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Tree Diversity, Biomass and Carbon Stock in Quartz Mined Area of Bilikal Hillock, hunasaekatte, Bhadravathi, Karnataka, South India

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Abstract

To learn about the abandoned mined area tree diversity, aboveground biomass and carbon stock a study was conducted in quartz mined Bilikal hillock area which is geographically adjacent to Umbalebylu 8 km to Bhadra wildlife sanctuary and 10 km of Kuvempu University. In the present study 0.14ha (350 m×4m) transect, we recorded 1527 individuals comprising 22 families among them Papilionaceae with 6 genera and 7 species, Combretaceae with 2 genera and 4 species followed by Rubiaceae with 3 genera and 3 species and Apocynaceae with 2 genera and 3 species. Based on girth class assessment nearly 1564 individuals comprising 1-10 cm had 559 individuals, the basal area was more within the girth class of 40-50 cm. But aboveground biomass and carbon stock were highest within the girth class of 20-30 cm. varying with species structure and girth class were a disturbed forest patch, the species composition needs management and restoration to retain the biodiversity intact to provide a niche for other co-species.

Keywords: Aboveground biomass, Carbon stock, Diversity, Ecological indices, Girth class, Quartz hillock, Mining, Trees, Restoration, Karnataka.

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Ethical: This study follows all ethical practices during writing.

Contents

Contribution of this paper to the literature
The present study provides baseline data of tree species composition, biomass and carbon stock in the abandoned mined area, which seeks further empirical research to know variation in species composition, edaphic characters and phenology for future restoration of the mined area.

1. Introduction

Biodiversity at all levels is important to the composition, structure, and functioning of ecosystems and it provides many of the ecological services underpinning the human economy. Hence biodiversity conservation is a major concern for all organisms [1]. Based on Bell, et al. [2] the duration and quality of mining the degradation of landscapes and the impact of biological community within the geological scale varies [2]. Tropical forest communities are the biologically most complex and diverse ecosystems. The diversity is not distributed uniformly but concentrated in certain patches. The species richness, a simple measure of diversity can vary from forest types, of southern India. The highest biological and genetic diversity exists in tropical forests [3]. Covering only 7 % of the earth's land surface these forests have more than half of the worlds' species [4].

Based on forest statistics and research studies indicate, 54 % are classified as dry deciduous, and 37 % as moist deciduous [5, 6]. Dry forest biodiversity population, dynamics and conservation efforts are very rare [7] even though their ratio compares to other forest is very less and are more threatened ecosystems. To assess the structure of tropical forest diversity and dynamics permanent plots of varying sizes were monitored[8, 9]. There has been increasing interest even in documenting the long-term dynamics of tropical forests through the establishment of permanent plots. Tropical forest inventories serve as basic information for the conservation and management tools [10].

Miles, et al. [11] have shown the landmass in tropics, tropical dry forests represents 42% as they detain 110 Gt (gigatonne) vegetation carbon compared to 134 Gt carbon in tropical rainforests, Foley [12]. A huge carbon pool in the forest ecosystem is a result of high rate of terrestrial carbon cycle and high productivity [13]. Carbon storage in trees through the process of biogeochemical processes [14]. Carbon store is a result of photosynthesis and respiration, are sources of atmospheric carbon the major disturbances by natural causes and by human activities leads to become atmospheric carbon in the process of carbon cycle it restores within carbon sinks during growth can be managed to sequester or restore significant quantities of carbon in nature [15]. The atmospheric CO_2 absorption is assimilated in plant tissue in the growth of the plant Chavan and Rasal [16]. Brown [15] has described the guidelines for estimation of carbon by Intergovernmental Panel on Climate Change (IPCC) in different landscape like forest, agriculture and other land uses. The three ways in which atmospheric CO_2 can be balanced: Carbon sequestration, Carbon conservation and Carbon substitution [17]. On a global scale mitigating carbon emission the accurate way to measure carbon in forest as well as other ecosystem is gaining attention globally [15, 18]. Net source and emission of greenhouse gas resulting in changes in forest cover historically [19, 20].

Brown, et al. [21] for the accurate estimation of above ground biomass (AGB), allometric equations are important with a non destructive method by measuring the independent variables like diameter at breast height (DBH). Forests are influenced by the large-scale occurrence of wildfire, fire control, over-harvesting, collection of non timber forest products, and conversion of land to agriculture and forest and mining. The present mined area is adjacent to Bhadra wildlife sanctuary the tree flora indicates the similar composition of species as recorded by Krishnamurthy, et al. [22].

