



Species Composition, Diversity and Status of Anurans in Agroforested Areas and Forested Highlands in Esperanza, Sultan Kudarat

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ABSTRACT

Anurans are highly sensitive amphibians that serve as important bioindicators of ecosystem health due to their permeable skin and dual life cycle. This study assessed the species composition, diversity, and conservation status of anurans in forested highlands and agroforested areas of selected barangays in Esperanza, Sultan Kudarat, Philippines. Anuran species were documented during nocturnal and diurnal period through opportunistic sampling, quadrat transects, capture–mark–release techniques and photo documentation, followed by taxonomic identification validated by experts. Anuran diversity and evenness were assessed and their endemism and conservation status. A total of seven anuran species belonging to five families were recorded across the study sites. These are *Rhinella marina*, *Fejervarya moodiei*, *Hoplobatrachus rugulosus*, *Limnonectes magnus*, *Kaloula pulchra*, *Hylarana grandocula* and *Polypedates leucomystax*. Both agroforested areas and forested highlands exhibited low species diversity using Shannon Weiner Diversity index ($H' = 1.50$ and 1.69) and Simpson's Diversity index ($D = 0.75- 0.78$). Pielou's evenness showed moderate to high evenness ($0.84- 0.87$) in the study sites. Two species were recorded as Philippine or Mindanao endemics such as *Limnonectes magnus* and *Hylarana grandocula*. *Limnonectes magnus* is classified as Near Threatened. This study provides baseline data essential for biodiversity conservation in Esperanza, Sultan Kudarat.

Keywords—anurans, species composition, diversity, forested highlands, agroforestry

INTRODUCTION

Anurans are tailless amphibians whose life cycle includes an aquatic and terrestrial phase. Early in development, after hatching, tadpoles survive by eating warts or small aquatic insects until they finally mature, and only then do they come onto land. According to Aureo and Bande (2017), anurans are very sensitive to changes in environment; their quality of life is affected by small changes in temperature and humidity due to their permeable skin and unshelled eggs. Nesting is affected by precipitation, humidity and temperature, so any change or variation in these abiotic factors will result in disruption of the life cycle.

The majority of anurans are generalist insectivores, and the range of their diets can differ depending on their species, life stage, and habitat. While adults feed on insects, other invertebrates, like tadpoles are often herbivorous or detritivores (López & Vera Candiotti, 2023). Depending on the availability and environmental conditions, a variety of anuran tadpoles can eat algae, debris, plant pieces, and microbes (Dey & Goswami S., 2015).

Anurans live in a range of environments, including temperate wetlands, tropical rainforests, and deserts. Certain microhabitats, such as leaf litter, tree canopies, bromeliads, streams, or ponds, are preferred by certain species. The Philippine Archipelago is recognized as one of the most important centers of herpetofaunal diversity in Southeast Asia. To date, Philippine anurans diversity is represented by 108 species, at least 80% of which are endemic to the archipelago (Coritico, 2018). As of 2015, the Philippines has a total of 110 anuran species and more species are expected in the coming years especially in the remaining rainforests, as more than 70% of

amphibians are restricted to forests, especially lowland forests (Mohagan et al., 2018). Forested areas are known to have a rich biodiversity of fauna and flora because of the cold climate and high altitude. Meanwhile, agroforest ecosystems have become prominent nowadays due to the spread of agriculture. Most agroforest ecosystems are composed of different plantations such as rice fields, corn fields, sugarcane and also fruit trees.

The municipality of Esperanza in the Sultan Kudarat Province, Philippines has a vegetation of dry evergreen montane forest type, where strands of natural vegetation interspersed among forests, bushlands, shrublands and other plantations that become a home to a variety of anurans. It also covers a wide, beautiful, green vegetation where a bigger portion of fertile plains becomes favorable either for rice or corn plantations. The canals in many areas in this place serve as sanctuary for irrigation purposes where a number of anurans can hibernate.

The expanse of agricultural activities in the Philippines becomes tremendously alarming and before another tragedy happens, saving both plants and animals must be undertaken. It is very threatening to witness a country's rapidly dwindling forest cover, and the signs of destruction are hard to miss scorched earth, balding hills, heavily silted bodies of water that overflow in the briefest downpour. According to Oda et. al. (2016), this environmental crisis and destruction of natural habitat resulting from man-made activities may eventually lead to the extinction or dispersion of some species. Moreover, the range of agriculture becomes one of the primary natural habitats which contributes largely to the loss of biodiversity worldwide. Likewise, amphibian biodiversity is gravely threatened and affected by habitat destruction, forest conversion, environmental pollution (Sularte et al., 2015) and destruction of riparian ecosystems (Almeida-Gomes et al., 2015).

Similarly, according to IUCN (2015), there are currently 48 threatened amphibian species in the Philippines including *Philautus schmackeri*, *Alcalus mariae* and *Platymantis paengi*. Nowadays, the threat of deforestation is very rampant in Esperanza, Sultan Kudarat leading to the emergent study of the diversity of anurans hindering their roles as bio-indicators of good and healthy ecosystem. Hence, this study sought to assess the species composition, diversity, and status of anurans in terms of conservation status and endemism in agroforested areas and forested highlands of Esperanza, Sultan Kudarat.

REVIEW OF RELATED LITERATURE

This study also concerns the taxonomy of anurans. Anurans belong to Kingdom Animalia, Phylum Chordata, Class Amphibia and Superorder Salientia. Under Superorder Salientia includes family Brachycephalidae or the shield toads, family Bufonidae or the toads, family Centrolenidae or the glass frogs and leaf frogs, family Dendrobatidae or the poison-dart frogs, dendrobatid frogs or poison frogs, family Heleophrynidae or the ghost frogs, family Hylidae or the hylid frogs and tree frogs, family Leiopelmatidae or the tailed and ribbed frogs, family Leptodactylidae or the neotropical frogs, family Microhylidae or the microhylid frogs, family Myobatrachidae or the Australian frogs, family Pelobatidae or archaic frogs, family Pelodytidae or the European Spadefoot toads, family Pipidae or tongueless frogs, family Ranidae or the riparian or true frogs, family Rhacophoridae or the Old World Tree Frogs and family Rhinophrynidae or the burrowing toads.

The morphological appearance of anurans is very critical on its taxonomic identification and habitat preferences. Anurans, which include the slender frogs and toads, are the most prevalent group of amphibians. There are currently 110 anuran species in the Philippines, divided into eight families and 23 genera (Mapi-ot, 2015). Because of their very porous skin, which is sensitive to environmental stressors including abrupt temperature changes and hazardous substances, anurans are regarded as indicator species in the ecosystem (Vidal, 2018). Amphibians are known to be sensitive to changes in the environment and are easily affected by logging, forest fragmentation, and shifts in microclimatic variables and habitat structure. Amphibians are also sensitive to changes in their natural environment caused by climate change and pollution which raises temperatures and lower humidity. As a result, amphibians are extremely sensitive bio- indicators of environmental health (Mapi-ot, 2015).

In order to identify species, comprehend evolutionary changes, and evaluate ecological roles, standard frog morphometrics measure several body sections to study size and shape. These measurements are useful for studying the growth and development of species, identifying species differences, and even analyzing fluctuating asymmetry.

Anurans' exceptional adaptability and significance in preserving environmental balance are reflected in their ecology. Many species of amphibians reproduce in riparian (stream and river) habitat and some of them spend their entire lives in close proximity to riparian systems. Herpetofauna in the Philippine archipelago was once thought to be depauperate; however, it is now recognized as one of Southeast Asia's most important centers for diversity and endemism. According to ACNA (2015), 99 (85%) of the 116 amphibian species found in the Philippines are endemic (endemicity is 90% if you exclude the six introduced species). In Cavite Province, little was known about the amphibians and reptiles found in the remaining forest fragments. Herpetofaunal research has only been limited to the Mount Palay-Palay/Mataas-na-Gulod Protected Landscape (hereinafter referred to as "Palay-Palay") area in Cavite.

