnam, temperature and rainfall are seasonal. Summers are hot and rainy and last from May to October. Humidity reaches from 80-100 percent during the months of June, July and August.

The Political framework of Vietnam is a single-party constitutional republic (Communist Party) where there is a President and Prime Minister of Vietnam (executive branch), in a one party system that is led by the Communist Party of Vietnam. The National Assembly makes up the Legislative branch and the Judicial branch consist of the Supreme People’s Court and Prosecutorial Supreme People’s Procuracy. Vietnam consists of 58 provinces, and five municipalities (Can Tho, Haiphong, Danang, Hanoi and Ho Chi Minh City).

The Capital city of Hanoi is comprised of nine urban districts (Ba Dinh, Hoan Kiem, Dong Da, Hai Ba Trung, Thanh Xuan, Tay Ho, Cau Giay, Long Bien, and Hoang Mai) and five suburban districts (Figure 2.2). The Hoan Kiem district is the city’s main business area.
Hanoi was founded in 1010c.e. and its history was influenced by multiple foreign cultures including the Chinese, French, Soviet and other western styles. Capitalist and socialist planning have occupied Hanoi; therefore, the Capital city has had numerous political influences. This is particularly true when one considers urban green space planning and management.

These influences can be divided into four major periods: the Feudal Period, the French Colonial Period, the Post Independence Period, and the Contemporary Period (Nguyen, 2008). During the Feudal Period, Hanoi was influenced by traditional Chinese and Vietnamese culture. Architecture and planning followed the feng-shui principles. According to those principles, green and water space are the two most important features of the urban environment. The philosophy holds that green space helps bring people closer to nature. This collectively benefits a city when people have the common knowledge that a resource system is important. This is a variable that will be discussed in more depth in the discussion section of the paper.
From 1873-1954 the French influenced Hanoi, though most of this influence on planning is seen in the French Quarter district of Hanoi. The French increased tree population and had an in depth management plan for preserving the trees in their region of the city. This influence is still seen where the trees in the French quarter are the most maintained and some of the oldest in the city (Nguyen, 2008).

The Soviet style planning approach was adopted in 1954. Much planning was focused around housing and industry construction in order to strengthen the economy of northern Vietnam. In spite of the rapid industrialization, there was little improvement on the city’s greenspace areas. Although this period experience little UF growth, it was important in increase the economy and livelihood of Hanoi, which has allowed them to allocate more time and resources to their UF during the Contemporary period (Nguyen, 2008).

An important aspect of the contemporary period is the Doi Moi (open door) policy during the Contemporary period which was motivation for increased urban development. By 2008, the city had more than 6 million people densely populating an area of 3,300 square kilometers. Hanoi is one of the fastest growing cities in the world in terms of GDP, which is certainly linked to population growth. However, the fast increase in population has put tremendous pressure on the city’s infrastructure. The contemporary period is still experiencing rapid urbanization, but an another important planning mechanism was introduced. This “Master Plan” of Hanoi mentions goals of increasing greenspace above the current 0.3%, concentrating on
solving major environmental problems in Hanoi and other urban planning goals for
the city. This master plan has expanded the city's boundaries to incorporated parts
of the rural areas in ha Tay and Hoa Binh province to increase greenspace. However,
the goal of more equal distribution of greenspace in the city as a whole has not been
met due to the lack UF concentrated in the inner city (Nguyen, 2008).

3.2 Environmental Pollution in Hanoi

These variables from the SES framework not only help us analysis a broad dynamic
(overall sustainability of Hanoi's urban forest), but it can be used as a tool to look at
specific outcomes, such as how a resource system can affect areas of environmental
pollution. Vietnam has a weak infrastructure. They deal with stormwater runoff and
due to heavy rains throughout the monsoon season; it is common for the streets to
flood around the city. Because the city was built so rapidly, there is not an efficient
stormwater system in place. Urban forest present many storage options. Estimates
can be made to determine how much storage a tree can provide, but there is no data
currently available for the street trees of Hanoi. Hanoi’s urban trees help reduce this
stormwater runoff, and help filter pollutants out of the water before it reaches the
main water supply. Hanoi has identified their major lake systems as an important
part of Hanoi’s history and future economic and tourism growth. Unfortunately
these lakes are very polluted due to high levels of pollution in their water runoff.
Although there are regulations on levels of water pollution, enforcement is weak. By
increasing greenspace, the city of Hanoi will see lower levels of pollutions in their
lakes.
Increased industry and automobiles due to economic freedom are contributing factors in Hanoi’s high levels of air pollution. Key pollutants are dangerous levels of benzene and sulfur dioxide, as well as PM10 (80 mg/m3). There is no policy regulating the amount of emissions from motorbike (the most common form of transportation in Hanoi). These emissions are the primary contributor to Hanoi’s dangerous air quality. Many government agencies have collected data on the air pollution in the city, but agencies do not communicate or share this information. The lack of this base data makes it difficult to expand pollution measurement stations and create any legal framework to control air quality. There is a joint project between the government of Vietnam and Switzerland to prevent the further degradation of air quality in Hanoi. Although policy reform, awareness programs, demonstrated pilot projects and the establishment of a database has been part of the program’s phase one, goals focus on proactive solutions of reducing emissions, rather than reduction in the current air pollution.

