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Research Article

Diversity and composition of riparian vegetation across forest and agro-ecosystem landscapes of Cabadbaran River, Agusan del Norte, Philippines

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Abstract

The Cabadbaran River Irrigation System (CabRIS) supports about 3,212 hectares of farmland for irrigation. Unfortunately, the local irrigation office reported an insufficient water supply for irrigation to serve the entire service area in the past cropping seasons. The water yield has been dwindling; hence, an irrigation system management plan will address the water resource crisis. As a component of the project "Cabadbaran River Irrigation System Management Plan for Irrigation Water Resources (2022-2026)", the biophysical team carried out a floristic assessment for the entire watershed. The study used the quadrat-transect sampling method to assess and characterise the structure and species composition of the riparian areas of the main Cabadbaran River, Cabadbaran City, Agusan del Norte, Philippines. Results recorded about 109 morpho-species belonging to 46 families and 88 genera from the sampling sites. Nineteen species were listed either on the Philippine Red List or the IUCN Red List of Threatened Species. The plant diversity assessment revealed that biodiversity in riparian forests in the watershed was low to very low due to the massive rampant disturbance in the area. The riparian ecosystem of the Cabadbaran River represents a fragile ecosystem that is threatened by increasing demands on the regional water supply and the conversion of lands into tree plantations

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and agriculture. Addressing these driving forces causing biodiversity loss will impart a significant challenge for irrigation and land managers in the region.

Keywords

Plant diversity, riparian flora, threatened species, irrigation system

Introduction

From the beginning of human history, the importance of rivers for human survival cannot be overstated and its significant role in the life of people, channels of materials and energy and in the development of the settlements (Tochner and Ward 1999; Maciukenaite and Povilaitienė 2013; Sankhwal et al. 2015). Even in modern life, it is surprising how much people rely on rivers for livelihood and the economy (Buzarboruah 2014). The value of rivers has not decreased in history. It has progressed from merely being used as a source of potable water to drink, for irrigation, agricultural purposes and source of food, to the transport of goods and services and, recently, in the development of hydroelectricity as a renewable source of energy (Ozigis et al. 2019). However, human activities gradually alter the inland water ecosystem and its catchments through land conversion, sand and gravel extraction and indiscriminate disposal of sewage, agricultural and industrial wastes to water bodies.

The Cabadbaran River is the main channel of the 16,025 hectares protected area of the Cabadbaran River Watershed Forest Reserve (CRWFR), established by Proc. No. 834 by President Corazon C. Aquino in 1991. The aim is to provide protection, maintenance and improvement of water yield and a restraining mechanism for inappropriate forest exploitation and disruptive land uses in the watershed (Government of the Philippines 1991). Supporting about 3,212 hectares of farmlands and benefiting 2,205 farmer-beneficiaries in Agusan del Norte, the watershed was a top priority for development and considered a critical watershed listed under the Department of Environment and Natural Resources (DENR-FMB 2013).

With more than a decade in service and operation, the local irrigation office reported a declining water yield in the watershed, especially during the dry seasons. Surface water was dwindling as a significant fraction of rice fields under the irrigation system were not served. Like other watersheds, riparian forests are increasingly threatened by urban expansion and land-use change (Burton and Samuelson 2008). It is, therefore, necessary to revisit, formulate and update the irrigation management plan to address the water crisis.

As riparian areas are amongst the most diverse, dynamic and complex habitats, it has become a priority worldwide. Information herein is critical for the better protection and conservation of the watershed (Naiman and De´Camps 1997; Zaimes 2020). This paper is a product of a comprehensive biological survey as part of an irrigation management plan formulation commissioned by the Philippine government. It provides an inventory as baseline information of the riparian flora of the main Cabadbaran River, including stand structure, plant diversity, endemism and ecological status.

Material and methods

Study area and sites

The main channel of the Cabadbaran River has an estimated length of nearly 15 kilometres from the irrigation dam structure as its outlet. As delineated using GIS methods, the sub-watershed has a total area of approximately 18,707 hectares. It is situated in the Province of Agusan del Norte on the Island of Mindanao, Philippines, extending from 9°05'36" N to 9°16'46" N latitude and from 125°36'15" E to 125°45'33" E longitude. It belongs to the Climatic Type II of Corona Classification with no definite dry season and maximum rainfall occurs from October to January. Its average annual rainfall is 171.29 mm, while the average annual temperature is 27.5 degrees Celsius (Philippine Atmospheric, Geophysical and Astronomical Services Administration 2022). This climate scenario may significantly impact agriculture, water supply, aquatic resource production, health and forestry.

The sub-watershed has 17,635.91 hectares classified as timberland and 909.40 hectares of Alienable and Disposable (A and D) lands (Fig. 1). The majority of its area intersects with Certificate of Ancestral Domain Title (CADT) 092 (Cola 2010), with an approximate area of 16,759.96 hectares. Within this CADT area, 16,309.67 hectares are timberland and 450.29 hectares are A and D land. Timber production comprises 2.48% of its forestland, while a significant portion (69.58%) are Community-Based Forest Management Areas. Mineral areas comprise 26.52%, which are located in the upland areas. A substantial portion of the forested areas was declared protected areas (DENR-FMB 2020).

