Fore Karst: A Biotope-focused planning approach for the ecological management of Susong Dalaga, Quirino

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Abstract. Conventional planning approaches that prioritize built-up areas and rapid urbanization for economic growth and social security, instead of the environment and the ecological services they provide have consistently been problematic in maintaining sustainability. Because of this, there is a growing need to shift from the conventional to a greener approach. The research argues that an ecological management approach is a viable choice of approach in protecting the ecological integrity of the landscape, especially in biotopes where ecological services are sought-after, such as the karst system Susong Dalaga found in Cabarroguis, Quirino Province. This approach is done by identifying the different biotopes to find the existing relations, services, and underlying issues of the place. In assessing the items mentioned earlier, the research finds that the natural systems are slowly dwindling due to the expansion of agriculture and built-up areas. Each biotope is then assigned with an appropriate approach, and with the consultation of the stakeholders, policies are then strategized for specific functions. It is hoped that the study would help push the application and integration of ecological management approach, and green approaches and principles in general, to future urban planning projects in the Philippines.

Keywords: biotope, ecology, ecological infrastructure, environment, urban planning

1. Introduction

According to the Philippine Statistics Authority [14], the rate of urbanization from 2010 to 2015 is recorded to be at 4.6 percent. This is reflected as the percentage of people who live in urban areas, comparing 2010 and 2015, had a remarkable leap of 45.3 percent to 51.2 percent. This data reflects the reality that the Philippines is being urbanized and developed at a swift rate. This is to be augmented by the government’s focus on infrastructure. In a report from Manila Bulletin in 2017, the National Economic and Development Authority stated that the government plans to spend a staggering 18.7 billion US Dollars on infrastructure under the “Build, Build, Build” Program, which focuses on transportation and social structures.

Situated in the Cagayan Valley as the youngest province, Quirino encompasses vast vegetative farmland covers, with rice and corn being the major crops, in addition to other fruit and vegetable produce. The province is also part of the Sierra Madre mountain range, which is home to virgin forests and complex riparian systems of the Cagayan, Addalam, and Ganano Rivers. This mountain range is currently secured by the Quirino Protected Landscape, which covers 175,943.62 hectares (around 67 percent of the total land area of the province). These natural systems offer excellent ecological services (such as protection from floods, landslides, and strong winds) and provide an economic and cultural livelihood to the residents.

Despite rural qualities, Quirino is proliferating – its population, for instance, is growing at a rate of 2-3 percent annually since the eighties [12]. From 148,575 in the 2000s, Quirino...
stands at 176,786 people as of 2010, increasing by 19 percent over the past decade. Also, households recorded in 2010 were at 39,770, which is higher by 9,189 from the past decade. This rapid development calls for the province to use its rich and untapped potential resources for infrastructural development.

Ultimately, its local government is confronted with the challenge of implementing the appropriate approach to urban planning and handle urbanization as a whole. The failure of this challenge invites future threats and fosters unsustainability to Quirino Province. This failure can be often brought about by conventional planning approaches that prioritize built-up areas and rapid urbanization in the name of economic growth and social security, rather than protecting the environment and the ecological services that it provides. These types of urban planning approaches have been proven by time to be ineffective in maintaining sustainability.

As the problem of negligence towards environmental issues increases and spreads worldwide, so does the concern and the need to mitigate and solve these arising issues. Ever since the 1980s, there has been a growing demand for sustainable development. This demand peaked at the release of the United Nations World Commission on Environment and Development’s 1987 report entitled “Our Common Future,” or simply and more commonly known as the Brundtland Report, where one of the widely recognized definitions of the topic can be described as a “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

With the growth of sustainable development comes the innovation of approaches that suits its ideals, goals, and priorities. Since its emergence and development in the 1980s, landscape ecology – a systems science that deals with the relationships between ecological services in habitats, became a relevant and valid field of study that serves bases for urban and natural growth developments as the science explores the different ecological factors and determinants in an area (Lin & Zheng, 2012). The global movement of green infrastructure brought about by the call for sustainable development made way for the use of green, renewable sources of energy, the consideration and prioritization of natural habitats and ecosystems over urbanization and infrastructure building, and the never-ending research to create more sustainable materials from either green or recycled sources – among others.