With the lack of collective-choice rules, sanctions, and provisional rules, Hanoi is currently unable to set up an urban forest to mitigate these major environmental issues. Enforcement of emission and water standards are relaxed, and the system to monitor these standards are poor. There are no incentives for users to reduce their pollution.

3.3 Analytical Methods

a) Framework and Theory
Elinor Ostrom’s research in “A General Framework for Analyzing Sustainability of Social-Ecological Systems” and “Governing the Commons” were key to the analysis in this research and used to assess the current and future state of Hanoi’s urban forest management. By identifying street trees and urban forests as common pool resources (Fischer and Steed, 2008) the design principles and SES framework were defined and adapted for use in this case study.

The SES framework is used to identify ten subsystem variables that affect the likelihood of efforts to achieve a sustainable Social-Ecological Systems. The framework adopts a diagnostic approach to investigate the relationship between a large number of potentially relevant variables and outcomes for a specific resource system. The framework helps to identify relevant variables for studying a single SES. Subsystem units are the Resource units (RU), Resource system (RS), Governance system (GS) and Users (U).

In this case study, Hanoi’s urban forest is the resource being studied. This SES framework was used to identify second-level variables that play into the potential sustainability of Hanoi’s urban forest. Specifically, the role sustainable urban forests play in addressing two of Hanoi’s major environmental problems, stormwater management and improving an areas air quality, are discussed. Looking at this framework we are able to diagnosis Hanoi’s urban forest’s sustainability, and its particular ability to address these specific environmental problems. We look at primary data in reports to construct a secondary analysis of the data using subsystem variables Ostrom’s identified as key in SES sustainability.
These Design Principles were developed upon Ostrom’s research of common pool resource systems. The principles establish characteristics of a resource system that allow it to persist (in other words, be sustained). The principles are the following: clearly defined boundaries, congruence between appropriation and provision rules and local conditions; collective-choice arrangements, monitoring, graduated sanctions, conflict-resolution mechanisms, minimal recognition of rights to organize, and nested enterprises. These characteristics provide theory upon which analysis of Hanoi’s urban forest management can rest.

A similar framework to the SES Framework and its related Design Principle Theory is Clark et al.’s “Model of Urban Forest Sustainability.” This model was used to define sustainable urban forestry. The criteria model developed by Clark is comparable to the SES framework, and specific theory built into this model is similar to the design principles but with a specific focus on urban forestry. Future management practices for Hanoi were proposed based on the combination of sustainable resource theories, such as the design principles and Clark’s model of UF.

b) Document Analysis

Another important primary resource for this research project was Lien Thi Hoang NGUYEN’s study (2008) of the cultural context of open space planning in Hanoi. The study examined the relationship between open space and livability, and investigated the difference between Eastern and Western views of open space planning. The case study showed the various historical and cultural periods in Hanoi’s history, and how
these influences have generated different approaches to urban planning management. One such trend was the “Doi Moi” policy that encouraged the country to develop and expand its international economic relationships. This paper highlights major green space in Hanoi and future city planning. It also brings to light many environmental issues that the city is facing. Document analysis of the thesis was conducted to support analysis.

An additional resource, The Vietnam EPA Report (date), discusses seven major environmental concerns in depth. Urban forests are recognized as providing many ecosystem services, as is proper tree management and increasing tree canopy cover in the city in order to help decrease the consequences of air pollution and stormwater runoff.

A final document, “Analyzing urban greenspace pattern and eco-network in Hanoi, Vietnam” (author, date), used in analysis provided quantitative data collected from Pham Duc Uy which analyzed urban green space patterns in Hanoi. Greenspace in Hanoi has become more fragmented over time, although street trees and public green space has increased.

c) Interviewing

It is important to create a well-balanced research methodology. Biophysical data from Hanoi was difficult to process in a limited time span due to language barriers, distance and lack of research in this area; therefore, conducting interviews of key informants was important to provide in-depth information to address this particular
Whereas quantitative research methods can gather a small amount of information from many subjects, interviews are qualitative and can gather a broad range of information from few subjects. Lien Thi Hoang NGUYEN’s, and Professor Tran Thuy were asked a series of semi-structured email questions regarding the biophysical, social and governmental challenges facing Hanoi in creating a sustainable urban forest, as well as questions about the current governmental natural resource policies.


d) Personal Experience

As part of the Scholars in Global Citizenship team that traveled to Hanoi during the summer of 2011, I was able to see some of the environmental issue Hanoi is battling first-hand. Working with Vietnamese students for a month, I was able to develop an understanding about their culture. This first-hand experience allows me to evaluate Hanoi’s urban forest sustainability with a deeper insight.