Knowing that anurans are sensitive to environmental change, their diversity status is a key determinant of the health of the forest ecosystem. To evaluate the condition of the terrestrial ecosystem, an assessment of the anuran variety is necessary. Moreover, anurans are essential members of the trophic food chain since they are both food for people and prey for predators. They are crucial to the ecology because they protect people from dangerous infections by lowering the number of insects that can spread illnesses such as flies and mosquitoes. In addition, they play a crucial role in the cycle of nutrients through seed dispersal, direct and indirect pollination, and waste excretion (Cortés-Gomez et al., 2015).

Microhabitat preferences of anuran species include (1) bodies of water (fishpond), (2) rock near the bodies of water (stream), (3) shrubs growing near the stream, (4) forest litter fall, (5) shrubs growing in the forest and (5) falling log (Coritico et. al., 2018). In the study of Coritico (2018), focused on anurans in Mt. Pantaron Range, Bukidnon, they observed some anuran species that live on bodies of water such as *Rhinella marina*, *Limnonectes magnus*, *Megophrys stejnegeri*, *Pulchrana grandocula*, *Staurois natator* and *Polypedates leucomystax*. Anurans in rock near the bodies of water (stream), these include *Ansonia muelleri*, *Limnonectes leytenensis*, *Limnonectes magnus*, *Leptobrachium lumadum*, *Megophrys stejnegeri*, *Chaperina fusca*, *Pulchrana grandocula*, *Sanguirana everetti*, *Staurois natator* and *Polypedates leucomystax*. For the shrubs growing near the stream, these include *Pelophryne lighti*, *Limnonectes magnus*, *Leptobrachium lumadum*, *Megophrys stejnegeri*, *Staurois natator* and *Polypedates leucomystax*. For the forest litter fall, the anuran species observed are *Kalophrynus sinensis* and *Oreophryne annulate*. For the shrubs growing in the forest, anuran species include *Platymantis corrugatus*, *Platymantis guentheri* and *Oreophryne annulate*. For the anurans in falling log, these include *Platymantis corrugatus*, *Platymantis guentheri*, *Kalophrynus sinensis* and *Sanguirana everetti*. (Coritico et. al., 2018).

The study of Relox and Camino in 2018 focused on anuran communities in Agusan Marsh Wildlife Sanctuary, Philippines. According to their study, in general there are more aquatic and arboreal species in the Agusan Marsh. Arboreal species outnumbered aquatic and terrestrial species in the Terminalia forest. In contrast to the terrestrial inhabitants, there were more aquatic species in Sago stands. Compared to the Sago and Terminalia woods, there are more terrestrial species found in the agricultural areas. The wet environment of the Sago forest and the nearby agricultural land was much preferred by the majority of *Occidozyga laevis*, *Limnonectes leytenensis*, *Fejervarya vittigera*, and *Fejervarya cancrivora* over the Terminalia forest. Frog survival and reproduction depend on the availability of soil and a steady supply of water. Tree frogs, which may grow to a height of over 18 meters and are mostly found in Sago forests.

By influencing microclimatic conditions, habitat structure, and resource availability, forested highlands and agroforested landscapes have a significant impact on anuran diversity, distribution, and survival. The extent of forest devastation is now becoming apparent in a variety of ways. Mountain slips, landslides, flash floods and extensive soil erosions have become a frequent occurrence in the country causing enormous misery and suffering to the people. These disasters are exacerbated by widespread rural poverty of individuals who continue to suffer while relying on the unstable uplands that they have cultivated yet damaged in order to survive, hence perpetuating the never-ending cycle of poverty and environmental degradation (Mohagan et al., 2018).

Mindanao, the second biggest island, stays to have one of the biggest excess woods cover and is rich with natural assets. However, Mindanao acquires lesser consideration as regards to herpetological studies compared with Luzon and a few regions of the Visayas. Herpetological biodiversity especially in Northern Philippines is still considerably observed and studied. On account of the Northern Sierra Madre Mountain Ranges in Luzon, it was lately found to house something like 101 types of herpetofauna with approximately 70% endemic species, the

very first report on the land water availability and presence of reptile variety nearby. In the Northern Cordillera Mountain Range and also in the southern Sierra Madre Mountain Range, new conveyance records of 58 and 35 types of herpetofauna, separately, were accounted for. Further endeavors could likewise lead to conceivable revelation of new anuran species (Mohagan et al., 2018).

Agroforestry's potential for mitigating and adapting to climate change makes it an attractive agricultural production method. In addition to sequestering carbon, shade trees help enhance regional climates and lessen soil moisture and microclimate variability. Given that climate change is predicted to diminish the amount of acceptable production land for commodities like coffee, agroforestry is especially crucial for the cultivation of coffee (*Coffea arabica* L.). The related shade tree species can offer a range of direct ecosystem services (ESs), including fuelwood, food, and fodder, in addition to regulatory services. Additionally, because of their diversity, agroforestry systems might offer a range of revenue streams that could serve as social safety nets, boosting farmers' financial stability in the face of potential crop failures and fluctuations in coffee prices on international markets. But when creating agroforestry systems, ecological factors, competition between related species in the system, and farmers' personal goals must all be taken into account to optimize the advantages and reduce the drawbacks of these systems (Wagner et al., 2019).

Agroforestry is a dynamic, environmentally sound natural process system for managing resources that consciously integrates woody perennials with animals or herbaceous plants and because of some configurations of spatial or temporal series on the same property that increased diversity and greater social and economic benefits for the environment. The more obvious benefits of agroforestry are widely valued and recognized by the Philippines' smallholder farmers, meeting their socio-economic needs in particular. The abstract and the secondary benefits of agroforestry should also be considered and emphasized in particular because environmental problems like global warming and climate change are reaching their heights in the last few years (Baliton, 2020).

Agroforestry has several definitions. According to the International Commission on Forestry, "agroforestry is the interaction of agriculture and trees, including the agricultural use of trees." This comprises agricultural trees and enclosed trees. In agricultural settings, it includes farming in forests and along forest margins, and production of tree crops such as cocoa, coffee, rubber, and oil palm. Interactions between trees and other agricultural components may be significant at several scales including fields where trees and crops are grown together; farms where trees may provide fodder for livestock, fuel, food, shelter, or income from products, including timber; and landscapes where agricultural and forest land uses are combined to determine the provision of ecosystem services. According to the FAO, it is a collective name for land- use systems and technologies in which woody perennial trees, shrubs, palms, bamboos, and so on are deliberately used on the same land-management units as grasses. The National Agroforestry Center (NAC) of the United States Department of Agriculture (USDA) describes agroforestry as the intentional integration of trees and shrubs into crop and animal farming systems to create environmental, economic, and social benefits.

Finally, the agroforestry system is a land use technique that is productive, sustainable, and easy to implement (Liu et.al., 2019). Over 80% of the world's terrestrial biodiversity lives in forests. Terrestrial biodiversity includes almost half of all bird species that have been identified. Forests provide a variety of ecosystem services, including endangered and endemic species conservation. However, these woods have been subjected to extraordinary pressure during the last few decades, resulting in a worldwide biodiversity crisis which is worse than climate change (Driscoll et al., 2018). There is no dispute that habitat loss due to forest conversion to non-forest land uses such as agriculture and urban development places is the most serious threat to biodiversity. As a result, many endemic species have either become extinct or threatened with extinction.