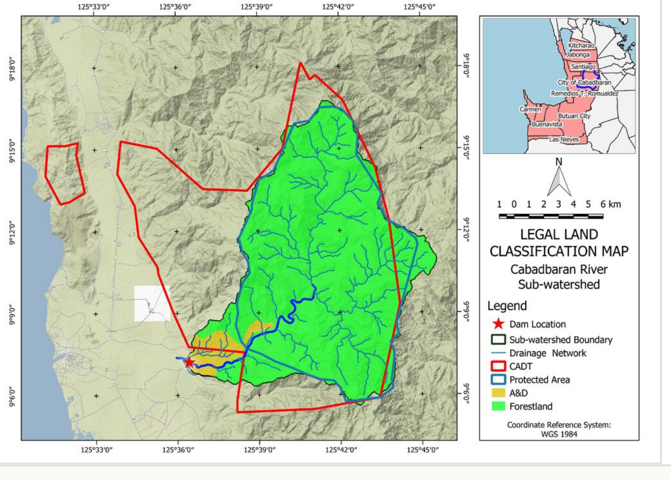

Figure 1.

Legal land classification map of the Cabadbaran River sub-watershed.

The headwaters of the sub-watershed originate from the upper slopes of Barangay Del Pilar of Cabadbaran City and Barangay Poblacion I of Santiago forested areas. Generally, it is made up of flat and rolling terrain characterised by mountain ranges with uneven plateau distribution, rivers and plains. Its elevation ranges from 40 m to 1,900 m above mean sea level. The riparian areas have less than 3% slopes up to 5-8%. A large portion of the watersheds has a slope > 50%. Per the initial reconnaissance survey, agricultural and industrial tree plantations were the most dominant land use in the riparian areas.

Sampling procedure

The biophysical team carried out the floristic inventory in August 2021 within the vegetated patches alongside the Cabadbaran River. The main river channel was divided into downstream, mid-stream and upstream sections starting from the irrigation dam structure upwards. The study used the line plot method to assess and characterise the structure and species composition of the different plant communities using a 20 m x 20 m sampling quadrat. Five quadrats at an interval of 250 m were laid out on each side of the river (10 quadrats per section). Diameter measurements at breast height (DBH) and total height (TH) were taken in all large woody plants found inside the sampling quadrat.

Five additional quadrats were established in the headwater forests to assess other tree species found in the protected areas of the watershed. A digital camera was used to document all species, including rattans, bole climbers, bamboos, lianas and palms. Overall, a total of thirty-five quadrats were surveyed with elevations ranging from 50 m to 250 m above sea level (Fig. 2).

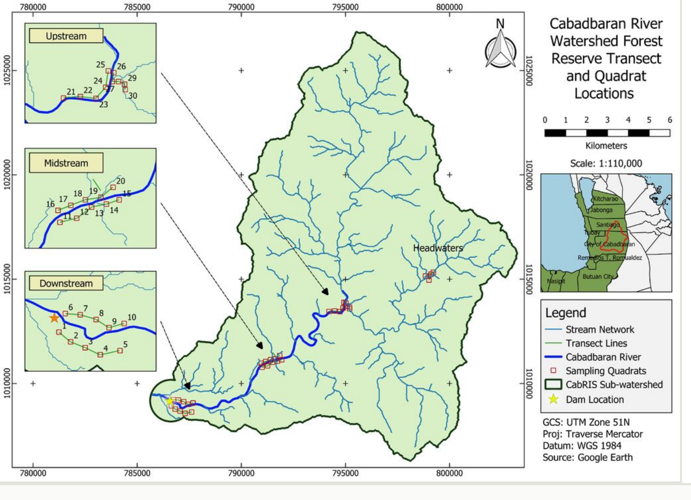

Figure 2.

Location map of the different sampling quadrats along Cabadbaran River.

An additional survey was made using the transect method to account for other flora species occurring outside sampling quadrats. The 1-km transect in-lined with the sampling quadrats was laid out along the riparian zone and its opposite bank for every section in the main river. Additional transects were also laid out on other forest patches adjacent to the main river channel. The survey involved only a listing of species encountered without any measurements.

Statistical analysis

The Paleontological Statistics Software v.4.03 (Hammer et al. 2001) was used to generate the different diversity indices (i.e. Shannon (H'), Simpson's (D) and Evenness (J) for each quadrat. Shannon Index gives an estimate of species richness and distribution. Evenness Index indicates how evenly species and/or individuals are distributed inside a plot or quadrat. Simpson's Index gives the probability of getting different species when two individuals were drawn (without replacement) inside a plot (Malabrigo et al. 2014).

In addition, the ecological and conservation status of the different species was assessed using the IUCN (2021-2) and the Philippine Red List (Fernando et al. 2008) for threatened species. Species names were counter-checked in WFO (2022), while the common names were adapted from Rojo (1999).

Results and Discussion

Results of the floristic inventory revealed that the riparian areas of the Cabadbaran River have an ordinarily low plant diversity despite the ample survey time and effort. Some areas were devoid of vegetation due to forest fires in the past months. While most low elevation species are common, some specimens encountered in the field were not identified to the species level, thus tentatively assigned to the most probable taxon. Most of these, especially in the protected natural forest, are juvenile or sterile specimens.