The limited studies on flora, tree biomass and carbon stock estimation in mined forests of India are limited, hence the present study describes the quartz mined area in Bhadravathi, shivamogga, Karnataka state. The floristic diversity studies based on the impact of mining and the purpose of mining on forest structure and functioning is needed for the restoration which begins with assessment hence the present study was carried with the objectives 1. To know the tree diversity and species composition of the mined hillock forest patch? 2. To know aboveground biomass and carbon stock based on girth class structure. 3. To find out the strategies in restoration of mined area.

2. Material and Methods

2.1. Origin of the Problem

Quartzite**,** usually metamorphic rock composed of firmly cemented quartz grains. Quartzites occur in various metamorphic rocks in the form of solid sheet-like bodies extending for great distances. Quartzites in which the SiO_2 content reaches 98–99 per cent are used for manufacturing Dinas, refractories, for obtaining metallic silicon and its alloys, and as a flux in metallurgy. Initially, mining activity began (the exact date is unavailable pertaining to the residents interaction it is 1970-1985) a lease granted to Vishveshwaraiah Iron and Steel Limited (VISL), Bhadravathi, Karnataka. The present mined area lay close to the dry deciduous forest of the Bhadra wildlife sanctuary and social forest (eucalyptus and acacia plantation) of Mysore paper mills, paper town, Bhadravathi. At present no mining activity (information from the residents of the surrounding two village area).

2.2. Study Area

The study was conducted during (2013-2015) in and around Bilikal mined area where the forest is partially disturbed without excavation. which is geographically adjacent to Umbalebylu forest patch 8 km and 10 km of Kuvempu University campus 13° 47' 425" N Lat, 75° 37' 394" E Long, the altitude is above 2229 feet MSL (Figure 1). Champion and Seth [23]classification characterize these forests as Southern dry mixed deciduous forests. This site receives an annual rainfall of about 100-542 mm annually spread from May to December a winter period from November-January and a dry period from February-April with a minimum and maximum temperature varying from (15.3°-30.3°; 19.3°-36.6°) during the study period. The characteristic tree species of this site are *Terminalia paniculata*, *Anogeissus latifolia*, *Tectona grandis*, and *Cassia fistula* etc.

Figure-1. Study area of quartz mined Bilikal hillock Bhadravathi, Karnataka. India.

3. Methodology

To prepare a database of plant species for the Bilikal mined area. All trees were randomly recorded within the respective transects of 350 m × 4 m, (0.1ha). Species were photographed and maintained as digital herbaria, in the Environmental Study Centre. The tree species were confirmed to the taxonomic level by referring to the various regional floras [24-27] of Karnataka, south India.

3.1. Statistical Analysis

Different ecological indices were performed to know the tree diversity as follows - Dominance, Abundance, Frequency and Diversity

The dominant species in a community are those assumed to be most important ecologically. They may be most numerous or of especially large size or high frequency of occurrence. Quantitative dominance may not automatically be translated into ecological superiority, but provides a useful way of classifying communities. For plant communities measuring dominance usually entails determining three attributes of the species in the community: density (number of stems or individuals per unit area) which is a measure of the numerical dominance relative to other species: frequency (how many samples contain individuals of a given species), which measures the commonness of the species and coverage (basal area) which is a measure of the amount of space occupied by individuals of a given species. Transect and Plot data obtained were summarized according to the standard protocols.Density, frequency and basal area (as πr^2) along with the abundance and their relative measures for each species have been calculated as follows, Magurran [28].

Density (D) = Total no. of individuals / Total no. of quadrats studied.

Abundance (Ab) = Total no. of individuals / No. of quadrats of occurrence.

Frequency (F) = No. of quadrants of species occurrence / Total no. of quadrats studied.

3.2. Measuring Species Diversity

There are a number of ways to measure diversity. The differences among them are not particularly profound. Most take into account species richness (the total number of species in the community). However, there is another aspect of species diversity that is frequently not accounted for by diversity indices, the evenness of distribution of individuals among species (also called equitability).

3.3. Alpha Diversity

Species richness - Alpha diversity is measured within the community. Scale is specified and species richness is expressed as the number of species in a given standard sample (like the number of tree species per one-hectare sample). The simplest measure of species diversity is through the use of a species richness index, which is the number of species in the community regardless of dominance Margalef's species richness index was used to assess the species richness in the present study.

Margalef's Species richness index D = (S-1) ln N

Where S= number of species, N= total number of individuals

Species richness is the easiest to understand the component of diversity, but the problem is that the actual number of species usually unknown. Species richness must be estimated by sampling the community. This, in turn, is affected by sample size and taxonomic error. The larger the sample the larger the species richness will be. We might estimate species richness by looking at the rate of increase with increasing sample size but we are assuming that the rate of increase will be constant. This may be untrue if our samples are large enough.

3.4. Equitability or Evenness

If we are using samples, the results are then affected by differences in the numbers of individuals per sample. In this case, the role of dominance versus equitability or evenness becomes a factor. In the present study, Pielou's Equitability index was calculated for knowing the evenness.