There is a need to shift to green methods of planning to prevent Quirino, a province full of natural resources, from suffering the same fate if conventional planning techniques where built infrastructure remains a priority over the environment are to be applied. New methods should focus more on sustainable goals and priorities.

2. Problem Setting
One of the areas in Quirino that can be potentially threatened by conventional urban planning is the sub marginal forest resting on top of a hill jutting out in the middle of the agricultural lands of Barangays Gundaway, Zamora, and Villamor. The locals call this hill Susong Dalaga, named after its panoramic breast-like shape.

Susong Dalaga is one of the many karst landscapes found in the province. Karst landscapes, formed when the underlying rock is soluble, are characterized by unique and highly specialized ecosystems that house specific flora and fauna and give off an abundance of ecological services. Karst landscapes provide an abundant source of drinkable freshwater via its aquifers; influence the microclimate due to how water filtration acts differently than regular soils and rocks; contain the collection of minerals in these landscapes; house not only specific and rare flora and fauna, but also act as a shelter to our indigenous people; and preserve any prehistoric data for multiple millennia that may indicate and increase our knowledge about the culture of ancient people. These stress the need to protect these systems.

For as much as it is a valuable resource, karst landscapes are very fragile as well. Even the slightest disturbance by human activity can disrupt and degrade these services as harm
can quickly induce significant effects on the whole system. Human disturbances are activities done within or near the karst landscape, such as agriculture, which might cause soil degradation, soil erosion due to deforestation and overgrazing; urban development and land use, which might lead to the infilling of sinkholes, poor management of sinkholes and caves, water pollution especially in streams and aquifers; tourism which might lead to the destruction of rock formations, vandalism, and infrastructure; and so on [7][18].

3. Methodology

Patterned after Danao’s ecological infrastructure planning approach [3], the research focuses on the study of different biotopes (habitat). Careful and meticulous on-site visits and mapping are done to identify the different biotopes in the area, and identify its aesthetic, biodiversity, culture, and risks. Identifying and consolidating the date will create a biotope map, which will be the foundation of the assessment of ecological values and the formulation of the ecological management plan (preservation, conversion, improvement, or conversion). This ecological management plan will then be used to create and enact the different strategies and policies for each biotope, ultimately protecting the area's ecological integrity (in this case, Susong Dalaga).

![Figure 1 The Methodology of The Study](image)

3.1 Collection, Analyses, and Interpretation of Existing Maps and Data

Data provided by the LGU of Quirino include: statistics and word documents of the three barangays involved in the research, and remote sensing and geographic information system technology files of the Quirino province. The data will be analyzed to determine the existing conditions of the immediate surroundings of Susong Dalaga.

3.2 On-site Observation

Site visits are conducted in and surrounding Susong Dalaga to crosscheck the existing conditions of the site and the different biotopes present in and surrounding the karst landscape. Observation of the different biotopes will help determine the best approach to each biotope in terms of the dimensions of aesthetic, biodiversity, and culture in ecological infrastructure.
3.3 Discussion of Biotopes

Biotopes are studied and analyzed to determine the current situation of the area. Identification of characteristics, distribution, and the following dimensions of ecological infrastructure – biodiversity, aesthetic, culture, and risk – will be enumerated. Biodiversity pertains to the variety of flora and fauna found. A biotope is considered to have zero biodiversity if the data finds no sign of life, and the amount of biodiversity increases as the amount of plant and animal life increases. High biodiversity is considered when there is a wide variety of plant life, which encourages animal life to thrive.

Aesthetic deals with the visual interest and beauty of the biotope. Aesthetic can be the scenic views of the natural and manmade landscapes (or lack thereof), such as the rivers and creeks flowing in the site, the vast agricultural land, the presence of greenery, etc.

Culture encompasses all interactions, activities, and traditions that take place in the biotope. It can be as simple as day to day life activities or even as grand culturally and historically as festivals and celebrations. Culture can also encompass how much human traffic is in one place.