In the Philippines, there are more than 20,000 endemic species of plants and animals (Conservation International Philippines, 2020). The country is home to 20% of all known flora and fauna species (Mapi-ot, 2015). This mega-diverse country has long been recognized as one of the top biodiversity hotspots in the world due to the constant exploitation and destruction of its forest resources. This habitat destruction can generate zoonotic diseases (UNEP, 2020), such as COVID-19 that caused a worldwide pandemic (Cucinota & Vanelli 2020). Biodiversity also protects humans against infectious disease.

The Philippines is one of many countries that was heavily forested. Previously, 90 percent of the country, or 27 million acres, was covered in lush tropical rainforest. The Spaniards invaded the Philippines in 1521 and when commercial crops developed throughout their reign, deforestation began. In the year 1900, two years after the Spaniards left, the Americans arrived while approximately 70% of the country's land was still forested until they introduced the first modern logging operations in 1904 and the Philippines became one of the world's major exporters of Dipterocarp lumber.

hunting for food or pets, and the spread of the chytrid fungus. The loss of habitat, pollution, overexploitation such as excessive hunting for profit, illicit wildlife trading and introduction of invasive species pose serious threats to the biodiversity in the Philippines. Lowland dipterocarp forest loss and fragmentation on a broad scale have already had negative effects on the country's flora and wildlife. Due to widespread and unrestrained killing of wildlife and habitat destruction via slash-and-burn cropping or kaingin mercilessly done by residents both inside and outside of the villages, biodiversity loss in the Silago forest, Philippines is in serious danger. It is believed that the interactions of manmade and natural factors such as climate, geographic ranges, and vegetation types have a substantial impact on the richness and distribution of species. The construction of roads is also a major threat to wildlife species as a result of urbanization. Studies claim that one of the taxa most adversely affected by urbanization are anurans. Numerous ways such as road construction can affect anuran populations: act as a barrier to the individual's movement, fragment habitats, resulting in the division of the existing population, contamination of habitats with road salt, alter a population's gene pool, cause direct mortality from vehicle collisions and increase habitat loss as a result of physical changes in the environment.

In a range of a long time starting around 2012, two new types of frogs were found and to be specific: *Platymantis quezoni* from the karst limestone area of Quezon Protected Landscape in south-eastern Luzon Island and *Pulchrana guttmani* from Mt. Busa, Sarangani and South Cotabato areas in southern Mindanao Island (Brown et al., 2015). Information on species wealth of anurans in forested regions in Mindanao incorporated those reviews led by Nuñez et al. (2006) who kept 26 species in Mt. Malindang, Relox et al. in 2011 archived nine types of anurans in Mt. Hamiguitan, and Beukema in 2011 kept 10 species in Mt. Kitanglad. Nuñez et al. in 2012 detailed 22 types of anurans in Mt. Sambilikan, Mt. Ararat, and Mt. Berseba of Diwata range in Agusan del Sur. Almeria and Nuñez in 2013 documented 17 types of anurans in the bog timberlands of Agusan Swamp in Agusan del Sur, and Calo and Nuñez (2015) kept 13 types of anurans in Bega Watershed, Prosperidad, Agusan del Sur.

Montane backwoods have records of pinnacle anuran variety. Living space obliteration which incorporates timberland freedom and discontinuity was viewed as the most quick and clear danger to herpetofauna and influences something like 85% of the species including frogs. Despite this, findings demonstrated that *Sphenomorphus* spp. and *Pulchrana similis* were the most common frog species in the region, while *Platymantis corrugatus* was the least common and there are 14 species of anurans that are currently known to originate from the protected area (Causaren, 2009).

A study on anurans was also made by Pitogo et al. (2021) focusing in Mt. Busa, Sarangani Province. According to their study, there were at least 68 species of herpetofauna, of which 28 species were amphibians and 40 species were reptiles. Around 65% of the species recorded are endemic to the Philippines. Mount Busa appears to harbor a relatively rich herpetological diversity that is needing conservation and scientific attention. One species of the anurans that was recorded is the *Pulchrana grandocula*.

This common stream amphibian is widespread in Mindanao faunal region in both disturbed and undisturbed areas (Sanguila et al., 2016). They aggregate in carabao wallows and fishponds, while some solitary individuals perch on riparian shrubs. Polymorphism is evident for this species, particularly on the dorsal pattern. Individuals mostly have blotched dorsum, rarely dotted. This species was tested positive for Bd infection, but no known harmful impacts have been recorded yet. It lives in syntopy with the morphologically similar and enigmatic *Pulchrana guttmani*, which was known only from a single specimen collected in 1993 in Mount Busa, Sarangani (Brown, 2015). Their extensive fieldwork in the area, however, did not produce any new additional specimens of *P. guttmani* (Pitogo et al., 2021).

On the study of Coritico et al (2018), they focused on the three barangays surrounding Mt. Pantaron Range in Bukidnon. They collected and documented 18 anuran species belonging to seven families and 15 genera, and

about 61 % (11 species) are Philippine endemics. The four (4) endemic Mindanao islands are *Ansonia muelleri*, *Leptobrachium lumadorum*, *Megophrys stejneri*, and *Pulchrana grandocula*. As to the conservation status, *Limnonectes magnus* was categorized as vulnerable. Majority of the anurans were observed near bodies of water such as ponds and streams while other species were collected in the ground microhabitat especially in the leaf litter and fallen and decaying logs.

Another study from Delima-Baron et. al. (2019), documented anurans in Montane Forest of Marilog District, Davao City, Southern Mindanao, Philippines. They gathered 124 individuals representing four species of *Philautus*. Three of which are currently known, located only from forested areas of Mindanao. *Philautus acutirostris* is the most encountered species. These *Philautus* species were located on the thirty-four genera of plants as their microhabitats.

Another study from Delima-Baron et. al. (2022), focused on green spaces of Davao City, Mindanao Island, Philippines. They recorded eighteen species representing seven families. The three endemic species are *Pelophryne brevipes*, *Fejervarya moodiei*, and *F. vittigera*, which were added to the current list of anurans known from green spaces of Davao City, accounting the total known species for Davao City to 23. Thirteen of this anuran species recorded are endemic. Two species under the Near Threatened category of IUCN, *Limnonectes magnus* and *Sanguirana everetti*, were also documented. The study also documented four invasive species: *Rhinella marina*, *Eleutherodactylus planirostris*, *Hoplobatrachus rugulosus*, and *Kaloula pulchra*.

On the study of Gersava et. al. (2020), their study is titled “Native and invasive alien anuran species in urbanized areas in Davao City, Philippines, with preliminary study of feeding biology,” the results of their study revealed a very low anuran diversity (Shannon-Weiner; 1.165), which is dominated by invasive alien anuran species. They used Jackknife 1 species richness estimator that indicated that 77-100% of the anuran species in the area were already detected which include three invasive: *Rhinella marina*, *Kaloula pulchra*, *Hoplobatrachus rugulosus*, and two natives; *Polypedates leucomystax* and *Limnonectes leytensis*. Moreover, assessing the diet of 33 randomly selected anuran samples revealed that Formicidae dominated their food item. Invasive anurans also displayed more diverse diet composition compared to native frogs, in which diet overlaps were observed. To sum it all, the study supports the idea that urbanization decreases anuran diversity and supports the dominance of invasive anurans which compete for food with their native and endemic counterparts. Continuous deforestation and tree cutting occurred. The country had the least forest cover in 1988, with about 6.5 million acres of forested area. It rose by 0.3 million ha by 2010, covering 23 percent of the total area, or 6.8 million ha. According to the DENR, the country's forest cover in 2015 was approximately 8.205 million ha. The Philippines' continuing loss of forest cover should be a source of concern and motivation for researchers to conduct studies on forest conservation and rehabilitation in the country.