Pielou's Equitability Index $E = H^1 / \ln S$

Where S= number of species

N= total number of individuals,

H1= Shannon-Wiener Diversity index

Later ecologists introduced a second component, the evenness component into species diversity considerations. The richness and evenness components are combined into a single value, the heterogeneity index. The best known of these are the Shannon-Weiner and Simpson diversity indices which are calculated as follows.

Shannon-Weiner Diversity Index $H^1 = - \sum pi \ln pi$

Simpson'sDiversity Index D = (ni (ni-1) / (N (N-1)

Where 'ith' species = one of all the enumerated species

pi = the proportion of the 'i'th species = (ni /N)

ni = number of individuals of the 'i'th species

N = total number of individuals.

Species aggregation concentrations were studied using Simpson's Concentration dominance index.

Simpson's Concentration dominance index $Cd = E (Ni /N)^2$

Where Ni = density of the 'i' th species, N = total number of individuals.

Tree total Biomass and carbon stock of the different tree species based on varying girth classes we calculated using allometric equations developed by Brown, et al. [21]; Takimoto, et al. [29]; Khan [30]; Sundarapandian, et al. [31]. Pearson's correlation was performed with different parameters to know the significance of the available data, Zar [32].

Table-1. Tree species composition based on mined forest structure.

Total Families	22
Dominant family	Papilionaceae
Total Genera	35
Dominant genera	Terminalia spp.
Total Species	42
Dominant species	*Anogeissus latifolia*Wall.
Dominant canopy tree	*Anogeissus latifolia*Wall.
Dominant understorey tree	*Helicteres isora*L.
Total individuals	1527 - 64
Dominant individual	*Anogeissus latifolia*Wall.

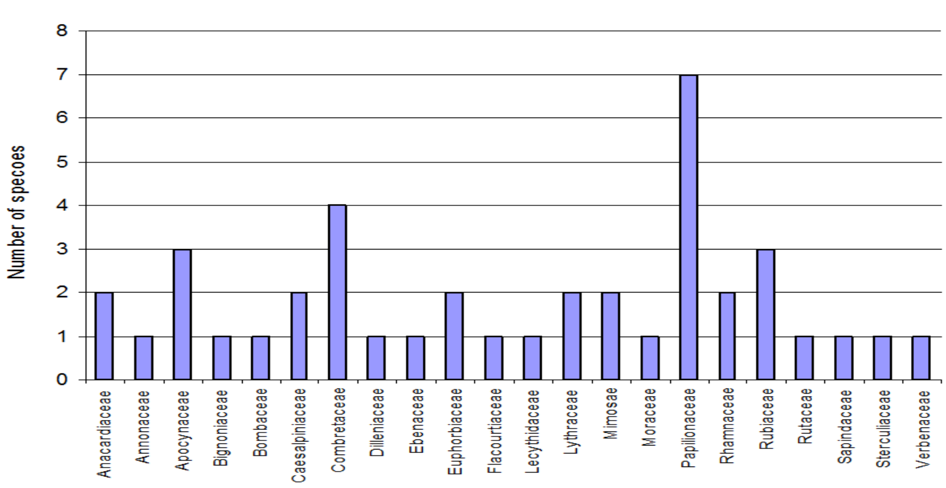

Figure-2. Proportion of families in the Bilikal quartz mined area Bhadravathi, Karnataka.

4. Results

The present study recorded a total of 1527 trees belonging to 42 species, 35 genera and 22 families during the study Table 1. Based on the diversity of distribution Papilionaceae with 6 genera and 7 species, Combretaceae with 2 genera and 4 species followed by Rubiaceae with 3 genera and 3 species and Apocynaceae with 2 genera and 3 species Figure 2.

Canopy / top storey of the Bilikal composed of *Terminalia paniculata*, *Terminalia tomentosa*, *Pterocarpus marsupium* and middle storey by *Tectona grandis*, *Dalbergia latifolia* and *Lannea coromandelica*, while in the under/lower storey *Randia dumetorum*, *Wrighitia tomentosa*, *Holarrhena antidysentrica* and *Helicteres isora* were dominant. Table 2.

Table-2. Tree species of Bilikal mined area of Hunasaekatte, Bhadravathi, Karnataka, India.