Risk looks into the underlying threats that loom in certain conditions. As the site is near creeks and rivers, this aspect will take into consideration the flooding and erosion aspect of the site. If the biotope is prone to the dangers mentioned before, it is considered to be at high risk and should be taken into account the amount of damage it sustains. Risk also encompasses any threat that a biotope may encounter in such the case that improper management of other biotopes was to take place.

3.4 Assessment of Ecological Values

Ecological values are assigned to each biotope after its identification, study, and analysis. Since the study focuses on the ecological integrity of Susong Dalaga’s ecological services, ecological values are heavily determined on its current environmental conditions.

An assessment of ecological values will help determine which biotopes currently have excellent conditions of biodiversity and which biotopes do not. Identifying the different values will be used in simulating changes, predicting or projecting future issues, threats, opportunities and possibilities. The assessment will also help prioritize which biotopes must be protected and which biotopes should be regulated, as guided by the ecological management approach.

3.5 Ecological Management Approach

Ecological management approaches and strategies are adapted to each biotope after having assessed the ecological values. These approaches are the following: preservation, conservation, improvement, and conversion.

Preservation is the highest form of protection - biotopes under preservation are to remain intact, with zero intervention, before they get damaged by change or development. These are usually nature and wildlife preserves, national parks, and large patches of intact vegetation.

Next is conservation, which aims to protect the existing landscape elements by implementing action. These areas are usually suffering from impending pressure, such as development.

Improvement comes after conservation. Improvement involves implementing actions, management, and reconfiguration of structures, so that the existing manmade elements do not destroy the existing landscape. These are usually built-up areas that threaten nearby natural biotopes.

The last approach, which has the most amount of intervention, is conversion. Conversion recognizes that the biotope needs to be changed so that its ecological functions will be restored, or so that adjacent biotopes will not be threatened. Determining these approaches will help create and implement different strategies for each biotope.
4. Findings, Results, Discussion

4.1 Discussion of Biotopes
Below is a thematic map that showcases the current distribution of the natural, semi-natural, and built-up areas of the three barangays, along with a table showing a comparison of the different biotopes in terms of total area. The table also shows the different categories of biotopes: the densely vegetated natural systems, the manmade but still vegetated semi-natural systems, and the urbanized and developed built-up systems. It also shows the appropriate ecological management approach for each biotope based on the study’s findings (to be discussed further in 4.4. Ecological Management Plan).

![Biotope Map of Barangays Surrounding Susong Dalaga](image)

**Figure 2 Biotope Map of Barangays Surrounding Susong Dalaga**

| BIOTOPES                  | AREA (HA) | PLANNING APPROACH      |
|---------------------------|-----------|------------------------|
| **SEMI-NATURAL SYSTEMS**  |           |                        |
| Agricultural Land         |           |                        |
| Rice Paddy                | 409.7351  | Conservation, Improvement |
| Mixed Crops               | 379.6083  | Conservation           |
| Plantation                | 17.5891   | Improvement, Conversion |
| **NATURAL SYSTEMS**       |           |                        |
| Grassland                 | 104.699   | Preservation           |
| Brushland                 | 769.581   | Preservation           |
| Sub Marginal Forest       | 23.4902   | Preservation           |
| Pond                      | 4.796     | Preservation           |
| **BUILT-UP SYSTEMS**      |           |                        |
|                           | 224.4132  | Improvement, Conversion |

Source: Cabarroguis’ Comprehensive Land Use Plan (CLUP) [1]

As seen in the table, natural biotopes still dominate in terms of the amount of area that encompasses the barangays, as seen in the east of the area, surpassing the manmade agricultural lands by around a hundred hectares, which can be found at the west. Build-up areas are still sparse, at around 11.6 percent (compare to 46.7 percent of the total area of natural biotopes, and 41.7 percent of agricultural lands). These build-up areas are situated in the middle of the semi-natural biotopes.

The following map reflects these systems (with aquatic systems to differentiate them from the terrestrial natural systems) about Susong Dalaga.
Figure 3 Map Showing Key Points

Based on the site’s land classification map, alienable and disposable lands are to the east of the map while a strip of land on the west remains forested. The data shows that there is currently a build-up of urbanization happening in the east side of Gundaway, as well as the majority of Zamora, all located on the east side of Susong Dalaga.