In order to maintain the structural and physicochemical properties of aquatic environments, riparian habitats can be crucial. As a result, they play a significant role in determining the community makeup of these habitats. In fact, anuran assemblages usually follow a continuum of riparian habitats, which are important for amphibian species that are fragile in tropical forests. Moreover, riparian habitats help amphibian populations communicate with one another and connect isolated forest sections. Given that many amphibian species are dependent on these habitats for reproduction and that some of them spend the majority of their lives in close proximity to water bodies with riparian vegetation, protecting the latter may be essential to include *Philautus acutirostris*, *Pelophryne lighti* and *Oreophryne anulata*. Tall grasses and trees' leaves and branches are home to these species. Rather, *Rhinella marina* and *Polypedates leucomystax* are thought to be biological markers of habitat disturbance in the marsh. The increase in their population is a result of the woods experiencing the highest level of disturbance (Relox & Camino, 2018).

Statement of the Problem

This study aimed to assess the species composition, diversity and status of anurans in agroforested area and forested highland in Esperanza, Sultan Kudarat. Specifically, this study was conducted to determine the following:

1. Determine the species composition and species richness of the anuran species present in

- 1.1. agroforested area; and
- 1.2. forested highland.
2. Assess the ecological indices of anurans in agroforested area and forested area using
 - 2.1. Shannon- Weiner Diversity index;
 - 2.2. Simpson's Diversity index; and
 - 2.3. Pielou's evenness.
3. Determine the conservation status and endemism status of the identified anurans.

Scope and Limitation

This study was conducted in the four forested areas in Esperanza Sultan Kudarat: three forested highlands in Brgy. Marguez and one agroforested areas in each barangay namely Brgy. Poblacion, Brgy. Sagasa and Brgy. Villamor. All of the anuran species that were sighted and collected in an area were documented. Necessary permission letters and permits were secured in conducting this study. Quadrat transect, opportunistic, capture-mark-release sampling technique was also utilized to gather more data on anurans for the distribution of the species. All life stages are represented among the anurans gathered, which include both juveniles and adult anuran species. A group of 8-10 local researchers participated in the sampling method. The sampling was done during night time (6-10 PM Philippine Time) and daytime (10 AM-2 PM Philippine Time) from September to October 2025 or longer (depending from the results of species accumulation curve).

There was no sampling in approximately 8-9 days during the duration of the sampling process because of the heavy rain, in protection of the local researchers. Taxonomic identification was done by the experts in identifying anuran species contacted by the researcher.

Research Design

This study utilized the quantitative-descriptive research design. It described the biodiversity of anurans in forested highlands and agroforested area in terms of species composition, distribution and diversity indices. This study also included the conservation status of anurans using IUCN Red List.

Using standardized sample techniques like transect surveys and quadrat counts, as well as planned field observations, this methodology enabled researchers to collect objective, numerical data. It ensured that observed trends in anuran distribution, species richness, and population density accurately represent ecological reality by avoiding experimental manipulation and maintaining the natural conditions of habitats.

Additionally, using only naturally existing changes, this method allowed statistical investigation of the correlations between anuran populations and environmental variables (such as temperature, humidity, and vegetation type). Quantitative descriptive research is a reliable and moral approach to evaluating biodiversity and ecosystem health because the resulting dataset offers a thorough and objective baseline for comprehending the ecological roles of anurans, tracking population trends, and guiding conservation management.

Determination of Study Site

Sampling of anurans was conducted in Esperanza, Sultan Kudarat. Sampling of specimens was conducted in the four barangays, namely Brgy. Poblacion, Brgy. Sagasa and Brgy. Villamor with one site, and Brgy. Marguez with respective three sites (see appendix A). A 1-2 kilometer is the distance separation per site. Opportunistic sampling techniques were utilized in this study, whereby all anurans found in an area were counted and documented.

Specifically, the sampling process was done in the agroforested areas of Brgy. Poblacion, Brgy. Sagasa and

Brgy. Villamor in the municipality of Esperanza, Sultan Kudarat. It included also one forested barangay such as Brgy. Marguez. Agroforested areas topography is flat terrain. The fields located in these barangays were a flooded field of arable land used for growing rice crops. These fields are supplied by a seasonal irrigation that allows rice plantation. Some human interventions may include the use of inorganic fertilizers on the rice fields, as well as pesticides and herbicides.

Agroforested areas- these are located Brgy. Poblacion, Brgy. Sagasa and Brgy. Villamor in Esperanza, Sultan Kudarat ($6^{\circ}43'06''N$ $124^{\circ}31'11''E$). It has an elevation of 45.54 masl (see appendix A). Its vegetation includes *Oryza sativa* (rice) fields, *Zea mays* (corn) fields, *Mangifera indica* (mango) fields and *Cocus nucifera* (coconut) fields. Population of per site is about 150-300 residents in an area. In order to assure ecological independence, agroforested sites that were situated in Esperanza's lowland barangays and kept a minimum distance of 1-2 km from other sample sites were included. Sites that were too close to wooded highlands that would result in habitat overlap or that were less than one kilometer from another site were eliminated.

This site was selected because of the following reasons, first is because of habitat heterogeneity and microclimate regulation. Agroforested regions have trees, crops, and sometimes understory plants. These places create a patchwork of microhabitats that can support a wide range of anurans. Tree cover controls the temperature, humidity, and soil moisture, which are all very important for amphibians to live, procreate, and find food. Second is because of indicator value for environment quality. Because anurans are sensitive to changes in microclimate, water quality, and pesticide exposure, their existence and abundance in agroforested systems can serve as bioindicators of ecosystem health. Sampling in such regions allows researchers to examine how sustainable land-use practices influence amphibian diversity and ecological equilibrium. Third is sustainability and agroecological benefits because agroforestry systems are marketed as economically viable alternatives to intense monocultures. By fostering anuran diversity, these systems can naturally reduce pest populations, minimizing the demand for chemical pesticides and enhancing farm profitability through ecosystem-based pest management. Lastly, because of ecosystem service valuation. Understanding the ecological significance of anurans in agroforested landscapes helps assign economic value to ecosystem services such as pest regulation and soil fertility enhancement. This supports arguments for payment for ecosystem services (PES) and incentive-based conservation in agricultural situations.

Site 1 is located in Barangay Poblacion, Esperanza, Sultan Kudarat ($6^{\circ}42'31.390''N$, $124^{\circ}31'8.3808''E$). It is an agroforested region with rice, corn, calamansi, and coconut crops. It is home to approximately fifty people and a variety of livestock. In a landscape with fragmented vegetation, increased light penetration, reduced humidity, and wider temperature fluctuations—some of which are influenced by adjacent residential heat-retaining surfaces anurans use microhabitats such leaf litter, bushes, and fallen logs. Compacted soil and vegetation dominated by grasses, shrubs, and disturbance-tolerant species rather than mature native trees are likely to result from human activities such as land clearance, construction, garbage disposal, and regular foot activity.

Site 2 is located in Barangay Sagasa, Esperanza, Sultan Kudarat ($6^{\circ}43'53.155''N$, $124^{\circ}31'54.360''E$). It is an agroforested region containing crops of rice, corn, calamansi, mango, and coconut, as well as roughly thirty neighboring inhabitants who raise small animals. In a comparatively more humid and cooler climate, anurans live in microhabitats including leaf litter, bushes, and fallen logs. This is probably due to increased canopy cover, a variety of understory vegetation, and improved soil moisture conditions. The vegetation mostly consists of regenerating secondary growth, such as young trees, shrubs, and herbaceous plants that maintain modest faunal diversity, despite occasional human activity and small-scale farming causing disturbances.