No.	Species	Family	Life-form*	Individuals	Density	Abundance	Frequency
1	*Acacia concina* (Willd.) DC.	Mimosae	Wl	12	1.71	4	0.4
2	*Adina cordifolia* (Roxb).Ridsd.	Rubiaceae	C	14	2	4.6	0.4
3	*Aegle marmelos* Corr.	Rutaceae	Us	4	0.57	4	0.1
4	*Albiziz lebbeck* Benth.	Mimosae	C	2	0.28	2	0.1
5	*Anogeissus latifolia* Wall.	Combretaceae	C	269	38.42	44.8	0.8
6	*Bauhinia malabarica* Roxb.	Caesalpiniaceae	Us	2	0.28	2	0.1
7	*Bombax malabaricum* DC.	Bombaceae	C	4	0.57	4	0.1
8	*Butea monosperma* (Lam.) Taub.	Papilionaceae	Us	10	1.42	3.3	0.4
9	*Careya arborea* Roxb.	Lecythidaceae	Us	15	2.14	2.5	0.8
10	*Cassia fistula* L.	Caesalpiniaceae	Us	1	0.14	1	0.1
11	*Dalbergia latifolia* Roxb.	Papilionaceae	C	33	4.71	11	0.4
12	*Dalbergia lanceolaria* Roxb.	Papilionaceae	C	1	0.14	0.3	0.4
13	*Dilenya pentagyna* Roxb.	Dilleniaceae	C	11	1.57	1.8	0.4
14	*Diospyrous melanoxylon* Roxb.	Ebenaceae	Us	49	7	8.1	0.8
15	*Embilica officinalis* Gaertn.	Euphorbiaceae	Us	4	0.57	4	0.1
16	*Erythrina indica* Lam.	Papilionaceae	Us	12	1.71	6	0.2
17	*Ficus bengalensis* L.	Moraceae	C	2	0.28	2	0.1
18	*Helicteres isora* L.	Sterculiaceae	Us	142	20.28	28.4	0.7
19	*Holarrhena antidysentrica* wall.	Apocynaceae	Us	116	16.57	19.3	0.8
20	*Lagerstroemia lanceolata* Wall.	Lythraceae	C	2	0.28	2	0.1
21	*Lagerstromia parviflora* Roxb.	Lythraceae	C	30	4.28	15	0.2
22	*Lannea coromandelica* (Houtt.) Merr	Anacardiaceae	C	21	3	7	0.4
23	*Mallotus phillippensis* M.Arg.	Euphorbiaceae	Us	18	2.57	18	0.1
24	*Mitragyna parviflora* Korth.	Rubiaceae	C	2	0.285	2	0.1
25	*Polyolthia cinnaroides* Hk.f.andT.	Annonaceae	Us	8	1.14	2.6	0.4
26	*Pongamia pinnata* L.	Papilionaceae	Us	2	0.28	2.6	0.1
27	*Pterosperum diversifolium* Blume	Papilionaceae	Us	15	2.14	15	0.1
28	*Pterocarpus marsupium* Roxb.	Papilionaceae	C	14	2	14	0.1
29	*Radermachera xylocarpa*	Bignoniaceae	Us	12	1.71	12	0.1
30	*Randia dumetorum* (Thunb.) Tirven.	Rubiaceae	Us	112	16	28	0.5
31	*Schleichera oleosa* (Lour.) Oken	Sapindaceae	C	2	0.28	2	0.1
32	*Scolopia crenata* Clos.	Flacourtiaceae	Us	1	0.14	1	0.1
33	*Semicarpus anacardium* L.f.	Anacardiaceae	C	15	2.14	7.5	0.2
34	*Tectona grandis* L.f.	Verbenaceae	C	251	35.85	62.7	0.1
35	*Terminalia paniculata* Roth.	Combretaceae	C	90	12.85	22.5	0.5
36	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	C	7	1	7	0.1
37	*Terminalia chebula* Retz.	Combretaceae	C	1	0.14	0.2	0.1
38	*Terminalia tomentosa* W. and A.	Combretaceae	C	106	15.14	53	0.5
39	*Wrighitia tomentosa* R.and S.	Apocynaceae	Us	87	12.42	87	0.2
40	*Wrightia tinctoria* R.Br.	Apocynaceae	Us	1	0.142	0.5	0.1
41	*Ziziphus rugosa* Lam.	Rhamnaceae	Wl	25	3.57	12.5	0.2
42	*Ziziphus oenoplia* Mill.	Rhamnaceae	Us	2	0.28	0.6	0.4

Note: *Life-form - Wl – Woody liana, C – Canopy tree, Us – Understorey tree.

A dominant among the tree composition is *Anogeissus latifolia*, (Combretaceae) with 269 individuals, density 38.42, abundance 44.8 and frequency 0.85, *Tectona grandis*, (Verbenaceae) with 251 individuals, density 35.85, abundance 62.75 and frequency 0.14, *Terminalia tomentosa* (Combretaceae) with 106 individuals, density 15.14, abundance 53 and frequency 0.5. Table 2 Tree diversity parameters are summarized in (Table 3). Diversity indices indicate that a moderate diversity in the human-disturbed area.