Two patches of built-up areas are visibly seen from the map: one from Gundaway-Zamora, and a smaller one at Villamor. The two patches are slowly connected by a slim strip of urbanization that barely connects the two via the road that connects the barangays together. Alarmingly, to the south, there is also a small patch forming, and considering what surrounds Susong Dalaga is alienable land, it is a possibility for the rice fields that surround the karst landscape be converted into a built-up area. This possibility has been attempted before, like the subdivision attempt along Tourist Road a few years back.

Meanwhile, the undisturbed, forested west of Susong Dalaga acts as a long corridor of shrublands and grasslands that connect the karst landscape upward to Capitol Hill and downward to Villamor Hill. However, during the researcher’s site visits, some of the natural systems have been slowly converted into rice and corn fields. They are trickling along roads and rivers, fragmenting the shrublands and grasslands and further isolating Susong Dalaga. Considering the topography and slope of the barangays, converting too many woodlands into agriculture may not bode well for the constituents in the long run. The creation of more agricultural land to the west also invites for more agricultural residences. This possible influx of residences may turn into patches of urbanized areas, further isolating Susong Dalaga.

4.2 Assessment of Ecological Values
Presented in Figure 4 is a map that shows the different ecological values of the biotopes, ranging from high, average, to low ecological value.

A biotope of high ecological value means that based on the dimensions of ecological infrastructure, they have immensely sought-after qualities. In terms of biodiversity, a plethora of different species of plants and animals are present. These biotopes are encouraged to grow and be sustained. Included in this category are the shrublands, the grasslands, the aquatic systems, and the sub marginal forest, where Susong Dalaga is located.

Meanwhile, a biotope of average ecological value based on the area’s biodiversity might mean a vastly vegetated area, dominated by a handful of species. While these biotopes benefit from being sustained, they do not necessarily need to expand, especially not at the expense of high ecological valued biotopes, where several species are found. Included in this category are the rice paddies, mixed crops, and residential-agricultural lands.
Lastly, a biotope of low ecological value means that based on the dimensions of ecological infrastructure, they have lesser qualities than the other two categories. While these biotopes may have high culture, their built-up nature means less area for wildlife. They are encouraged to be sustainable, which might mean shifting these biotopes to cultivate qualities that will help grow their ecological qualities. Included in this category are the plantations, and the residential lands.

With the ecological values set in place, theoretical simulations are created to present any hypothetical and possible benefits, dangers, and issues in map form. Simulations can present the best possible outcome, as well as the worst. These projections can help formulate the ecological management plan, and subsequently, create and enact policies to prevent issues in the future and foster sustainability.

### 4.3 Simulation of Ecological Values

Based on the data from Cabarroguis’ CLUP for 2013-2023, current trends, such as agricultural fields following the streams, the trickling down of built-up areas, are assumed and projected by spreading these areas out. Assuming that the people’s dereliction and negligence to Susong Dalaga and the other natural systems allowed the spread and growth of biotopes with average and low ecological value, this trend leads to the conversion of high to average/low and average to low, as seen in the map (Figure 5).

![Figure 4 Map Showing The Differing Ecological Values of Biotopes](image1)

**Figure 4** Map Showing The Differing Ecological Values of Biotopes

Agricultural fields have continued to fragment the shrublands of Barangay Villamor, which also continue to sever the corridor that allows Susong Dalaga to connect to the Villamor Hill.

![Figure 5 A Map Showing A Simulation That Portrays The Negligence of Biotopes with High Ecological Value in Favor of Biotopes with Lesser Ecological Value](image2)

**Figure 5** A Map Showing A Simulation That Portrays The Negligence of Biotopes with High Ecological Value in Favor of Biotopes with Lesser Ecological Value
(which in itself is also suffering from the expansion of agriculture) located below. This is likely caused by two factors:

The first factor would be the fast growth of Quirino Province as a whole. In the 2000s, Quirino was expected to double its population by 2027. In a later report by the Philippine Statistics Authority, the population in Quirino in 2013 – 176, 786, is expected to double in 2053. While an increase in population would not necessarily reflect heavily on the three barangays’ population, it might mean more demand for food production in the province, which may be a factor in expanding agricultural land. This expansion of agriculture, and the doubling of population soon, would mean the shift to residential-agricultural lands spreading along with these newly created fields, and in turn, expanding the residential hub.