Tree Species diversity and assessment

For trees and other arborescent species inside sampling quadrats, a total of 465 individuals with 52 species were recorded to have a DBH of more than 10 cm. The majority of the quadrats surveyed have less than 20 individuals per quadrat (Fig. 3) and only five quadrats have recorded 20 individuals or more. The average number of trees per quadrat is only 13 individuals or an average density of 0.03 tree/m^2 (three trees for every 100 m^2) only. The majority of the surveyed quadrats are classified to have "very low" diversity with index values less than 2.00 (Fig. 4). The low tree density of the quadrats can be attributed to the massive clearing of the riverbanks for plantation and agricultural purposes since most of the quadrats fall on areas planted with *Falcata* (*Falcataria moluccana* (Miq.) Barneby & J.W.Grimes.). In addition, most riparian tree species (e.g. *Ficus* spp.) are naturally small-diameter trees. The tree with the largest diameter was While Lauan (*Shorea contorta* S.Vidal) which recorded a DBH of 176.5 cm, followed by Bagtikan (*Parashorea malaanonan* Merr.), Tagkan (*Palaquium pinnatinervium* Elmer), Tanguile (*Shorea polysperma* (Blanco) Merr.) and Panau (*Dipterocarpus gracilis* Blume). All of these were recorded in the forested areas of the headwaters (protected area) of the watershed.

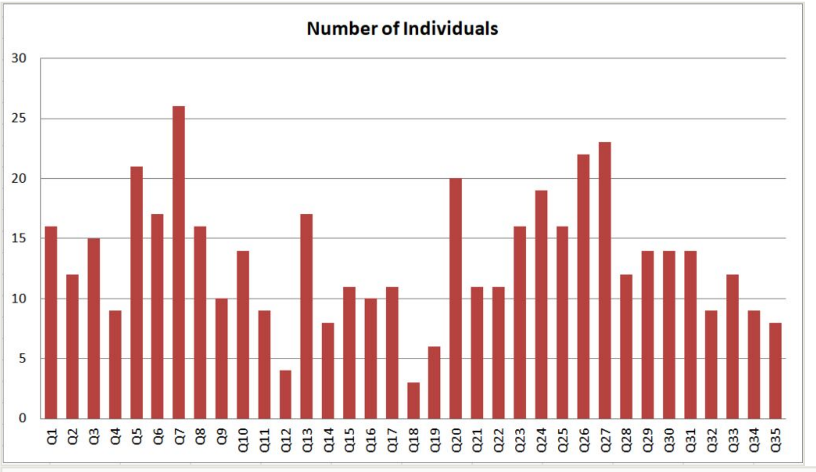

Figure 3.

Number of individuals per sampling quadrat.

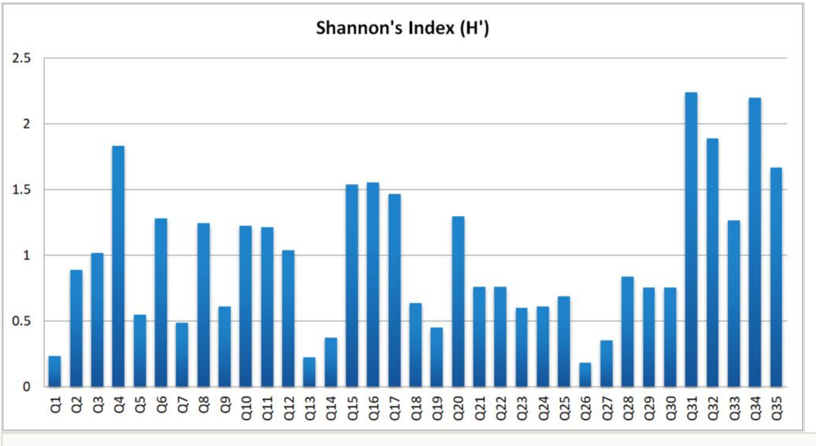

Figure 4.

Computed Shannon's Diversity Index (H) of the sampling quadrats.

Importance Value

The data was tabulated on a spreadsheet to determine the relative density, relative dominance and relative frequency values for each tree species; the requisite values needed to obtain the Species Importance Value (SIV). High Importance Values of species indicate a composite score for high relative species dominance, density and frequency. Based on the computed IV (Table 1), the five most important species (with the highest IV) for the whole watershed area are *Falcata* (*F. moluccana*) (82.95), White Lauan (*S. contorta*) (26.38), Coconut (*Cocos nucifera*) (24.59), Antipolo (*Artocarpus blancoi*) (15.70) and Lapnis (*Broussonetia papyrifera*) (11.63). Since most of the sampling quadrats fall on disturbed agricultural and plantation areas, it was expected that species composition will be those that can be traded commercially like *Falcata* and Coconut and other miscellaneous species that occur after disturbance known to be water-loving species, hence, commonly found in rivers and creeks.

Table 1.

Top ten species with the highest Species Importance Values (SIV).