Based on transect the girth class, biomass and carbon stock was assessed for 1564 individuals. The number of individuals was highest within a girth class of 1-10 cm, followed by 20-30 cm, whereas basal area was highest within the girth class of 40-50 cm and total carbon stock is 0.776 t/ha, and for the present study of (0.14ha) it is 0.108 t/ha. Table 4 and Table 5.

Table- 3. Ecological indices for tree species in Bilikal mined area of Bhadravathi, Karnataka.

Parameters	Values
Taxa_S	42
Individuals	1527
Dominance_D	0.09
Shannon_H	2.77
Simpson_1-D	0.90
Evenness_e^H/S	0.38
Menhinick	1.07
Margalef	5.59
Equitability_J	0.74
Fisher_alpha	7.98
Berger-Parker	0.17

Table-4. Different girth class, basal area, biomass and carbon stock for tree species in Bilikal mined area of Bhadravathi, Karnataka.

Sl. No	Girth-class	No of individuals	No. of species	DBH (cm)	Basal area	Biomass	Carbon stock (t/ha)	Carbon stock (t/0.14ha)
1	1 – 10	559	32	1630.09	4118.05	212.84	106.42	14.89
2	10 -20	305	30	1583.24	6616.9	209.35	104.67	14.65
3	20-30	312	29	2482.81	15711.25	335.88	167.90	23.05
4	30-40	186	29	2061.24	18057.55	285.52	142.76	19.98
5	40-50	119	26	1706.36	19288.30	241.64	120.82	16.91
6	50-60	43	15	742.77	10102.14	107.06	53.53	7.49
7	60-70	17	10	345.04	5510.13	50.56	25.28	3.53
8	70-80	10	9	235.86	4372.70	35.12	17.56	2.45
9	80-100	5	4	138.14	3013.59	20.95	10.47	1.46
10	100-150	7	7	263.56	7842.04	41.50	20.75	2.9
11	>200	1	1	70.02	3851.54	11.97	5.98	0.83

Table-5. A total assessment of different parameters for tree species in Bilikal mined area of Bhadravathi, Karnataka.

Parameters	Total values	Ton/ha	0.14ha (350 x 4 mt)
DBH	11259.19	11.25919	1.57628
Basal area	98484.16	98.48416	13.7877
Biomass	1552.36	1.55236	0.21733
Carbon stock	776.181	0.77618	0.10866

Species composition and basal area indicate the present forest patch has more juvenile individuals compare to mature Figure 3 hence the restoration have greater importance in nurturing the forest ecosystem. The girth class with diameter indicates the (20-50 cm) girth class has a maximum number of basal area and carbon stock. Figure 4. Based on dbh (cm) and basal area ($r = 0.53$, $p<0.05$), basal area and biomass ($r= 0.57$, $p<0.05$), had a positive significance (Figure 5a, b). Whereas biomass and carbon stock ($r=1.0$, $p<0.01$) and dbh and carbon stock ($r=0.98$, $p<0.01$) had a strong positive significance Figure5 c, d.