The second factor would be the increasing number of makeshift homes and illegal settlements in the barangays, particularly in the natural systems. They are trying to make a living by clearing out natural systems to convert to agricultural lands. As mentioned briefly in the findings, there are currently over a hundred people under this category. This societal issue will only increase as more people will illegally settle over the years, and those who already have been in the past will continue to grow as families exponentially grow per generation. In twenty to forty years, the existing population will double or triple, and in fifty to seventy years it will grow even fivefold, creating patches of built-up and semi-natural systems if neglected.

The overall degradation of ecological value of the biotopes will result in the diminishing of the services that it provides. This will cause a decline in production, a lesser observable biodiversity, etc.

To avoid this scenario (among many other circumstances), an ecological management plan must be created to plan for a scenario that favors the landscape as a whole. The plan must also be beneficial not only for the environment, but also for its constituents.

4.4 Ecological Management Plan

By assessing the current situation, the researcher decided upon the action needed for each biotope based on the four approaches of ecological management approach (preservation, conservation, improvement, and conversion). The researcher was then able to produce an ecological management plan based on these decisions:

![Ecological Management Plan](image)

**Figure 6** Ecological Management Plan

The plan was based on the decision that the researcher felt most justified with the study’s aims and goals:
Biotopes of high ecological value should be preserved to maximize the ecological network, biodiversity, and sustainability, and to prevent Susong Dalaga from being fragmented and separated from its other natural biotopes.

Next, the agricultural land that surrounds Susong Dalaga and envelops the preservation areas will act as buffers and shields to the ever-expanding urbanization happening in the east. Meanwhile, the agricultural-residential lands will act as places of bustling culture and activity that will protect these farmlands. Therefore, most of these areas should be conserved. Exceptions are fields that are encroaching and permeating on biotopes of high ecological value. In this case, they would have to be converted instead.

Finally, there needs to be an improvement on the built-up areas of barangay Zamora and Gundaway, where commercial activity happens – biotopes of low ecological value can be slowly restructured back into agricultural villages. They can serve as agro-business hubs to further flourish the agricultural economy that Quirino boasts.

5. Conclusion

Despite being about one percent of the total area of the scale of the study, Susong Dalaga contributes so many services to its constituents. Whether it is of economic, social, environmental, cultural, or ecological significance, there is enough justification for protecting the karst from existing and potential threats.

Analyzing the biotopes, it is clear that while Susong Dalaga’s constituents thrive from these services, existing issues in the area arise from anthropogenic pressures. Future issues will also spread if they are neglected, and will cause a steady decline not only for Susong Dalaga’s ecosystem itself, but also to those who benefit from it.

By assessing the present conditions and ecological values of these biotopes and then assigning them with the appropriate ecological management approach, the result presents policies that, in theory, maximize the protection of natural systems, which will benefit society in the long run.

In addition to this, there is of grave importance to contribute to the study of one of the rarest, if not the rarest ecosystem/landscapes in the earth, especially studies conducted in the Philippines. The Philippines has a lot of karstic environments, some of them are lesser known, such as Susong Dalaga. Karst landscapes provide services that benefit society, and studying them will advance what we already know about karsts, and the mysteries that these landscapes keep, such as the bountiful flora and fauna, the culture and history, among others.

Planning is a long-term process that deals with the organization and selection of choices based from the information gathered. With these objectives accomplished, it is concluded that undergoing a biotope analysis, assessment, and an ecological management approach is a viable way of urban planning, especially now that there is a need and emphasis for the protection of the environment.

As of the writing of this study, biotope analysis has never been considered in comprehensive land-use plans. This study sheds new light on one of the many greener options of urban planning. Hopefully, in the years to come, ecological management approach, as well as the principles and strategies akin to the ones done in this study, can be integrated to many more urban planning approaches in the future.

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