Species	R. Frequency	R. Dominance	R. Density	SIV
Falcataria moluccana	13.01	44.95	24.99	82.95
Shorea contorta	2.74	1.29	22.35	26.38
Cocos nucifera	6.16	9.46	8.96	24.59
Artocarpus blancoi	8.22	4.73	2.75	15.70
Broussonetia papyrifera	6.16	3.87	1.60	11.63
Leucaena leucocephala	3.42	4.52	1.78	9.72
Parashorea malaanonan	2.05	0.65	6.50	9.20
Pterocarpus indicus	4.11	2.15	2.14	8.40
Gliricidia sepium	2.74	3.44	1.73	7.91
Dipterocarpus gracilis	2.05	1.72	3.67	7.44

Diversity Indices

The computed Shannon Index from the different sampling quadrats varies from very low 0.377 to a low of 2.243 (Table 2). Following the diversity classification scheme, based on the suggested range of Shannon Index by Fernando et al. (1998), only two quadrats were considered to have low diversity, the remaining quadrats being classified as very low diversity. Q31 emerged as the most diverse quadrat since it has the most number of species amongst the quadrats. However, it should be noted that this quadrat was located in a protected forest area, thus contains more species compared with the other quadrats. Similarly, Simpson's Index and Evenness Index are highest in Q34 because no species is dominating over the area. Q26 (not shown in the table) provided the lowest value for the two indices (H' and D) because the quadrat has only two species and is exploited for growing *Falcata* which dominates the area.

Table 2.

Top Ten quadrats with the highest diversity indices and the number of species.

Quadrat	Shannon's	Simpson's	Evenness	Number of Species	Relative Values
Q 31	2.243	0.888	0.942	10	Low
Q 34	2.197	0.889	1.000	9	Low
Q 32	1.889	0.840	0.945	7	Very Low

Quadrat	Shannon's	Simpson's	Evenness	Number of Species	Relative Values
Q 4	1.831	0.815	0.892	7	Very Low
Q 35	1.667	0.781	0.883	6	Very Low
Q 16	1.557	0.780	0.949	5	Very Low
Q 15	1.540	0.727	0.778	6	Very Low
Q 17	1.468	0.744	0.868	5	Very Low
Q 20	1.297	0.705	0.914	4	Very Low
Q 6	1.282	0.561	0.515	7	Very Low

Analysis of the stream sections of Cabadbaran River shows the same relative diversity values ranging from “low” to “very low” (Table 3). The additional quadrats, located on the forests of the headwaters which is part of the protected area, were computed to have a higher diversity value (“moderate”), yet the overall composite diversity index of the whole river is still on the “low” range only. The forests on the headwaters are at risk of deterioration due to the ongoing road construction connecting the Provinces of Agusan del Norte and Surigao del Norte as road constructions increase fragmentation of habitats, influence landscape pattern and alter the physical environment (Vaiškūnaitė et al. 2012).

Table 3.

Summary of diversity indices per section of Cabadbaran River.

Stream Section	Shannon’s Index (H’)	Evenness	Relative Values
Downstream	2.099	0.3884	Low
Mid-stream	2.298	0.6222	Low
Upstream	1.028	0.1864	Very Low
Headwaters	2.967	0.7770	Moderate
Riparian Total	2.491	0.2277	Low

The low to the very low classification of most quadrats can be attributed to the conversion of riparian areas into agriculture and forestry plantation purposes. Most surveyed quadrats were opened, cleared or have been newly established for growing *Falcata* and Corn (*Zea mays*). In addition, huge areas in the mid-stream section were affected by forest fires in July 2021. Steep slope vegetations, grassland areas and *Falcata* plantations were totally wiped out (Fig. 5).

Overall Species Diversity

The complete listing of the different plant families and species for the sample plots, as well as those encountered in the line transect are listed in Table 4. A total of 109 morpho-species belonging to 46 families and 88 genera were recorded and identified from the study area. The highest number of species was found in the family Moraceae with 13 species, followed by Fabaceae (12 species) and Dipterocarpaceae (8 species). Tree species of the family Moraceae, Fabaceae and Rubiaceae dominate the lower elevations

(50 - 150 m a.s.l.) surveyed while in higher elevation of 150-250 m a.s.l., woody species of Dipterocarpaceae and Myrtaceae were identified and naturally growing in the undisturbed area where the plots were established.

Figure 5.

(Left) Areal view of the riparian zone in the downstream section cleared for agricultural and industrial purposes; (Right) Areal view of forest fire damage in the mountainous areas of the watershed.

Table 4.

List of species encountered in the quadrats and transects.

Family	**Scientific Name**	**Common Name**	**Growth Habit**	**Endemicity**
Anacardiaceae	*Mangifera indica*	Mangga	T&S	Native (NE)
Annonaceae	*Annona muricata*	Guyabano	T&S	Native (NE)
Annonaceae	*Cananga odorata*	Ilang-ilang	T&S	Native (NE)
Araceae	*Colocasia esculenta*	Gabi	OGDH	Native (NE)
Araliaceae	*Polyscias nodosa*	Malapapaya	T&S	Native (NE)
Arecaceae	*Areca catechu*	Bunga	PC&P	Native (NE)
Arecaceae	*Arenga pinnata*	Kaong	PC&P	Native (NE)
Arecaceae	*Caryota mitis*	Pugahan	PC&P	Native (PE)
Arecaceae	*Cocos nucifera*	Niyog	PC&P	Native (NE)
Aspleniaceae	*Asplenium nidus*	Bird's Nest Fern	E	Native (NE)
Asteraceae	*Chromolaena odorata*	Hagonoy	G&GLP	Native (NE)
Burseraceae	*Canarium ovatum*	Pili	T&S	Native (PE)
Byttneriaceae	*Kleinhovia hospita*	Tan-ag	T&S	Native (NE)
Byttneriaceae	*Theobroma cacao*	Cacao	T&S	Exotic
Cannabaceae	*Trema orientalis*	Anabiong	T&S	Native (NE)
Caricaceae	*Carica papaya*	Papaya	OGDH	Exotic
Casuarinaceae	*Casuarina equisetifolia*	Agoho	T&S	Native (NE)
Combretaceae	*Terminalia catappa*	Talisai	T&S	Native (NE)
Convolvulaceae	*Merremia peltata*	Bulakan	T&S	Native (NE)