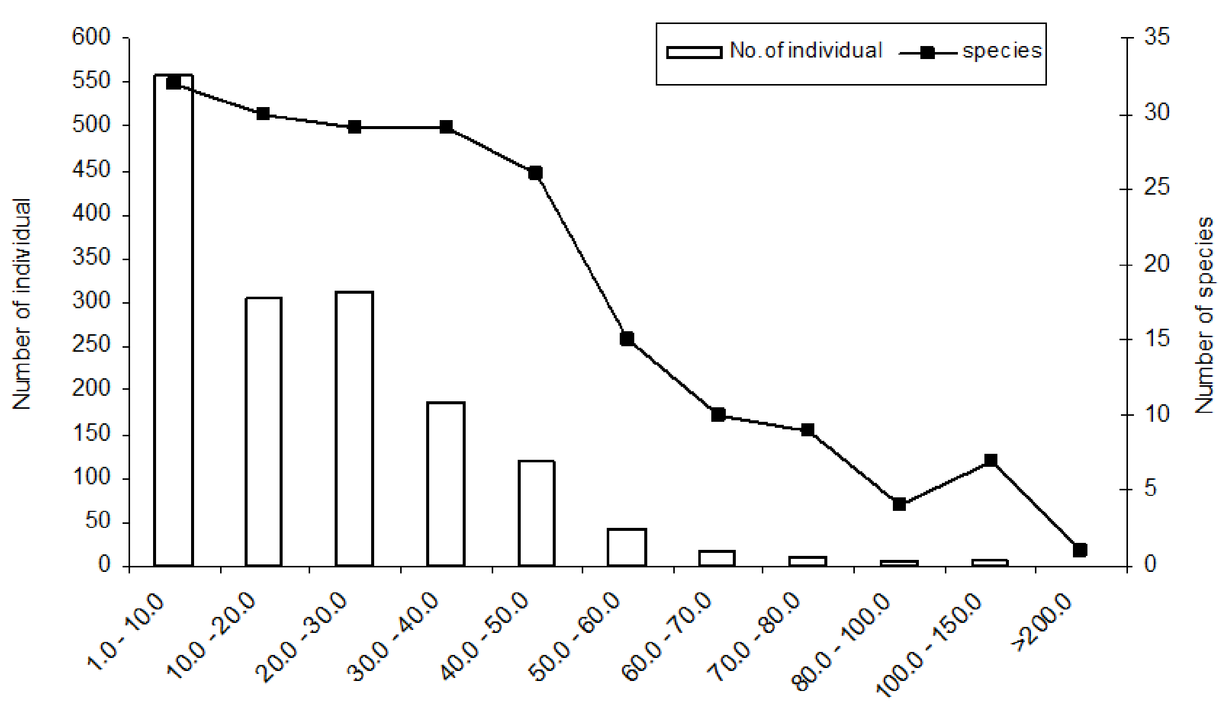

Figure-3. Number of Individual, species and girth class wise in the study area.

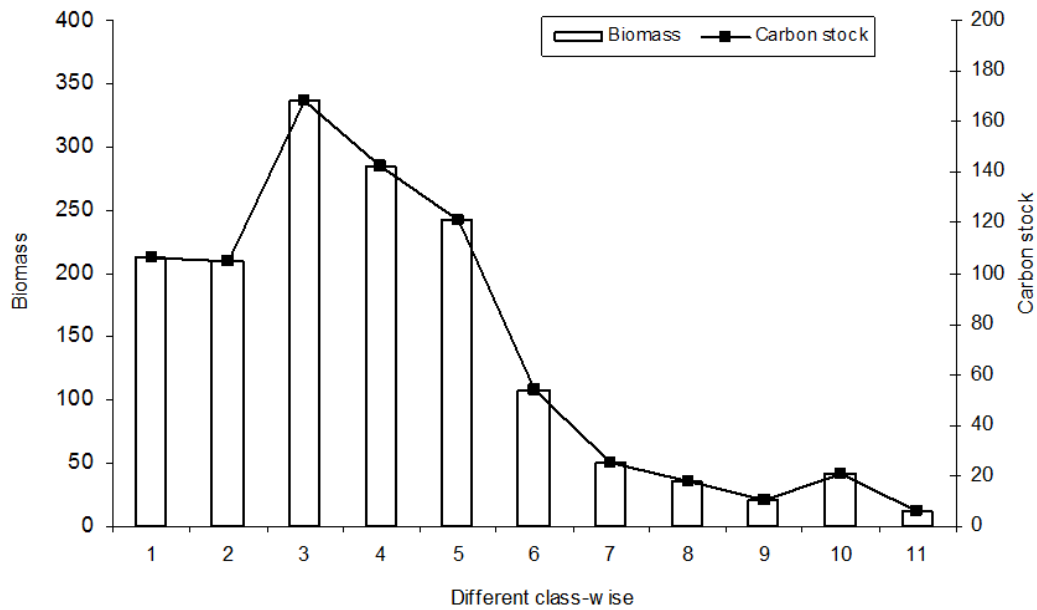

Figure-4. Biomass and Carbon stock among different girth class in the study area.