Results and Discussion

Although Hanoi is a rapidly developing region, the city has reached a high level of economic development that they can start to allocate more of their time and resources to preserving, protecting and rebuilding their urban forest (UF). It would be ideal for Hanoi to have a sustainable urban forest, but at their current rate of use they are below that level. Using the SES framework we can assess the standard of Hanoi’s UF and its likelihood of enhancing its sustainability.
4.1 Identifying SES variables

Understanding the variables that affect Hanoi’s urban forest transition is key to creating improvements in the system that result in the sustainability of an urban forest. The framework is applied to identify relevant variables in studying the urban forest of Hanoi. Ostrom’s social-ecological systems framework has been used to organize our findings and examine the relationship between collective action and the urban forest in Hanoi. Variables are identified in terms how they variables positively or negatively affect the likelihood of achieving a sustainable UF.

This framework helps identify variables for studying the urban greenspace (a proxy for urban forest) of Hanoi. Second level variables are analyzed under the resource system (RS), governance systems (GS), resource units (RU) and users (U). These variables are identified as having a positive or negative trend that will affect the outcome of a sustainable urban forest.

4.2 Users

Hanoi has a rich history and the amount of natural? resources used has increased dramatically in the last two decades due to the large population (i.e. the number of users). In an overpopulated city of 6.5 million citizens, squeezed into an area of 3,300 kilometers, it is not difficult to identify the number of users (U1) as an important variable influencing UF sustainability since generally all the people of Hanoi are receiving the benefits of greenspaces. Since so many people will be benefiting from the Urban Forest, this variable is identified as a positive trend.
The socioeconomic attributes of users vary (U2). In the last decade there has been a trend that wealthier people are moving out to the suburbs to acquire more land, with the result that the poor people left in the inner city have less accessibility to the urban parks. The average GDP per PPP is $2,682. Education and disciplines in science, math and other profession are highly respected in the city, and Hanoi plays host to the majority of public universities in Vietnam. The migration of the middle and upper class to the outskirts of the city can be identified as a negative variable. Although their property may contain more trees, and be privately managed, the increase in sprawl results in more construction and land altering, which ultimately reduces greenspace.

The greenspace in Hanoi has changed throughout its four major time periods, and this history of UF use has an effect on the current sustainability of the urban forest (U3). From 1010-1873 there was major Chinese influence in Hanoi, and there was closeness to nature because of the feng-shui. Citizens were also able to use their tree resources more freely because there were more resources available and private use was not as restricted. This principle still applies currently and positively affects Hanoi’s UFM sustainable outcome because the Vietnamese people highly appreciate the values of tree and this become important in terms of how to protect trees from urbanization and construction. During the French period greenspace was increased and beautified in the French quarter specifically (still evident in this district currently where trees are very well managed and some are over 50 years old). The Soviet regime improved and rapidly increased infrastructure, lacking focus on
greenspace. Since 1985 (contemporary period), there has been more urban and international development because of the Doi Moi policy, and the national budget is focusing on improving the amount and quality of livable areas. The Master plan focuses on environmental problems and address greenspace as a way to improve water quality. This master plan both positively and negatively affects the likelihood of sustainable UF outcomes. This is because it makes increasing greenspace a main objective, but it lacks a defined definition of how much this increase is or what specific goals the city has (i.e. most cities have defined goals such as the following: increasing tree canopy cover by 20%).

Greenspace areas (i.e. West Lake, parks) are important tourist locations, but are in threat because of increased land loss and pollution. Appropriators recognize the unequal distribution of greenspace and land demand is decreasing due to overdevelopment. Users can establish businesses with ease as a result of relaxed government restrictions on permits and zoning. This allows users to have leadership in their enterprises, but as a result of increased development, greenspace is decreased and fragmented, as determined by Pham (2007). There is leadership (U5) within the city government that is positively influencing Hanoi’s UFM sustainability. The Chairman of the People’s Committee of Hanoi City, Mr. Nguyen Te Thao, is a powerful leader in urban planning, and has helped influence the city’s decisions on urban greenspace planning.

Another important variable that influences a sustainable outcome is “Importance of resource” (U8). There are three important variables to sustainable development:
There has recently been a growing awareness about the roles and benefits of greening urbanized areas, resulting in a strategic concept of city planning in Hanoi that incorporates increasing greenspace and its connectivity. Open space planning is leaning toward developing livable communities and “city planning obtaining community participation.” The city government and other users recognize increasing pressures of lack of clean water, air, accumulating garbage and deficiencies in open space. They also recognize that public parks contribute to the local economy. Even though individual street trees are not mentioned, water quality, open space area, conservation space and species protection are indicators for environmental quality and protection, and this base common knowledge that the resource is important (U8) positively affects Hanoi’s UF outcome.

4.3 Resource Units

As a result of the lack of quantitative data, with the exception of Pham’s greenspace analysis paper, identifying resource unit variables was difficult. Since a tree inventory for Hanoi has not been established, there are no known growth or replacement rates, nor are the number of units known. Several qualitative measurements have been recognized, but there is insufficient data to support the indicators adapted by Lien (i.e. crime in public open space, city parks expenditure, rare and endangered species protected). It is known that 78% of tree species within the city are native, and most of these trees were planted by French scientists before
1945 (Tran, 2012). Controlling exotic species levels in Hanoi has been identified as a goal for the city.