Site 3 is an agroforested region in Barangay Villamor, Esperanza, Sultan Kudarat ($6^{\circ}42'29.466''N$, $124^{\circ}31'17.496''E$) which is home to roughly 50 people and a variety of livestock. Anurans live in leaf litter, shrubs, and fallen logs in a microclimate that is comparatively cooler and more stable. This microclimate is probably affected by denser canopy cover which preserves soil moisture and reduces temperature swings. Despite minimal natural disturbances, the site sustains a structurally complex microhabitat with well-developed leaf litter and layered vegetation, including old trees and shade-tolerant understory plants, suggesting a relatively stable successional stage.

Forested highlands- these are forested areas in Prk. I, Brgy. Marguez, Esperanza, Sultan Kudarat ($6^{\circ}39'54''N$

124°25'31"E). It has an elevation of 935.5 masl (see appendix A). It is located in the vicinity of Ga-as Hot and Cold Spring Resort. Its vegetation includes angiosperms and tree species like *Pterocarpus indicus* (Narra), *Acacia* sp. (*Acacia*) and *Swietenia macrophylla* (Mahogany). This resort is also composed of a natural stream where the herpetofauna and other micoroinvertebrates thrive. Even though this area is near to the well-known resort, the management ensures that the forested area is not disturbed by the tourists. This resort is visited by approximately 100-200 tourists daily. In order to avoid spatial autocorrelation, forested highland sites in Brgy. Marguez that were at a higher elevation and 1-2 km away from other sites were included. Sites that exhibited substantial habitat disturbance that jeopardized the integrity of the forest or were within one kilometer of agroforested areas were not included.

This site was selected first because of high habitat complexity and microclimatic stability. Forested highland areas offer a structurally complex ecosystem with multilayered vegetation, leaf litter, and shaded understories that create stable microclimatic conditions—cooler temperatures, increased humidity, and lower evaporation. These qualities are vital for anurans, which rely on moist skin for respiration and hydration, making such habitats optimal for their survival and reproduction.

Secondly, because of high species diversity and endemism. Highland woods often host unusual assemblages of anurans, including endemic and specialized species that have adapted to cooler and more humid settings. Sampling at these areas allows researchers to document species that might not occur in lowland or disturbed habitats, contributing to a more thorough understanding of amphibian diversity and distribution patterns. Next is because of biodiversity-based ecotourism potential. Many highland forests are biodiversity hotspots that attract eco-tourists, researchers, and conservation organizations.

Documenting and protecting anuran variety boosts the tourist attraction of these locations, offering economic opportunities for local communities through guided tours, research partnerships, and conservation incentives. It served as a basis for conservation funding and policy support. Proposals for protected area designation, payment for ecosystem services (PES) programs, and conservation funding can all benefit from data on anuran diversity and ecological roles from wooded highlands. Evidence-based management and policy-making are supported when the ecological and economic benefits of preserving intact highland forests are demonstrated.

Site 1 is a tropical forest located in Barangay Marguez, Esperanza, Sultan Kudarat

(6°41'26.903"N, 124°28'14.258"E). It features climbing ferns, molave, narra, mahogany, bamboo, bracken, and a creek that is home to crayfish. Ponds, streamside rocks and bushes, leaf litter, forest understory, and fallen logs are just a few of the varied microhabitats that anurans inhabit. They live in a moderately humid microclimate that is defined by partial canopy cover and slight elevation-driven moisture gradients. There are indications of previous disturbance in the area, and the vegetation is probably dominated by pioneer shrubs, hardy grasses, and sporadic trees that have adapted to greater sunshine and sporadic human activity.

Site 2 is a tropical forest region in Barangay Marguez, Esperanza, Sultan Kudarat (6°41'46.760"N, 124°28'55.341"E), with rice, calamansi, mango, and coconut farms scattered throughout. The vegetation includes molave, narra, mahogany, bamboo, bracken, and climbing ferns. Anurans live in a highly protected microclimate that is probably defined by denser canopy cover, higher soil moisture, and thicker leaf litter. They can be found in ponds, streamside rocks and bushes, leaf litter, forest understory, and fallen logs. A regenerative vegetation structure dominated by shrubs, saplings, and medium-sized trees is supported by moderate disturbances from small-scale farming, selective harvesting, and natural occurrences.

Site 3 is a tropical woodland close to the MonaLisa Hot and Cold Spring Resort in Barangay Marguez, Esperanza, Sultan Kudarat (6°41'31.502"N, 124°28'24.101"E). Climbing ferns, bracken, bamboo, mahogany, and molave are among the vegetation. There are no animals in the private area. Crayfish live in streams, and anurans live in ponds, forest bushes, fallen logs, leaf litter, and streamside boulders and plants. Ten to twenty people visit each day; on weekends, with permission, that number rises from thirty to fifty. It may be the most mature or exposed of the Marguez sites depending on its location in the landscape; if it were higher up and more open, it would be exposed to more intense light, stronger winds, and larger temperature swings; if it were higher up and more forested, it would be more susceptible to these conditions.

Entry Protocol

All data samplings were done with special care on the basis of the cultural view of the local communities in the study area. Letters signed by the Municipal Mayor (see appendix C) down to the barangay chairman of the said barangays were secured informing the purpose and scope of this study. Informants were informed that the objectives of the research are not for commercial purposes but for academic reasons (see appendix F). A wildlife gratuitous permit from the office of the DENR was secured (see appendix D and E).

Sampling Technique

Anuran species were sampled using the opportunistic sampling technique, which is useful for species like frogs and toads that are elusive, patchily distributed, or active at irregular times because it enables researchers to record and collect individuals whenever and wherever they are encountered. This approach ensures a more comprehensive picture of the anuran population by optimizing observations without stringent time or location limits. The researcher utilized quadrat transects, rope, and biosafety tools such as disinfectants in the sampling process.

The sample specimen and fieldwork were conducted between September-October 2025, approximately 60 days of sampling. Each transect made in all sites was 100 m long and 100 m wide using meter stick and rope, stationed randomly in each site. Quadrat transect, opportunistic, capture-mark-release sampling technique were also utilized to gather more data on anurans for the distribution of the species. Ecology researchers utilized the capture-mark-release (CMR) sampling methodology to examine wildlife populations (see appendix H). To assess population number, mobility, or activity, individuals of a species were collected, identified by a harmless marking, released back into their natural habitat, and then recaptured.

The group of local researchers was composed of 8-10 people in collecting the specimen of anurans species. Qualifications of local researchers include the educational background (at least elementary graduates that can read and write), field experience (must be oriented with the anurans sampling process) and local ecological knowledge (must be a resident in an area and knowledgeable with the different anurans located in an area).

They were acquainted and oriented with different anuran species before sampling. All life stages are represented among the anurans gathered, which include both juveniles and adults. The sampling was done during nighttime and daytime between 6-10 PM Philippine Time, 3-4 hours per sampling. They collected also during daytime between 10 AM-2 PM, 3-4 hours per sampling. They collected anuran specimens using hand picking and use of nets. They were the one also assigned in the marking process using non-toxic paint (see appendix H). The data documented includes the date, locality and its microhabitats. Local researchers were provided with notebooks and writing materials for documentation.

Photo Documentation and Pre-Identification

The process of photo-identification (Photo-ID) uses consistent photography using DSLR (Digital Single-Lens Reflex) camera and mobile phone camera to identify individual amphibians based on their distinctive, naturally occurring patterns. Taken pictures of anuran species were from conventional angles such as ventral and dorsal angles, emphasizing body parts with unique patterns (e.g., facial markings, thigh colors, and belly blotches).