Family	Scientific Name	Common Name	Growth Habit	Endemicity
Cyatheaceae	*Cyathea contaminans*	Tree fern	F	Native (NE)
Cyperaceae	*Cyperus flabelliformis*	Umbrella grass	G&GLP	Native (NE)
Datiscaceae	*Octomeles sumatrana*	Binuang	T&S	Native (NE)
Dennstaedtiaceae	*Pteridium aquilinum*	Bracken Fern	F	Native (NE)
Dilleniaceae	*Tetracera scandens*	Katmon-baging	T&S	Native (NE)
Dipterocarpaceae	*Dipterocarpus gracilis*	Panau	T&S	Native (NE)
Dipterocarpaceae	*Hopea mindanensis*	Yakal-magasusu	T&S	Native (PE)
Dipterocarpaceae	*Parashorea malaanonan*	Bagtikan	T&S	Native (NE)
Dipterocarpaceae	*Shorea almon*	Almon	T&S	Native (NE)
Dipterocarpaceae	*Shorea assamica*	Manggasinoro	T&S	Native (NE)
Dipterocarpaceae	*Shorea contorta*	White Lauan	T&S	Native (PE)
Dipterocarpaceae	*Shorea negrosensis*	Red Lauan	T&S	Native (PE)
Dipterocarpaceae	*Shorea polysperma*	Tanguile	T&S	Native (NE)
Euphorbiaceae	*Endospermum peltatum*	Bay-ang	T&S	Native (NE)
Euphorbiaceae	*Macaranga tanarius*	Binunga	T&S	Native (NE)
Euphorbiaceae	*Manihot esculenta*	Kamoteng-kahoy	T&S	Exotic
Fabaceae	*Acacia auriculiformis*	Auri	T&S	Exotic
Fabaceae	*Acacia mangium*	Mangium	T&S	Exotic
Fabaceae	*Albizia saman*	Rain Tree	T&S	Native (NE)
Fabaceae	*Bauhinia integrifolia*	Agpoi	T&S	Native (NE)
Fabaceae	*Falcataria moluccana*	*Falcata*	T&S	Exotic
Fabaceae	*Gliricidia sepium*	Kakawate	T&S	Native (NE)
Fabaceae	*Inocarpus fagifer*	Kayam	T&S	Native (NE)
Fabaceae	*Leucaena leucocephala*	Ipil-ipil	T&S	Exotic
Fabaceae	*Mimosa pudica*	Makahiya	G&GLP	Native (NE)
Fabaceae	*Pongamia pinnata*	Bani	T&S	Native (NE)
Fabaceae	*Pterocarpus indicus*	Narra (Smooth)	T&S	Native (NE)
Fabaceae	*Pterocarpus indicus* f. *echinatus*	Narra (Prickly)	T&S	Native (NE)
Fabaceae	*Senna alata*	Akapulko	T&S	Native (NE)
Fagaceae	*Lithocarpus celebicus*	Ulaian	T&S	Native (NE)
Gentianaceae	*Fagraea racemosa*	Balat buaya		Native (NE)
Graminae	*Bambusa bambos*	Kauayan-tinik	G&GLP	Native (NE)
Graminae	*Gigantochloa levis*	Bolo	G&GLP	Native (NE)
Hypericaceae	*Cratoxylum formosum*	Salingogon	T&S	Native (NE)
Hypericaceae	*Cratoxylum sumatranum*	Paguringon	T&S	Native (NE)
Lamiaceae	*Gmelina arborea*	*Gmelina*	T&S	Exotic