Due to the lack of inventory on the number of units (RU5), this is identified as a variable that negatively influenced the outcome of UFM sustainability. In terms of distinctive markings (RU6), there is no system to keep records of trees, or tracking system, though there is evidence of a level of care for trees. This is seen by the distinctive white paint on the trunk of trees to prevent pest damage. This could be seen as a positive variable because this sets a normative pattern of behavior for tree care since it might deter another person from damaging or removing a tree.

4.4 Resource System

The sustainability of an urban forest is dependent on the inputs of the users since users determine the number of trees removed, maintained and planted (RS1).

The boundaries (RS2) of the urban forest can be difficult to describe since city boundaries can sometimes not be clearly defined. The city of Hanoi has nine major urban areas and five suburban areas within 3,300 km². The Master Plan has encompasses rural areas to add to the city’s total area. This has increased the city’s total greenspace areas, but the boundaries of the system are still unclear due to its sprawling nature and lack of tree inventory. The absence of clear system boundaries negatively affects a sustainable UFM outcome. Because the exact system boundaries are not clear, it makes it difficult to determine the size of Hanoi’s UF (RS3), making this a variable negatively affecting the sustainability of the urban forest.
An urban forest can help reduce the cost of human-constructed facilities (RS4), and such is the case in Hanoi. The infrastructure in Hanoi is very weak and during the monsoon season the city typically experiences flooding due to the high concentration of impervious surfaces. Greenspace reduces stormwater runoff, and air pollutants, which can help make the system more efficient and less costly. This is identified as a negative and positive variable--Negative because of the poor infrastructure, but positive because of Vietnam’s government working with the Swiss government to tackle major environmental concerns such as stormwater runoff and water pollution. Increasing the UF in Hanoi has been identified as a potential solution.

Hanoi features a warm, humid subtropical climate. The productivity of the system (RS5) is a positive variable because this climate allows for a very productive ecosystem, due to the high precipitation, warm temperatures and plentiful sunshine. However, increased development, high amounts of pollutants and acid rain can reduce the productivity of the urban forest in Hanoi.

There are several ways to determine the predictability of an urban forest, such as annual tree inventories, maintenance plans, pruning, *et cetera*. Users need to establish a system in order to predict future results. For Hanoi, there is no system in existence; therefore, predictability in resource dynamics (RS7) is identified as a negative variable. Another variable that could address stormwater and air pollution and that affects the outcome of this SES is storage characteristics (RS8). Urban
forests present many storage options (i.e. absorbing water through tree roots).
Estimates can be made to determine how much storage a tree can provide, but there
is no data currently available for the street trees of Hanoi, thus, this variable is not
negatively impacting the sustainability of Hanoi’s UFM.

4.5 Governance System

There are many government organizations that positively influence the outcome of
urban forest sustainability in Vietnam (GS1). There are three main departments that
have control or management over Hanoi’s greenspace areas. The Department of
Transportation and Urban Public Works Services is responsible for urban trees and
parks management, specifically street trees. The Department of Natural Resources,
Environment and Housing is responsible for natural resource and environmental
management. The Park and Green Tree Company is responsible for trees in public
parks. In this network structure (GS3), there is no leading agency that is responsible
for the UF as a whole, but it is important that there are three departments that
manage different sections of the UF. This is because if one department were to
neglect its responsibilities, the other departments would be able to pick up their
tasks.

Although there are no established nonprofits dealing with UF, there are some
student and voluntary groups (GS2). Such groups are the student and environment
VNU- University of Science, and Go Green organizations. There is also a national tree
planning day (“Green Saturday”) during Tet (New Year’s celebration). The lack of
nongovernmental organizations is a variable with negative effects regarding UF sustainability.

Trees on streets and in parks are public owned, while trees in residential property are privately owned (GS4). In my research, I was unable to locate any tree ordinance that the public could access to determine the operational rules or constitutional rules of using the resource system (GS5 and GS7). This leads to citizen's resorting to normative behavior, and the lack of collective-choice rules because there is no evident effort to self-organize to sustainably manage their urban forest (GS6). With the exception of signs attached to trees (a public announcement with the goal of protecting trees), here is little monitoring and sanctioning (GS8). This will negatively affect the likelihood of sustaining the UF.

4.6 Related variables

In a complex SES, subsystem variables often interact to produce more multipart outcomes. When variables interact on a positive level, it is more likely that the SES contains more self-organizing value and the resource has the potential to be more sustainable. There are many relationships among the subsystems of an SES, as well as between social, economic, and political settings. These relationships are extremely important because they can support each other, making a system more sustainable. Several important relationships have been identified.

When accessing Hanoi's urban forest system “user” variables, one can see how U1-U8 can relate to other variables. Interacting variables included biophysical (size of
the resource system, built infrastructure, boundaries of resource) and governance. The number of users dramatically affects the size of the resources system and human-constructed facilities because the amount of users (urban dwellers) affects the built environment, which affects the amount of space for trees to grow. The more users, the more the city will have to manage the undesired consequences such as increased stormwater runoff and increased air pollution.