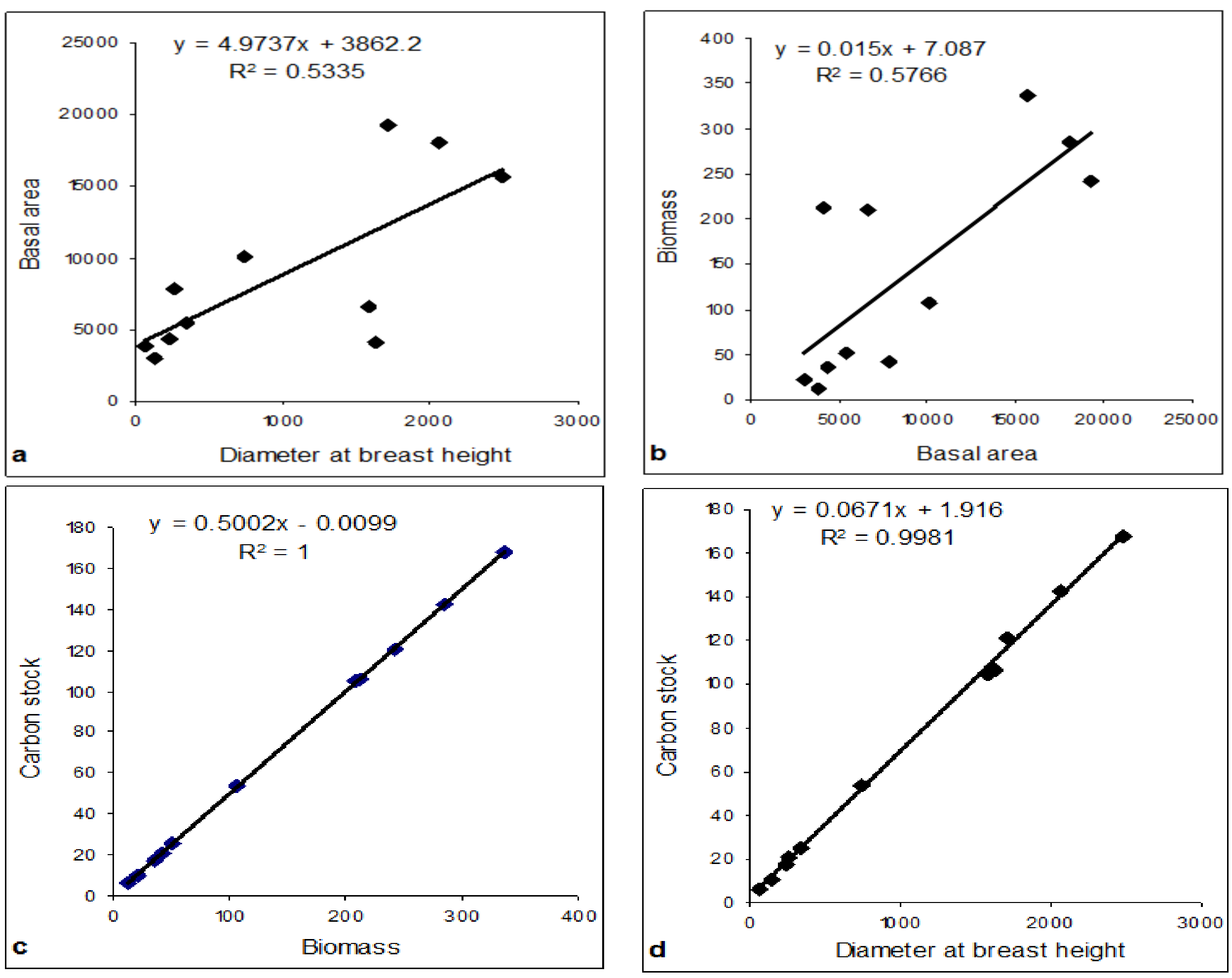

Figure-5. Relationship between (a). Diameter and basal area, (b) basal area and biomass. (c) Biomass and carbon stock, (d) diameter and carbon stock, in a quartz mined hillock area, Karnataka.

5. Discussion

The present tree species diversity is related to the quality and quantity of disturbance and the species composition structure. Wattenberg and Breckle [33] report the biodiversity of any forest is a measure of its species richness. The higher density of the small trees in the forest is likely to be related to the open canopy and low density of the larger trees [34]. In the present study highlights the species diversity based on the level of disturbance. But a higher level of disturbance gradually leads to the poorer stability of the forest [9]. This is supported by the present study that higher numbers of competent species like (*Randia dumetorum* and *Holarrhena antidysentrica*) than the tolerant species like (*Adina cordifolia*, *Aegle marmelos*, *Terminalia bellirica*, *Mitragyna parviflora* and *Embilica officinalis*). Thus the present study is concluded that stability and diversity are complementary and two central themes for the proper functioning of any ecosystem.

The sample size selected in the study area and species composition varies within and between different forest types of the earlier studies. 1527 individual trees in 0.14 ha of the present study are much higher compared to other earlier studies. Long term monitoring studies in different forest types show with 1766 trees in 2 ha permanent plot of Bhadra wildlife sanctuary, Karnataka [35] 540 tree/ha (≥ 1cm DBH) in the dry forests of Mudumalai, Tamilnadu, [36]. In KalakkadMundanthurai Tiger Reserve, 726 trees/ha [37]. In dry forests in Vindhya hill ranges and 446 trees/ha of tropical evergreen forests of VaragalairAyyappan and Parthasarathy [10]. Murali, et al. [38] study from Savanadurga State Forests of Karnataka with 30 quadrats of (25 m × 25 m) recorded 133 species.

Condit, et al. [39] lower girth class was more in the present study (i.e 43 % 794 stems), it may be due to the mortality of big trees that led to the creation of canopy gaps which helps to penetrate more solar light by supporting the level of recruitment of understory species and establish faster. Gordon and Newton [40] to minimize biodiversity loss by tropical deforestation and taking the biodiversity inventory as a tool for guiding conservation planning at a local scale by the international community especially in tropical countries where technical capacity is often limited. As this mined hillock area lies nearer to the natural dry forest of Bhadra wildlife sanctuary, the species richness and its diversity may be a chance by the dispersal mechanism of accompanying bird, and animal species. (Personal observation). Different parameters of ecological indices are in support with other tropical forest diversity studies (Krishnamurthy, et al. [35] and Murali, et al. [38]. But long term monitoring with diversity and dynamics observations are required in the present changing climate to understand species composition for the restoration of the mined area in the present study area and elsewhere.