Data Analysis

The assessment data was summarized using frequency and mean in a descriptive statistical study of anuran diversity. The number of individuals observed for each species was calculated using frequency counts, which gave information about the relative presence and abundance of each species in the investigated areas. To determine typical population levels and distinguish between dominant and rare species, the mean number of individuals per species was computed. This method made it easier to compare different study sites by providing a clear, quantitative picture of species composition and abundance patterns.

Results and Discussion

Species composition of the anuran species in Esperanza, Sultan Kudarat. A total of 7 species representing five anuran families were recorded in forested highlands and agroforested areas in Esperanza, Sultan Kudarat (Table 4). The family Dicroglossidae had the greatest number of species of 3 while Bufonidae, Microhylidae, Ranidae and Rhacophoridae were represented by one species each. Family Dicroglossidae includes *Fejervarya moodiei*, *Hoplobatrachus rugulosus*, and *Limnonectes magnus*. On the other hand, under Family Bufonidae is *Rhinella marina*, Family Microhylidae is *Kaloula pulchra*, Family Ranidae is *Hylarana grandocula* and Family Rhacophoridae is *Polypedates leucomystax*.

The anuran species identified in the study were also recorded in other parts of Mindanao. Sanguila et al. (2016) recorded *Pulchrana grandocula* or *Hylarana grandocula* in Mt. Busa, Sarangani Province. This common stream amphibian is widespread in Mindanao faunal region in both disturbed and undisturbed areas. They also perch on riparian shrubs. Polymorphism is evident for this species, particularly on the dorsal pattern. Coritico et. al (2018) identified *Limnonectes magnus* on the three barangays surrounding Mt. Pantaron Range in Bukidnon. Delima-Baron et. al. (2022) cited *Rhinella marina*, *Hoplobatrachus rugulosus*, *Kaloula pulchra*, *Fejervarya moodiei* and *Limnonectes magnus* in green spaces in Davao City, Mindanao Island, Philippines.

Gersava et. al. (2020) also identified *Rhinella marina*, *Kaloula pulchra*, *Hoplobatrachus rugulosus*, and *Polypedates leucomystax* in Davao City. This study showed that more anuran species are found in the forested highlands (7 spp) compared to the agroforested area (6 spp.). The species commonly found in both vegetation are *Rhinella marina*, *Fejervarya moodiei*, *Hoplobatrachus rugulosus*, *Limnonectes magnus*, *Kaloula pulchra* and *Polypedates leucomystax*. *Hylarana grandocula* is the only species that is located in agroforested area.

Rhinella marina is native to the Neotropics (Central and South America), *Rhinella marina* Linnaeus, 1758 (previously *Bufo marinus*) is a big terrestrial amphibian belonging to the Bufonidae family. Its massive global translocations for biological control and agricultural pest management have made it one of the most studied and introduced invasive animals. The snout-vent length (SVL) of an adult toad is usually between 10 and 17 cm, yet in certain populations it can reach up to 24 to 30 cm. Usually between 1 and 1.5 kilogram, with record specimens weighing around 2.7 kg. Females are generally bigger than males. Each eye has a unique parotoid gland that secretes strong poisons known as bufotoxins. These glands play a key role in defense. Adults have noticeable cranial crests down the snout and above the eyes. The pupils are horizontal; the fingers are not webbed, but the toes are (Crossland et al., 2021).

Eggs are found in water in long, gelatinous threads; typically, thousands (8,000– 30,000 per clutch) are laid. Tadpoles are black, closely packed, bottom-dwelling organisms that transform into juveniles in two to seven weeks. Toadlets are small (\approx 10–12 mm SVL), dark, smooth-skinned at birth, and later acquire parotoid glands.

Rainfall or warm weather are typically associated with seasonal breeding. However, in tropical areas, breeding can take place all year round. External fertilization takes place when males call in or close to freshwater bodies (ponds, sluggish streams). One female's eggs may be fertilized by several men. The eggs hatch in around two to seven days. It takes a few weeks for toads to transform into juveniles. In many societies, sexual maturity usually occurs between the ages of 18 and 24 months (Cabrera-Guzmán et al, 2013).

All life stages—eggs, tadpoles, juveniles, and adults—produce bufotoxins that are toxic to a variety of vertebrates and predators. The parotoid glands and other skin macroglands contain the majority of adult poison; they include substances such as bufadienolides that have an impact on the heart and neurological system. Population growth is facilitated by rapid metamorphosis and extremely high reproductive output. As generalist omnivores, toads eat plant matter, tiny animals, invertebrates, and even human food waste in cities. Certain transplanted populations exhibit fast phenotypic change, such as differences in limb proportions and parotoid gland size associated with urban settings or invasion stage. Due to poisoning (native quolls in Australia, for example) and changed social relationships, invasive cane toads have reduced predator numbers (Kerckhoff et al. 2016).

Rhinella marina is found on aquatic microhabitats which include streams, rivers, and creeks as well as standing bodies of water (Vidal et. al., 2018). This is also similar to the study of Coritico (2018) and Mapi-ot (2015). Also, according to the study of Causaren et. al. (2016), it can also be found in grassland. Coritico (2018) also cited that it thrives in an agro-ecosystem.

Fejervarya moodiei (Taylor, 1920) belongs to the Dicroglossidae family. Its identity as a separate taxon across much of coastal South and Southeast Asia has been resolved by current morphological and molecular research, which previously considered it as a member of the *Fejervarya cancrivora* (crab-eating frog) complex. *F. moodiei* is a medium-sized to comparatively big frog. According to morphometric research conducted throughout Southeast Asia, adult snout-vent length (SVL) spans roughly 42.7–62.7 mm for males and 50.0–81.8 mm for females. When seen dorsally, the snout is pointed, and the skull is slightly longer than broad. Dorsal skin differs from similar species in that it has irregular skin folds that are not grouped in series, as well as spinules and glandular warts, which are frequently accompanied by darker markings on limbs. The inner metatarsal tubercles are noticeable, and the fingers and toes have moderate webbing.

Male adults have triangular dark spots on the throat area and vocal sacs with wrinkled skin (Chandramouli et al., 2020).

However, there is not a specific reproductive study for *F. Moodiei*, the *Fejervarya cancrivora* complex's typical patterns indicate external fertilization, with females dispersing their eggs in freshwater or slightly brackish bodies of water. After tadpole growth, juveniles emerge and spread to terrestrial or littoral habitats; metamorphs approximately 15 mm SVL were discovered in the Andaman Islands in February, suggesting possible seasonal breeding connected to regional climatic cycles. Although specific reproductive studies for this taxon are scarce, it is likely that eggs are laid in shallow or semi-brackish pools, just like those of other coastal *Fejervarya* species. The clutch size and precise time are not described by the evidence that is currently available (Yodthong et al., 2019).

Fejervarya moodiei can be found in both terrestrial and freshwater (Mapi-ot, 2015). *F. Moodiei* inhabits a variety of wetland and coastal habitats; it is more frequently seen in freshwater or brackish settings than in deep freshwater forests. Mangroves, mudflats, fish ponds, rice paddies, estuarine borders, and water-filled ditches are common places to find them, indicating a high degree of adaptability to dynamic, water-rich microhabitats. Individuals were found in small coastal depressions created after the tides receded and on mudflats close to mangroves in the Andaman Islands, suggesting that they used littoral microhabitats. These habitats coincide with those of other amphibians and aquatic predators, indicating that this species can withstand dynamic brackish conditions and sporadic saltwater incursion (Chandramouli et al., 2020).