Some variables relate to affect amount of knowledge users have about the resource. U2, U7, GS1, GS6 and GS2 all relate because the socioeconomic attributes of users determine how much knowledge is related to them. The higher the economic status, the more education received. If the user is more educated about the system, they are more likely to create non-government organization through collective-action. In the United States, there are dozens non-government urban forestry programs that have been created because the users have knowledge of SES and recognize the importance of the resource. Unfortunately, in Hanoi, there is a lack of knowledge of the economic benefits of urban forests (social part of a SES) negatively affecting the outcome due to the lack of information about the economic value of the trees.

Because the exact system boundaries are not clear, it makes it difficult to determine the size of Hanoi’s UF (RS3). This will affect the monitoring and enforcement of the resource system (GS8), since the responsible parties will not know exactly where to allocate their resources. This ultimately will affect the likelihood of Hanoi to sustainably manage their urban forest because theory shows it is key to have proper
assessment tools and a city-wide management plan to implement efficient enforcement of operational and constitutional rules.

The internal network structure (GS3) between departments managing their UF is identified as negatively influencing their sustainable outcome. There is overlap in UF management and poor communication and information sharing. Even so, the government has allocated more funds for research and/or protection for UF areas. Externally, the network activities (I7) are a positive variable because of international involvement and aid such as Ausiad, CIDA, and SIDA.

Operational rules, collective-choice rules, constitutional rules, economic value of an UF (energy savings provided by trees by absorbing solar radiation and providing shade), government resource policies, and market incentives will influence how users view the importance of the resource. In Hanoi, the government recognizes how much stress is being put on the area’s natural resources. They also address the environmental problems that rapid development has created (increased stormwater runoff and air pollution), and have created projects that could restore urban trees, and lift environmental standards. Enactment and enforcement in these program are low. These projects have been defined as increasing greenspace in the city, their Clean Development Mechanism program (CDM), Tree Planting Tet, reducing invasive species (such as *Nerium* and *Orleander*) and incorporating rural land into the city boundaries. If the government is not portraying the urban forest as a vital resource and is not creating any market incentives, then the full importance of the resources is not being stressed to the users. Government resource policies are
extremely important in a communist society when users rely on the government for specific instruction.

The economic value of an urban forest is dependent on the productivity of the system, predictability of system dynamics, storage characteristics, and monitoring process (monitoring tree inventory and for damage, diseases and safety).

Performance indicators of sustainable UFM include a complete tree inventory and GIS. Urban forest provides strong storage characteristics and can save the city money. If the economic benefits of Hanoi’s urban forest are clarified and stressed, then the importance of the resources, market incentives, and other outcomes will positively increase. If users recognized a potential economic benefit, more resources would be put into the system, and there is the potential of self-organizing activities to preserve and maintain trees. Hanoi is in a transitional period in which they are still a developing country, but have reached a stage in which they can start allocating more money and time into preservation and protection of their natural resources now that their economy has improved dramatically. Negative environmental consequences are being recognized, but more emphasis has to be placed on the urban forest so that projects will be implemented, and the benefits of the UF will increase. Instead of building expensive infrastructure to manage stormwater runoff and mitigate air pollution, a rich, diverse UF can have a hierarchy of benefits. It will not just help mitigate major environmental concerns, but address other environmental, social and health problems the city is dealing with. If the economic and environmental benefits are publicized then there is a high chance for the UF to grow (RU2).
The size and productivity of the resource system largely relates to the interactions of many of the first-level core subsystems. The government will influence the UF with its policies, organizations, operational rules and monitoring processes. Currently, the development in Hanoi is booming, and has been increasing annually due to the Doi Moi policy. Lately, there has been a shift and the benefits of natural resources are being recognized. Not only is governmental policy key, but social participation is also key. There have been efforts by research institutions and universities to increase construction projects of Hanoi’s urban forest. Most projects are focusing on restoring existing urban trees. Economic development will strongly influence the resource system. Historically, sections of the urban forest in Hanoi have been deemed a culturally significant point of interest. The French increased greenspace, but during the Soviet era, the expansion of greenspace was paused. It was when the Doi Moi policy was enacted that the economic wellbeing of users increased. Since the users have an increased fiscal and social capital, more attention has been devoted to other aspects, such as natural resource protection.

The productivity of a resource system is decreased when related factors decrease predictability. The demographic trend of a rapidly increased population and infrastructure, as well as increased industry, has created a shift in greenspace in the city. Greenspace areas have become more fractured. In a period of less than 10 year, greenspace patches almost doubled from 357 to 669 (7139 ha.). Greenspace area reduced 1,310 hectares. Not only has the urban forest been fragmented due to an increase in number of users, entrepreneurship, economic development and other
demographic trends, but the urban forest is less connected, further reducing its benefits. Fortunately, some public greenspaces, and street trees have increased (figure 4.1).

Figure 4.1 Changes in greenspace patches from 1996 to 2003 (Pham, 2007).

4.7 Design Principles

Ten second-level variables can affect the likelihood of users’ self-organizing to manage a resource. These have been identified as Size of resource system (RS3), Productivity of system (RS5), Predictability of system dynamics (RS7), Resource unit mobility (RU1), Collective-choice rules (GS6), Number of users (U1), Leadership/entrepreneurship (U5), Norm/social capital (U6), Knowledge of SES (U7), and Importance of resource (U8). These variables are associated with the design principles, which foster long enduring common pool resources.
Analysis of these variables can be challenging because the impact of one variable can depend on the other subvariables. This is a very dynamic system in which outcomes of an SES will vary depending on the rules established and attributes of RS, RU, U and GS.