Family	Scientific Name	Common Name	Growth Habit	Endemicity
Lamiaceae	*Premna odorata*	Alagau	T&S	Native (NE)
Lauraceae	*Persea americana*	Avocado	T&S	Exotic
Lythraceae	*Lagerstroemia piriformis*	Batitinan	T&S	Native (NE)
Malvaceae	*Pterospermum acerifolium*	Bayog	T&S	Native (NE)
Malvaceae	*Sterculia foetida*	Kalumpang	T&S	Native (NE)
Marantaceae	*Donax canniformis*	Banban	OGDH	Native (NE)
Melastomataceae	*Melastoma malabathricum*	Malatungaw	T&S	Native (NE)
Meliaceae	*Azadirachta indica*	Neem	T&S	Native (NE)
Meliaceae	*Dysoxylum gaudichaudianum*	Igiu	T&S	Native (NE)
Meliaceae	*Sandoricum koetjapi*	Santol	T&S	Native (NE)
Menispermaceae	*Arcangelisia flava*	Panyawan	T&S	Native (NE)
Moraceae	*Artocarpus altilis*	Rimas	T&S	Native (NE)
Moraceae	*Artocarpus blancoi*	Antipolo	T&S	Native (PE)
Moraceae	*Artocarpus camansi*	Kamansi	T&S	Native (NE)
Moraceae	*Artocarpus heterophyllus*	Nangka	T&S	Native (NE)
Moraceae	*Artocarpus odoratissimus*	Marang bangohan	T&S	Native (NE)
Moraceae	*Broussonetia papyrifera*	Lapnis	T&S	Exotic
Moraceae	*Ficus balete*	Balete	T&S	Native (PE)
Moraceae	*Ficus benjamina*	Baliteng salisi	T&S	Native (NE)
Moraceae	*Ficus congesta*	Malatibig	T&S	Native (NE)
Moraceae	*Ficus minahassae*	Hagimit	T&S	Native (NE)
Moraceae	*Ficus nota*	Tibig	T&S	Native (NE)
Moraceae	*Ficus pseudopalma*	Niyog-niyogan	T&S	Native (PE)
Moraceae	*Ficus septica*	Hauili	T&S	Native (NE)
Moraceae	*Ficus ulmifolia*	Is-is	T&S	Native (PE)
Moraceae	*Neonauclea formicaria*	Hambabawud	T&S	Native (NE)
Muntingiaceae	*Muntingia calabura*	Datiles	T&S	Native (NE)
Musaceae	*Musa × paradisiaca*	Banana	OGDH	Native (NE)
Musaceae	*Musa acuminata*	Agutay	OGDH	Native (PE)
Musaceae	*Musa textilis*	Abaca	OGDH	Native (NE)
Myrtaceae	*Eucalyptus deglupta*	Bagras	T&S	Native (NE)
Myrtaceae	*Leptospermum javanicum*	Payuspos	T&S	Native (NE)
Myrtaceae	*Psidium guajava*	Bayabas	T&S	Exotic
Myrtaceae	*Syzygium malaccense*	Makopa	T&S	Native (NE)
Myrtaceae	*Xanthostemon verdugonianus*	Mankono	T&S	Native (PE)
Oxalidaceae	*Averrhoa bilimbi*	Iba	T&S	Native (NE)

Family	Scientific Name	Common Name	Growth Habit	Endemicity
Pandanaceae	*Pandanus copelandii*	Bariu	PC&P	Native (PE)
Phyllanthaceae	*Bischofia javanica*	Tuai	T&S	Native (NE)
Phyllanthaceae	*Flueggea flexuosa*	Anislag	T&S	Native (NE)
Poaceae	*Eleusine indica*	Paragis	G&GLP	Native (NE)
Poaceae	*Imperata cylindrica*	Cogon	G&GLP	Native (NE)
Poaceae	*Saccharum spontaneum*	Talahib	G&GLP	Native (NE)
Poaceae	*Zea mayz*	Mais	G&GLP	Native (NE)
Polypodiaceae	*Drynaria quercifolia*	Kabkab	E	Native (NE)
Rubiaceae	*Mussaenda philippica*	Kahoy-dalaga	T&S	Native (PE)
Rubiaceae	*Nauclea orientalis*	Bangkal	T&S	Native (NE)
Rubiaceae	*Neonauclea bartlingii*	Lisak	T&S	Native (PE)
Rubiaceae	*Neonauclea media*	Wisak	T&S	Native (PE)
Sapotaceae	*Chrysophyllum cainito*	Caimito	T&S	Exotic
Sapotaceae	*Palaquium pinnatinervium*	Tagkan	T&S	Native (PE)
Sapotaceae	*Pouteria macrantha*	Red Nato	T&S	Native (NE)
Solanaceae	*Capsicum annuum*	Sili	T&S	Exotic
Solanaceae	*Solanum torvum*	Talong-talongan	T&S	Native (NE)
Urticaceae	*Dendrocnide meyeniana*	Alingatong	T&S	Native (NE)
Urticaceae	*Leucosyke capitellata*	Alagasi	T&S	Native (NE)

The identified plants were classified into seven easily recognised groups (mainly lifeforms); namely, i) ferns (F), ii) grasses and grass-like plants (G&GLP), iii) other ground-dwelling herbs (OGDH), iv) epiphytes (E), v) vines & climbers (V&C), vi) palms, cycads and pandans (PC&P) and vii) trees and shrubs (T&S). Based on the classification, 74% were classified as trees and shrubs, comprising most of the species identified in the study area. Grasses and grass-like plants followed at 8% and the other ground-dwelling herbs as 5% of the total species (Fig. 6).

The geographical distribution of plant species has been beneficial for assessing the biodiversity values of regions, countries and islands. One particular example is the richness of the *Leptospermum-Xanthostemon*-Alstonia community over a particular island, suggesting an ultramafic soil classification of the area (Sarmiento 2018). Species confined to a particular site should be given particular conservation management strategies as they are more vulnerable to disturbance due to their narrow range (Malabrigo 2013). The figure below (Fig. 7) shows the distribution of plant species, based on endemism (Pelser et al. 2011).