The Chinese tiger frog from China, *H. rugulosus* is a member of the family Dicroglossidae. Freshwater marshes, intermittent freshwater marshes, arable land, pastureland, rural gardens, urban areas, ponds, aquaculture ponds, open excavations, irrigated land, seasonally flooded agricultural land, canals, and ditches are among these species' natural habitats (Diesmos et al. 2006). Tiger frogs from Eastern China were gathered by Lin and Ji (2005), who discovered that the frogs' insectivorous diet included certain invertebrates as prey (Jaboneta et. al., 2019). Mapi-ot (2015) cited that it can be found both terrestrial and freshwater.

In natural and artificial water bodies (such as ponds and rice paddies), breeding often takes place in the spring to early summer. During this time, males vocalize to entice females; the frequency and duration of these cries vary and are tailored for mate seduction. A number of somatic developmental changes take place during the tadpole stage. Traijitt et al. (2021) provided a chronological account of the larvae's journey from hatching to metamorphosis, emphasizing morphological alterations that take place before juvenile emergence. Tadpole survival, growth, and transformation are all influenced by salinity; in comparison to fresh water, salinities below 4‰ might increase survival and accelerate metamorphosis, indicating the species' adaptability to low salinity conditions.

Genetic diversity and species boundaries among Mindanao fanged frogs have been made clear by research on the *Limnonectes magnus* complex. The complex actually contains fewer species than previously believed, according to molecular and morphological research that revealed some previously described species were incorrectly identified (Abraham et al., 2021). The species is widely dispersed in the Mindanao faunal region and was first reported from Mount Apo in Mindanao. It is regarded as a large-bodied fanged frog that lives in riparian settings and forested streams. Hunting pressure for food has contributed to the species' listing as Near Threatened (Diesmos et al., 2015). *Limnonectes magnus* can be found in aquatic microhabitats which include streams, rivers, and creeks as well as standing bodies of water (Vidal et. al., 2018). Moreover, the study of Coritico (2018) cited

that *L. magnus* is located in bodies of water (fish pond), rock near the bodies of water (stream) and shrubs growing near the stream.

The medium-sized frog *Kaloula pulchra*, which belongs to the Microhylidae family, usually has a snout-vent length of 5.4 to 8 cm. With a small, rounded head and a short, narrow nose, the body is robust, sturdy, and chubby. Usually dark brown or chestnut-brown, dorsal coloring is accompanied by two broad, lighter bands that go down the flanks from behind the eye and can be cream, yellow, or salmon in hue. Ventral surfaces typically have lighter hues or are speckled. Males typically have a darker neck patch during the breeding season, and females are typically larger. In order to ward off predators, people may release sticky protective skin secretions and expand their bodies to seem larger when threatened.

K. pulchra spend much of their time underground or on land, coming out to feed and mate mostly at night or after rain. It is resilient to dry circumstances because of its fossorial habits. As insectivores, adults consume termites, ants, beetles, and other small invertebrates found in agricultural fields or on the forest floor. The distinctive larval morphology of tadpoles—such as their mouthparts and spiracle position—is tailored for suspension feeding in still bodies of water. Although they do not create highly toxic substances like some other amphibians, individuals can inflate their bodies to appear larger when disturbed and release sticky, moderately irritating skin secretions to deter predation (Shahrudin, 2021).

K. pulchra is a frog from the Microhylidae family. This species thrives in disturbed habitats including flooded grasslands, roadside puddles and hidden areas like burrows, holes, or crevices in trees and buildings (Diesmos et al. 2006). These species voraciously prey on flies, crickets, moths, grasshoppers, earthworms and more (Kuangyang et al. 2004 as cited in Jaboneta et. al., 2019). Mapi-ot (2015) cited that it can be found in both terrestrial and freshwater. It can also be found in agroforest, grassland and riparian forest (Causaren et. al., 2016).

The big-eyed frog or *Hylarana grandocula* (Taylor, 1920) is a true frog belonging to the Ranidae family. It is native to the southern Philippines and can be found in a range of upland and lowland stream-associated habitats. The morphological characteristics of *H. grandocula*, a medium-sized ranid, includes the body size and shape, where adult snout-vent length (SVL) usually runs around ~50 mm (with little variation among populations). The head and eyes are the species' common name which comes from its comparatively large head and huge, noticeable eyes. Individuals may have dorsolateral light lines and pale upper eyelid markings, but dorsal coloration is typically dark brown with irregular mottling. The skin texture is like that of many ranid frogs, the skin is smooth and non-warty. The limbs and toes in riparian environments, leaping and swimming are made easier by well-developed hind limbs and webbed feet (Venturina et al., 2023).

During the breeding season, males create choruses calling to females beside flowing water, and adults are linked to rivers and streams. Eggs are laid in streams that are moving, and these eggs grow into aquatic tadpoles there. Tadpoles grow in stream environments before undergoing a transformation into froglets, which then spread out into nearby riparian zones. When stream water levels are lower, males have been seen calling, indicating that certain hydrological conditions constitute the peak for reproductive activity (Venturina et al., 2023).

One species is not sited in forested highlands and that is *Hylarana grandocula*. It was often seen on rocks that protruded above a stream of water (Solania et. al., 2021). For the rivers and streams, it grows on the banks and shallow edges of streams that are running, frequently on rocks that are above water or in nooks and crannies where moisture is retained. Individuals are found close to clear, clean waters in both disturbed and undisturbed habitats (such as degraded forests and agricultural edges). Adults may travel onto adjacent vegetation a short distance from the water, but they still need watery habitats to reproduce. Its adaption to lotic (flowing water) systems and the significance of permanent freshwater for its life history are reflected in this microhabitat utilization (Venturina et al., 2023).

Polypedates leucomystax is a medium-sized rhacophorid or "tree frog," with sexually dimorphic size: females have an average snout-vent length of around 80 mm, while males have an average of about 50 mm. The dorsal coloration of adults varies from brown, gray, yellow-brown, and reddish tones, and they frequently have longitudinal stripes or mottling. They also have smooth skin. Although some populations lack noticeable striping, dorsal patterns may include four stripes (hence the name "four-lined tree frog"). For arboreal climbing,

the tips of the digits generate huge adhesive pads, and the toes are entirely webbed. The skull has a pronounced tympanum and supratympanic fold, and it is slightly wider than long.

Like many anurans, *Polypedates leucomystax* has a biphasic (aquatic–terrestrial) amphibian life cycle. On vegetation or surfaces hung over static or transient bodies of water (such as puddles or shallow pools), females lay 100–400 eggs in a foam nest. The nest shields embryos against infections and desiccation and is composed of epidermal secretions, such as proteins and antibacterial peptides (Shahrudin et al., 2017). Within the foam nest, eggs typically hatch into larvae after three to four days. Tadpoles continue their aquatic development after dropping into the water. Depending on environmental factors including rainfall and water availability, larval development typically takes 7 weeks (42–60 days) (Ingrai, 2022).

P. leucomystax can also flourish in urban roadside environments, where it has been shown that both species frequently flourish in vegetated roadside regions (Gersava et. al., 2020). It is also found in agroforest, forest, grassland, mixed forest and riparian forest (Causaren et. al., 2016). Coritico (2018) cited that it inhabits in an agro-ecosystem. It usually perches several meters above the ground on low foliage, bushes, and leaves close to water sources, where it forages and cries. Shallow rain pools, ephemeral ponds, irrigation ditches, and artificial water containers are examples of still or sluggish water bodies where breeding takes place. This frog can be found in a variety of settings, including urban and agricultural settings, damp forests, and wetlands (Brown et al., 2010).