As identified before, the urban forest boundaries in Hanoi are not clearly defined. There is no existence of a tree ordinance, which establishes tree ownership or a responsible party. Since there is no active tree identification program or maintenance of trees, it is difficult for Hanoi to put a value on the productivity of the resources or create any pattern for the predictability of the system. Defining boundaries is key in the first step in organizing for collective action. In this case, users are not aware of the benefits of the urban forest resources; therefore, users risk losing the resource all together because they freely withdraw the units. In Hanoi, benefits of trees are just starting to be recognized, but the increase in economic wellbeing encourages further industrial/infrastructure development. This open, free access reduces and fragments greenspace, limiting the long-enduring potential of the urban forest.

Hanoi has a high volume of appropriators, and due to the economic freedom set up by the Doi Moi policy, entrepreneurship in the city is increasing. Many families have started their own business out of their homes, or will use the streetscape in front of buildings. This has also increased social capital, rising peoples standards of living. Now that basic necessities are being provided and users are economically stable,
environmental problems and other humanitarian efforts are now becoming recognized. The city of Hanoi is facing major stormwater runoff management issues as well as high levels of air pollution. Unfortunately, users do not know the full importance of greenspace because the public does not recognize the social side of the SES (due to the lack of data available and shared with the public).

If a social-ecological system displays positive values for these specific variables, then some level self-organization of appropriators typically follows. In the case of greenspace in Hanoi, there are several values that lack emphasis. This results in a lack of collective-choice, and operational rules. There is some congruence between the districts of Hanoi, but the operational rules between some districts vary. The French quarter notably stands out. It is very obvious that the urban forest in this section receives more maintenance and care than anywhere else in the city.

Although there are several departments that are responsible for the management of greenspace and the urban forest in Hanoi, management is poor due to the overlap in objectives and lack of information sharing and communication. The urban forest of Hanoi is part of a more complex CPR. There are many levels of jurisdiction. There is the national level (which influences major goals of the city), the municipal government (Department of Transportation, Department of Natural Resource Management, and Park and Green Tree Company) and People’s Committees (composed of district management). Establishing rules at one level, without rules at other levels, or the lack of educating other levels about those rules, will result in an
incomplete system. This will negatively influence the likelihood of Hanoi to sustainably manage their UF.

4.8 Achieving Sustainability

The SES framework provides a common set of variables that organize many isolated variables in a way that relates them to one another. This collected data then can be used to analyze the level of sustainability of the system. Once this level is determined the management of the resource can be improved. Urban areas that sustain substantial forest resources have the potential to significantly improve the quality of their urban environment.

There are two outcomes for Hanoi’s urban forest: 1) overall sustainability and 2) ecological performance measures (how UF can help reduce air pollution and stormwater runoff). While Hanoi’s SES framework has many important variables—which are all important when looking at the complete sustainability of a system—a few specific variables relate to Ostrom’s design principles, and Clark’s model of urban forest sustainability.

Similar to the design principles, which identify defined boundaries as an important aspect for a community to reach sustainability, the model for UF also determines criteria that help set boundaries for the resource system. Achieving a climate-appropriate tree cover, optimal age distribution, high biodiversity and preserving native trees in the community are all important components that will result in a UF
with a continuous high level of net benefits. Hanoi does not have an assessment of these values; therefore, their key objective should be establishing a tree inventory.

There are many community aspects apparent in the design principles that can alter a SES sustainable outcome. These are collective-choice agreements, and the rights to organize. These principles are similar to the UF model in neighborhood action, citizen-government-business interaction, public agency cooperation and involvement of large private and institutional landholders. These theories show that it is very important for a SES to have a high level of positive community interaction. In Hanoi, there is a lack of this interaction, which will make it more difficult for the city to build a community framework.

Luckily, there is some small group participation, and if these small organizations were to expand, the UF in Hanoi would most likely achieve a higher level of sustainability. It is recommended that there is increased involvement from public agencies (i.e. Parks and Green Tree Company, Department of Natural Resources), and these agencies should operate with common goals and objectives. Achieving this cooperation involves more communication, increased legislation and involvement from city committees, and key stakeholders.

Monitoring, sanctions, and nested enterprises must all be managed carefully in order to achieve a sustainable urban forest. Specific policies must be in place to protect the resources. A comprehensive management plan, with appropriate funding, must be in place to develop Hanoi’s UF. The Master Plan for Hanoi has
stated that increasing greenspace in Hanoi is a goal, but this is too broad. There needs to be a developed management plan for their urban forest that addresses specific UF criteria (i.e. performance goals and standards for tree care, tree preservation, planning and planting, funding, proper staffing, assessment tools). For example, even though there are three main departments that encompass some level of management of the UF, there needs to be formal working teams and staff coordination to ensure all city departments operate with common goals and objectives in mind. The citizens of Hanoi have an increasingly very high awareness of the importance of trees and their role in the environment. By the government adapting specific goals and being transparent (sharing management objectives and figures), citizens will understand and participate in urban forest management.