Cluster Analysis

Using PAST 4.03 updated software, the hierarchical clustering of quadrats, based on the species composition and species abundance of each sampling transect, was generated

(Fig. 8). The figure shows the Bray-Curtis Similarity Index as percentage similarities amongst sampling quadrats. The Index compares the relative abundances of a community across two locations where a value of 0 indicates total dissimilarity, while the value of 1 indicates total similarity (Bray and Curtis 1957; Lee et al. 2021). Five significant clusters were formed and the majority of the quadrats, especially those located in the lower elevations, have very similar species composition (*F. moluccana*). The four cluster combinations have low similarity (few species in common), implying that each cluster combination has unique floral characteristics and is distinctive from the other clusters in species composition. The most similar quadrats are Q13 and Q24 of the third cluster, with almost 95% similarity. These two quadrats have two species in common and both are dominated by *Falcata* (*F. moluccana*). The remaining cluster is composed of sampling quadrats established in the natural forest. These quadrats have unique species composition not found in the down-, mid- and upstream sections of the sub-watershed and are dominated by *Dipterocarp* species.

The information can assist decision-makers and planners on the development of the particular areas where the quadrats were located. For instance, conversion of Q13 for other purposes will not significantly affect the overall diversity of the area since most of its species are also found in Q24. This implies that similar management strategies can be applied to related quadrat/habitats; however, it is always more important to consider the biological value of the species in the area, rather than their similarities (Malabrigo et al. 2014).

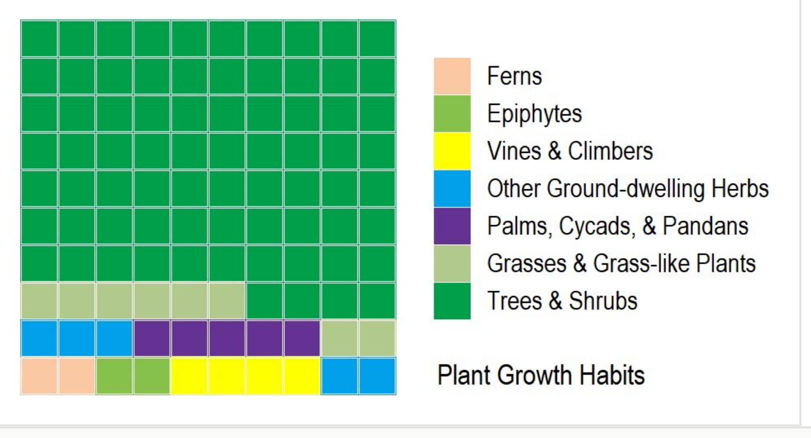

Figure 6.

Classification of plant species into groups, based on their growth habit.

Threatened Species

Nineteen species recorded from the area were listed under either the Philippine Red List (Fernando et al. 2008) or the IUCN Red List of Threatened Species (IUCN 2021). Noteworthy amongst the list were the critically endangered (CR) premium timber species

Hopea mindanensis and Pterocarpus indicus. A critically-endangered species faces an extremely high risk of extinction in the wild in the immediate future (Table 5).

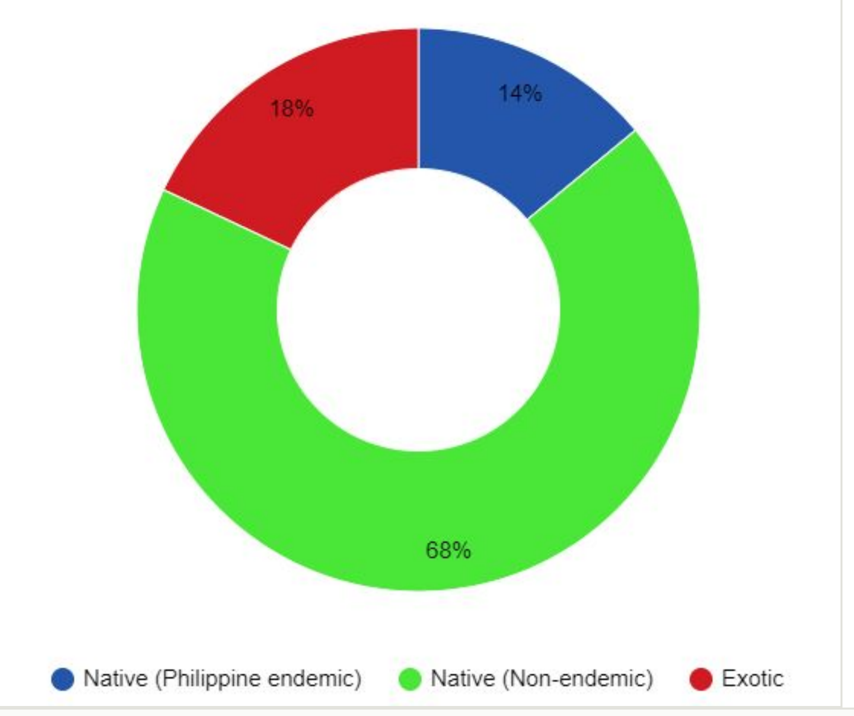

Figure 7.

Classification of plant species with reference to their ecological distribution.