TABLE 1. Anuran Species Present in Agroforested Area and Forested Highland in Esperanza, Sultan Kudarat

Family	Species	Local Name	Agroforested Area	Forested Highlands
Bufo	<i>Rhinella marina</i>	Bullfrog, Hawaiian	✓	✓
Dicroglossidae	<i>Fejervarya moodiei</i>	Frog	✓	✓
Microhylidae	<i>Hoplobatrachus rugulosus</i>	Palakang palayan	✓	✓
	<i>Limnonectes magnus</i>	Bak-bak	✓	✓
	<i>Kaloula pulchra</i>	Bubble	✓	✓
Ranidae	<i>Hylarana</i>	frog	X	✓
Rhacophoridae	<i>grandocula</i>	Manwit	✓	✓
	<i>Polypedates</i>			

leucomystax

Ecological indices of anurans. Table 2 shows the number of anuran species, diversity, and evenness in agroforested area and forested highlands in Esperanza, Sultan Kudarat. Agroforested Area was represented by 6 species while forested highland was represented by 7 species. Both sites have extremely low species diversity in agroforested areas and forested highland, $H' = 1.50$ and $H' = 1.69$ respectively. On Simpson’s Diversity Index, both sites displayed modest diversity values in agroforested area and forested highlands, 0.75 and 0.78 respectively. Both sites displayed high evenness values in agroforested area and forested highlands, 0.84 and 0.87 respectively.

High species richness is probably correlated with the availability of different microhabitat types, relatively constant environmental condition, high humidity and rapid decomposition (Causaren, 2009). Compared to

agricultural or agroforest systems, forested highlands typically feature a more complex vegetation structure (canopy cover, understory layers, leaf litter, bromeliads, etc.). For many frog species to survive, procreate, and regulate their body temperature, these structures provide stable microhabitats with increased humidity, colder temperatures, and plenty of hiding places. Agroforests, on the other hand, frequently lack this intricacy, particularly when shade trees are cut down to make way for crops. For reproduction, many frogs rely on tiny bodies of water, such as ponds, puddles, and streams. Ephemeral ponds covered by vegetation and intact stream networks are common features of forested highlands. Reproductive success may decrease in agricultural fields, including shaded agroforests, if there are insufficient breeding habitats or if water bodies have been altered (drained, redirected, or contaminated) (Decena et.al., 2020).

The niches accessible for forest-dependent anuran species are limited since even complex agroforestry systems lack the structural and environmental diversity of natural forests (e.g., fewer microhabitats, simpler canopy and understory) (Udawatta et. al., 2019). The forested highland sites showed somewhat higher but still very low values. It concludes that the once the forest is less disturbed, it will have much greater amphibian diversity and abundance than extensively altered ones. Additionally, the species composition changes from generalists in damaged regions to forest specialists in undisturbed ones (Decena et. al., 2020). This suggests that anuran communities in Esperanza, Sultan Kudarat are generally species-poor, either as a result of environmental factors impacting amphibian numbers, habitat disturbance, or a lack of microhabitats.

In all types of agroforests, the variety of amphibians (anurans) is far lower than in native forests. Compared to traditional forest communities, agroforests have a different species composition and support fewer species and individuals. This implies that native forests cannot be completely replaced by agroforestry in order to preserve amphibian biodiversity (Cervantes-López & Morante-Filho, 2024). While the forested highland sites displayed somewhat higher values, indicating slightly reduced dominance but still low overall diversity, the lower Simpson's diversity index in agroforested sites indicated stronger dominance by a few species. It links increasing disturbance intensity to decreased amphibian diversity, which is consistent with global trends, and demonstrates that primary forests maintain higher amphibian richness than disturbed environments (Musubaho et al., 2024).

A different trend can be seen in the Pielou's evenness quantification of the anuran species present in Esperanza, Sultan Kudarat. This suggests that individuals are distributed quite evenly among the species present, especially in the forested highlands. This implies that no single species, particularly in less disturbed wooded settings, disproportionately dominates the ecosystem despite the low species richness. High evenness communities are typically more stable since numerous species share resources and ecological responsibilities, which lessens the dominance of a small number of tolerant species. According to conservation research, maintaining evenness has a stronger correlation with ecosystem functioning (production, resilience), not merely species counts (Wilsey & Potvin, 2000).

TABLE 2 Species Richness and Ecological Indices Quantification of The Anuran Species Present in Esperanza, Sultan Kudarat

Species Richness		Shannon- Weiner Diversity index	Simpson's Diversity index	Pielou's evenness
Agroforested Area	6	1.50	0.75	0.84
Forested Highland	7	1.69	0.78	0.87

Conservation status and endemism status of anurans. The anuran assemblage in the study exhibited remarkably low degree of endemism (29%), with at least 2 species are endemic to the country such as *Limnonectes magnus* and *Hylarana grandocula* (Table 3). *Limnonectes cf. magnus* is a large-bodied species that is found throughout the faunal region of Mindanao. People were usually found concealed in cracks and bushes,

and they were rarely seen in open spaces. The taxonomic standing of this common low-elevation *L. cf. magnus* in relation to the elevated *L. Magnus* at its type of site in Mount Apo suggests more research (Sanguila et al. 2016). Although *Batrachochytrium dendrobatidis* (Bd) fungus was found in this species, no detrimental effects have yet been reported (Alcala et al. 2012 as cited in Pitogo et. al., 2021).

Other species are labeled as least concern such as *Rhinella marina*, *Fejervarya moodiei*, *Hoplobatrachus rugulosus*, *Kaloula pulchra*, *Hylarana grandocula* and *Polypedates leucomystax*. This means that at the moment, they are not in danger of going extinct. These species are plentiful and/or widely distributed. Its population is either constant or not decreasing quickly enough to be classified as threatened.

TABLE 3
 CONSERVATION STATUS AND ENDEMISM STATUS OF THE ANURAN SPECIES PRESENT IN
 ESPERANZA, SULTAN KUDARAT

Family	Species	Conservation status	Endemism status
Bufonidae	<i>Rhinella marina</i>	Least concern	Widespread
Dicroglossidae	<i>Fejervarya moodiei</i>	Least concern	Widespread
	<i>Hoplobatrachus rugulosus</i>	Least concern	Widespread
	<i>Limnonectes magnus</i>	Near Threatened	Mindanao Endemic
Microhylidae	<i>Kaloula pulchra</i>	Least concern	Widespread

CONCLUSIONS

Seven anuran species from five families were identified in this study's documentation of the anuran diversity in Esperanza, Sultan Kudarat's forested highlands and agroforested areas. There was just one species from each of the other families, with the Dicroglossidae family having the highest representation. In comparison to agroforested areas (6 species), forested highlands generally sustained a little higher species richness (7 species), highlighting the significance of less disturbed habitats in maintaining amphibian groups.

Diversity indices consistently showed low species diversity across both sampling sites, as shown by low Shannon-Weiner diversity index and Simpson's diversity index values, despite variations in species richness between vegetation types. This implies that the research area's anuran assemblages are species-poor and may be impacted by environmental constraints, habitat disturbance, or a decrease in the availability of specialized microhabitats. High Pielou's evenness values, on the other hand, show that individuals are spread fairly and evenly among species and that no single species dominates the group, especially in forested highlands.

The majority of the species that were identified were habitat generalists that could flourish in both disturbed and undisturbed settings. The degree of endemism was only 29% since just two species such as *Limnonectes magnus* and *Hylarana grandocula* that were found to be endemic. Due to habitat loss and overexploitation for food, *Limnonectes magnus* was classed as Near Threatened and was found in small numbers throughout the survey, raising conservation concerns. Due to their vast range and adaptability, the remaining species were categorized as least concern.

Overall, the results show that both habitat types now support average variety, even though forested highlands offer comparatively superior circumstances for anuran assemblages. If human pressures and habitat alteration are not adequately controlled, amphibian diversity may be further diminished.

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