Chapter 5: Conclusion

Ostrom’s social-ecological system framework was used as a guide to identify positive and negative variables that affect the sustainability of Hanoi’s urban forest. Several of these variables interrelate and their interactions can alter the outcome desired. Many documents, such as Lien’s (date) “Open Space Planning in Hanoi”, and Pham’s (date) analysis of greenspace changes were useful in identifying these variables. The framework, Lein’s thesis, and Pham’s analysis were useful tools in identifying and defining variable that affect UFM sustainability. Interviewing and personal experience were supplementary tools also enhanced the integrity of this research.
Hanoi has many variables that positively affect their likelihood to achieve a sustainable urban forest. Some of these significant variables include the SES’s history of use, the importance of the resource, productivity of the system, internal government organizations, and the economic value of an urban forest. This data suggests that the potential for Hanoi to manage a sustainable urban forest exists. Although, there are important positive variables, there are several significant negative variables that need to be addressed in order for Hanoi to achieve the desired outcome of a sustainable UF. The significant negative variables that need improvement are as follows: monitoring, the number of units, human-constructed facilities, networking structure/networking activities, operational rules, knowledge of the SES, collective-choice rules and self-organizing. Additional variables to improve upon would be communication between departments, establishing a tree inventory of the city, defining specific goals, monitoring and enforcing those goals could diminish many of the negative variables.

Although Hanoi is at a transitional phase in their development, they have come to include many positive variables that will help them achieve a sustainable urban forest. Other variables must be closely monitored or corrected since they will ultimately determine the rate of and success for a sustainable management of Hanoi’s UF. Achieving sustainability of an UF involves meeting the criteria listed in Clark’s UF model, and using the design principles as a guide. Hanoi can use the Social-Ecological-Systems framework as a guide to diagnose their current and future level of sustainability in their urban forest.
Appendix

Figure 6.1, the Social-ecological Systems Framework

<table>
<thead>
<tr>
<th>Resource unit mobility</th>
<th>Users (U)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RU1</td>
<td>U1 Number of users*</td>
</tr>
<tr>
<td>RU2</td>
<td>U2 Socioeconomic attributes of users</td>
</tr>
<tr>
<td>RU3</td>
<td>U3 History of use</td>
</tr>
<tr>
<td>RU4</td>
<td>U4 Location</td>
</tr>
<tr>
<td>RU5</td>
<td>U5 Leadership/entrepreneurship*</td>
</tr>
<tr>
<td>RU6</td>
<td>U6 Norms/social capital*</td>
</tr>
<tr>
<td>RU7</td>
<td>U7 Knowledge of SES/mental models*</td>
</tr>
<tr>
<td>RU8</td>
<td>U8 Importance of resource*</td>
</tr>
<tr>
<td>RU9</td>
<td>U9 Technology used</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interactions (I) → outcomes (O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1 Harvesting levels of diverse users</td>
</tr>
<tr>
<td>I2 Information sharing among users</td>
</tr>
<tr>
<td>I3 Deliberation processes</td>
</tr>
<tr>
<td>I4 Conflicts among users</td>
</tr>
<tr>
<td>I5 Investment activities</td>
</tr>
<tr>
<td>I6 Lobbying activities</td>
</tr>
<tr>
<td>I7 Self-organizing activities</td>
</tr>
<tr>
<td>I8 Networking activities</td>
</tr>
</tbody>
</table>

Related ecosystems (ECO)

ECO1 Climate patterns. ECO2 Pollution patterns. ECO3 Flows into and out of focal SES.