Nearly 37 individuals fall under the category of unidentified /partially disturbed species without access to leaf, flower and fruit for the identification and confirmation of taxonomic group but living, hence those individuals assessed for carbon stock.

Daubenmire [41] research reveals that trees in the dry (deciduous) forest face loss of water resulting in a reduction in stem diameter. In the present study number individual, species composition varies with girth class; the basal area is highest within the girth class of 40-50 cm with a 119 individual, least with a girth class of 80-100 cm with 5 individuals. Whereas the highest biomass 335.88 t/ha with 312 individuals. (Figure 3).May be reduction in loss of water in the stem biomass. Haripriya [42] Biomass per hectare based on aboveground large scale inventories analysis rages from 14 to 210 Mg/ha. According to Chaturvedi, et al. [43] carbon density ranging from 15.6 to 151 t-C ha-1 in tropical dry forests of India, but at the global level the aboveground carbon density in dry forest it varies between 14 and 123 t-C ha-1, as noticed by Murphy and Lugo [44] based on the girth class it varies from 10 -200 cm carbon stock for 0.14 ha 0.83 to 23.05 tons. Carbon stock is not dependent on biomass but independent on the basal area. (Table 1).Newbery and Gartlan [45] changes in species diameter used as an indicator of population changing structure. The present study is in agreement as the mined area indicates the different girth class from 10 to > 200 cm the anthropogenic perturbation changes the forest structure its basal area and biomass varies with a number of active individuals (Table 2).

A different diameter class indicates the resource utilization by the growing forest, Krebs [46]. The different age class in the present study shows the partition of resources like water, soil, sunlight, canopy and changing strata due to mining, girth class of 20-30 cm with a 312individual had more carbon stock with less biomass than 40-50 cm girth class had less carbon holding capacity this directly attributes the significance species composition and abiotic factors. (Figure 4). The high carbon storage is recorded especially through raising plantations in Indian forests (e.g. [47-50]). But the natural species composition and structure cannot be matched or compared with the man-made plantation hence we need to know species composition, structure, biomass and carbon stock capacity in the small patches of the forest even though disturbed by humans as it helps in rehabilitation based on species growth pattern and geographical features.

The Land Use and Carbon Sequestration Model (LUCS) model and estimated that under a regular plantation forestry scenario in India, 7 Pg of carbon would be sequestered between 2000 and 2050 by Suruchi and Roma [47]. In the estimation of long term, large permanent plots the small forest patches contribution of carbon stock is unnoticed as in the present study indicates the contribution of different girth class carbon holding capacity. (Table 4). Lal and Singh [51] found that the difference in biomass productivity of natural forest cover (1.1 Mg ha−1yr−1) and plantations (3.2 Mg ha−1yr−1), the carbon sequestration potential was in the range of 1.1 and 2.7 Pg C, respectively, by the years 2020 and 2045 (cumulative carbon uptake from the atmosphere).

The major deterrent characters of carbon stock are tree species, climate, age, size class distribution etc [52, 53]. Small patches of forest, as well as disturbed and partially mined forest ecosystem, shows their real vegetation if assessed and documented helps in having a basic database to understand the future consequences.

Pearson correlation analysis indicates a positive relationship with a diameter at breast height with the basal area and with basal area and biomass (Figures 5a and b), .the similar observation is noticed from, Sundarapandian, et al. [31]. Whereas biomass and carbon stock had a strong positive relationship as well as diameter at breast height with carbon stock shows a strong positive relationship similar observation has been recorded in other tropical forests [54, 55]. The carbon sequestration capacity is high in plantation than in natural forests is due to better silvicultural management practices [50]. If the forest ecosystems are better managed based on disturbance gradient probably we can achieve better species composition, biomass and carbon sequestration with an innovative restoration practice in the coming future.

6. Conclusion

Generally, when land is surface-mined, the entire forest including shrub layer, tree canopy, rootstocks, seed pools, animals, and microorganisms is removed. After mining, the forest takes enough time to restore to its original function and structure through a series of a process called forest succession. On exploration of floristic diversity to know the abandoned mined (affected) area. We found some species are thriving well; the abandoned mined area need eco protection from tree logging, domestic animal grazing. There is an urgent need to monitor, the diversity, distribution of native, exotic, herbs, shrubs, grasses, creepers, lianas and faunal diversity of birds and animals of the area with phenological observation [56] to know how they are coping with disturbances will help in forest restoration success in India and elsewhere.

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