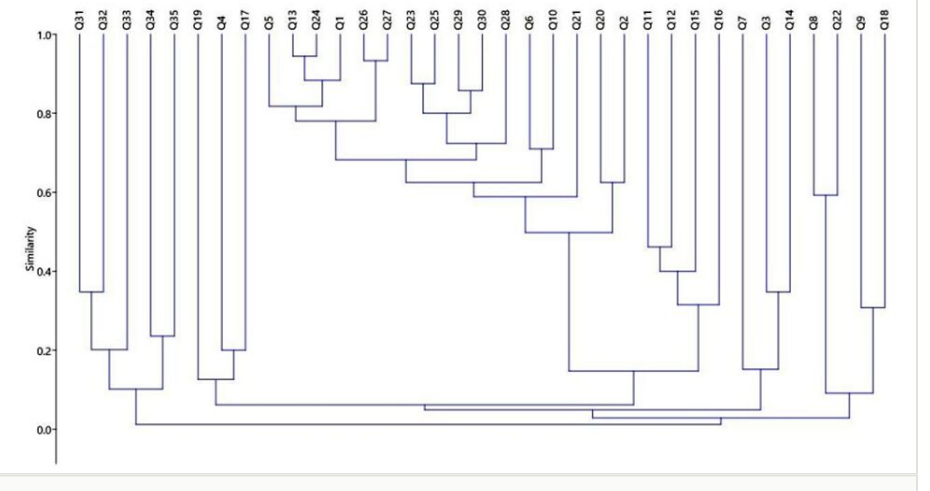

Figure 8.

Bray-Curtis Cluster Analysis of sampled quadrats.

Table 5.

List of threatened species recorded in the study area.

Taxonomic Name		Conservation Status	
Family Name	Scientific Name	Philippine Red List	IUCN Red List
Aspleniaceae	*Asplenium nidus*	VU	Not listed
Burseraceae	*Canarium ovatum*	OTS	LC
Cyatheaceae	*Cyathea contaminans*	VU	LC
Dipterocarpaceae	*Dipterocarpus gracilis*	VU	VU
Dipterocarpaceae	*Hopea mindanensis*	CR	EN
Dipterocarpaceae	*Shorea almon*	VU	NT
Dipterocarpaceae	*Shorea contorta*	VU	Not listed
Dipterocarpaceae	*Shorea negrosensis*	VU	Not listed
Dipterocarpaceae	*Shorea polysperma*	VU	Not listed
Fabaceae	*Pterocarpus indicus*	CR	EN
Fabaceae	*Pterocarpus indicus* f. *echinatus*	CR	EN
Moraceae	*Artocarpus odoratissimus*	Not listed	NT
Moraceae	*Ficus ulmifolia*	Not listed	VU
Myrtaceae	*Eucalyptus deglupta*	Not listed	VU
Myrtaceae	*Xanthostemon verdugonianus*	EN	VU
Phyllanthaceae	*Flueggea flexuosa*	VU	Not listed
Polypodiaceae	*Drynaria quercifolia*	VU	Not listed
Sapotaceae	*Palaquium luzoniense*	Not listed	VU
Sapotaceae	*Palaquium pinnatinervium*	Not listed	EN

On the other hand, vulnerable species (VU) are not critically endangered or endangered. However, they are under threat from adverse factors that will likely move to the endangered category. The *Asplenium nidus*, *Cyathea contaminans* and most *Dipterocarp* species fall in this category.

Other Threatened Species (OTS), such as *Canrium ovatum*, refer to species that are not critically endangered, endangered or vulnerable, but are under threat of adverse factors that will most likely move them to the vulnerable category in the future.

The *Xanthostemon verdugonianos*, known as the "Philippine Iron-wood," was listed as an endangered (EN) species on the Philippine Red List. An endangered species is a population of organisms at risk of becoming extinct because they are either small or threatened by changing environmental parameters, such as *X. verdugonianos* for furniture purposes.

Conclusions

The Cabadbaran River Watershed Forest Reserve is one of the primary sources of irrigation water in Agusan del Norte. However, with decades of providing irrigation water, the local irrigation office recorded a declining water yield for irrigation purposes. This can be the result of the massive disturbance happening in the watershed especially along the riparian areas. With the results of this assessment, the majority of the riparian areas were determined to have “low” to “very low” diversity values. The three sections surveyed were found out to have very similar species composition. In addition, recently, a large portion of the riparian areas were even damaged due to forest fires caused by illegal farming practices.

The area covered by this survey is only a small fraction, but the most integral section of the CRWFR. Only a few ecologically-important species were recorded and all of them are found only in the headwater forest. With the ongoing road construction in the protected area, there is no doubt that, in the near future, the fate of this ecologically-important species will be at risk similar to the rampant conversion happening in the riparian areas of the main Cabadbaran River channel.

The information generated by this study will better guide the stakeholders in formulating an irrigation water management plan. The plan should complement and enhance Agusan del Norte's already existing integrated watershed management plan in the proper management and conservation of the CRWFR.

Based on the findings of this study, the authors suggest the following recommendations to protect riparian areas better and conserve biodiversity:

1. Creation and establishment of an environment and watershed management unit that will be responsible for implementing, monitoring and evaluating the programmes/projects/activities set in the Cabadbaran River
2. Establishment, construction and operation of a central forest nursery within the local LGU level using indigenous timber-producing tree species, fruit trees and some industrial tree plantations species
3. Communication, education and public awareness for all stakeholders
4. Rehabilitation, reforestation and protection of riparian buffers especially in the degraded zones
5. Implementation of agro-forestry technologies and
6. Promotion of Agri-ecotourism activities.

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Conflicts of interest

The authors declare that there is no conflict of interest.

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