*Subset of variables found to be associated with self-organization.
## Table 1. Criteria of urban forest sustainability for the Vegetation Resource.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canopy cover</td>
<td>Achieve climate-appropriate tree cover, community-wide. Though the ideal amount of canopy cover will vary by climate and region (and perhaps by location within the community, there is an optimal degree of cover for every city.</td>
</tr>
<tr>
<td>Age distribution</td>
<td>Provide for uneven age distribution. A mix of young and mature trees is essential if canopy cover is to remain relatively constant over time. To insure sustainability, an on-going planting program should go hand in hand with the removal of senescent trees. Some level of tree inventory will make monitoring for this indicator easier. Small privately owned properties pose the biggest challenge for inclusion in a broad monitoring program.</td>
</tr>
<tr>
<td>Species mix</td>
<td>Provide for species diversity. Species diversity is an important element in the long-term health of urban forests. Experience with species-specific pests has shown the folly of depending upon one species. Unusual weather patterns and pests may take a heavy toll in trees in a city. It is often recommended that no more than 10% of a city’s tree population consist of one species.</td>
</tr>
<tr>
<td>Native vegetation</td>
<td>Preserve and manage regional biodiversity. Maintain the biological integrity of native remnant forests. Maintain wildlife corridors to and from the city. Where appropriate, preserving native trees in a community adds to the sustainability of the urban forest. Native trees are well-adapted to the climate and support native wildlife. Replanting with nursery stock grown from native stock is an alternative strategy. Planting non-native, invasive species can threaten the ability of native trees to regenerate in greenbelts and other remnant forests. Invasive species may require active control programs.</td>
</tr>
</tbody>
</table>
Table 2. Criteria of urban forest sustainability for the Community Framework.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public agency cooperation</td>
<td>Integrate all city departments operate with common goals and objectives. Department such as parks, public works, fire, planning, school districts and (public) utilities should operate with common goals and objectives regarding the city's trees. Achieving this cooperation, requires involvement of the city council and city commissions.</td>
</tr>
<tr>
<td>Involvement of large private and institutional landholders</td>
<td>Large private landholders embrace city wide goals and objectives through specific resource management plans. Private landholders own and manage most of the urban forest. Their interest in, and adherence to, resource management plans is most likely to result from a community-wide understanding and valuing of the urban forest. In all likelihood, their cooperation and involvement cannot be mandated.</td>
</tr>
<tr>
<td>Green industry cooperation</td>
<td>The green industry operates with high professional standards and commits to city-wide goals and objectives. From commercial growers to garden centers and from landscape contractors to engineering professionals, the green industry has a tremendous impact on the health of a city's urban forest. The commitment of each segment of this industry to high professional standards and their support for city-wide goals and objectives is necessary to ensure appropriate planning and implementation.</td>
</tr>
<tr>
<td>Neighborhood action</td>
<td>At the neighborhood level, citizens understand and participate in urban forest management. Neighborhoods are the building blocks of cities. They are often the arena where individuals feel their actions can make the biggest difference in their quality of life. Since the many urban trees are on private property (residential or commercial), neighborhood action is a key to urban forest sustainability.</td>
</tr>
<tr>
<td>Citizen - government - business interaction</td>
<td>All constituencies in the community interact for the benefit of the urban forest. Having public agencies, private landholders, the green industry and neighborhood groups all share the same vision of the city's urban forest is a crucial part of sustainability. This condition is not likely to result from legislation. It will only result from a shared understanding of the urban forest's value to the community and commitment to dialogue and cooperation among the stakeholders.</td>
</tr>
<tr>
<td>General awareness of trees as a community resource</td>
<td>The general public understands the value of trees to the community.</td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td>-----------------------------------------------------------------</td>
</tr>
<tr>
<td>Regional cooperation</td>
<td>Provide for cooperation and interaction among neighboring communities and regional groups.</td>
</tr>
<tr>
<td></td>
<td>Urban forests do not recognize geographic boundaries. Linking city's efforts to those of neighboring communities allows for consideration and action on larger geographic and ecological issues (such as water quality and air quality).</td>
</tr>
</tbody>
</table>
Figure 6.4 Clark's Model of Criteria of Urban Forest Sustainability for Resource Management

<table>
<thead>
<tr>
<th>City-wide management plan</th>
<th>Develop and implement a management plan for trees on public and private property.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A city-wide management plan will add to an urban forest's sustainability by addressing important issues and creating a shared vision for the future of the community's urban forest. Elements may include: species and planting guidelines; performance goals and standards for tree care; requirements for new development (tree preservation and planning); and specifications for managing natural and open space areas.</td>
</tr>
<tr>
<td>Funding</td>
<td>Develop and maintain adequate funding to implement a city-wide management plan.</td>
</tr>
<tr>
<td></td>
<td>Since urban forests exist on both public and private land, funding must be both public and private. The amount of funding available from both sources is often a reflection of the level of education and awareness within a community for the value of its urban forest.</td>
</tr>
<tr>
<td>Staffing</td>
<td>Employ and train adequate staff to implement a city-wide management plan.</td>
</tr>
<tr>
<td></td>
<td>An urban forest's sustainability is increased when all city tree staff, utility and commercial tree workers and arborists are adequately trained. Continuing education in addition to initial minimum skills and/or certifications desirable.</td>
</tr>
<tr>
<td>Assessment tools</td>
<td>Develop methods to collect information about the urban forest on a routine basis.</td>
</tr>
<tr>
<td></td>
<td>Using canopy cover assessment, tree inventories, aerial mapping, geographic information systems and other tools, it is possible to monitor trends in a city's urban forest resource over time.</td>
</tr>
<tr>
<td>Protection of existing trees</td>
<td>Conserve existing resources, planted and natural, to ensure maximum function.</td>
</tr>
<tr>
<td></td>
<td>Protection of existing trees and replacement of those that are removed is most often accomplished through policy vehicles. Ordinances that specify pruning standards and/or place restrictions on the removal of large or other types of trees on public and private property and during development are examples.</td>
</tr>
<tr>
<td>Species and site selection</td>
<td>Provide guidelines and specifications for species use, on a context-defined basis.</td>
</tr>
<tr>
<td></td>
<td>Providing good planting sites and appropriate trees to fill them is crucial to sustainability. Allowing adequate space for trees to grow and selecting trees that are compatible with the site will reduce the long- and short-term maintenance requirements and enhance their longevity. Avoiding species known to cause allergic responses is also important in some areas.</td>
</tr>
</tbody>
</table>
Works Cited


