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Full Length Research Paper

Vascular plant diversity with special reference to invasion of alien species on the Doon University Campus, Dehradun, India

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The present study was conducted to assess vascular plant diversity in a modified habitat in Shivalik region. Extensive surveys were conducted to document the species in each season and identification was done with the help of regional floras. A total of 191 species comprising 181 species of angiosperms (176 genera and 76 families), 2 species of pteridophytes (2 genera and 1 family), and 8 species of gymnosperms (7 genera and 5 families) were observed. The dominant Angiosperms families include Asteraceae (18 genera and 18 species), followed by Fabaceae (16 genera and 18 species), Lamiaceae (8 genera and 9 species), Solanaceae (5 genera and 9 species), Amaranthaceae (7 genera and 8 species), Euphorbiaceae (4 genera and 8 species) and Apocynaceae (6 genera and 7 species). In Gymnosperms, 5 families were recorded which include family Pinaceae, Cycadaceae, Zamiaceae, Araucariaceae and Cupressaceae. In pteridophytes, only two species of the family Pteridaceae were recorded. The categorizations on the basis of species habit, 96 species were recorded as herbs, 23 shrubs, 48 trees, 14 climbers, 8 grasses and 2 species of ferns. On the basis of species economic importance, 111 species had medicinal value, 43 ornamental, 8 medicinal-edible, 8 fodder, 7 edible, 2 medicinal-ornamental, 2 edible-fodder, 1 medicinal-timber, 1 fuel-fodder, 1 fuel-timber-edible-ornamental, 1 medicinal-fiber, 1 medicinal-fuel-fodder-religious, 1 ornamental-fuel, 1 ornamental-religious, 1 condiment uses while rests of the 2 species have other uses. In terms of occurrence, 36.64% species were native, while 63.35% species were non-native. The study provides baseline information on a modified habitat in an important eco-region and would be helpful in monitoring the changes in future.

Key words: Doon University, vascular plants, life form, nativity, exotic.

INTRODUCTION

India is one of the 19 megabiodiverse countries of the world and consists of 48,158 species of plants (Anonymous, 2016) and 97,514 species of animals (Anonymous, 2016) in its ten biogeographic regions. The

Shivalik or sub-Himalayan region is the youngest and ecologically fragile mountains have been categorized under the Indo-Gangetic plains with unique significance which integrates ecosystem of Indo-Malayan and palaearctic regions (Shivkumar et al., 2010). Shivalik Himalaya ranges over a stretch of 1500 miles long and 20 to 30 miles wide from the Indus to Brahmaputra in Assam (Kohli, 2002). In Uttarakhand State, the Shivalik Himalaya covers Tarai-Bhabhar, Shivalik and lesser Himalayan zones which include the part of district Pauri, Tehri, Dehradun and Haridwar, etc (Sharma et al., 2011).

Information on floral diversity of any region is a fundamental requirement to understand ecosystem type, biodiversity pattern and other ecological qualities pertaining to natural resource management and conservation planning at local, regional and global levels (Rajendran et al., 2014). Several studies have been conducted to understand vegetation diversity and pattern of Shivalik and its adjacent areas such as Upper Gangetic plains (Raizada, 1976), Chakrata, Dehradun and Saharanpur (Kanjilal, 1979), Mussoorie (Raizada and Saxena, 1984), Shimla (Collet, 1980), Garhwal Himalaya (Gaur, 1999; Sharma, 2013), Rajaji National Park (Singh and Anand, 2002), Dehradun (Adhikari, 2008, 2010) and Binog Wildlife Sanctuary (Kumar et al., 2012). Outstanding work on economically important plant species was also done by various workers (Nadkarni, 1910; Jain, 1968; Chauhan, 1999; Prajapati et al., 2003; Rawat and Vashistha, 2011).

Invasion of alien species has been considered a significant threat to an ecosytem which trigger the alteration of ecological characteristics of a habitat. Organisms immigrating to new habitats have been specified as alien, adventative, exotic, introduced and non-indigenous (Mack et al., 2000; McGeoch et al., 2010). Invasive species may occur through accidental, import for a limited purpose and subsequently escape or persistent introduction on a large scale (Ehrenfeld, 2003). These species affect natural ecosystem structure and function (Sekar et al., 2012), although have significant ecological benefits too. Alien species differ in their nutrient requirement, mode of resource utilization which cause changes in soil structure and profile (Negi and Hajra, 2007; Raizada et al., 2008). Invasion of exotic plant species might have significant adverse changes on the biodiversity and ecosystems functioning (Sharma and Raghubanshi, 2011) which further affect the environment as well as human health (Sekar, 2012). Over the years, invasion of various alien species of diverse origin has been increased in India and reported mainly from regions like Doon valley (Negi and Hajra, 2007), Kashmir Himalaya (Khuroo et al., 2007; Khuroo et al., 2010), Uttarakhand (Tewari et al., 2010), Uttar-Pradesh (Singh et al., 2010), Himachal-Pradesh (Jaryan et al., 2013), Assam (Das and Duarah, 2013), Jammu (Kaur et al., 2014), North-Eastern Uttar Pradesh (Srivastava et al., 2014), Karnataka (Kambhar and Kotresha, 2011), Madya-Pradesh (Wagh and Jain, 2015), Delhi (Mishra et al., 2015) and Haryana (Singh and Mohammed, 2015).

Over the years, as developmental activities are continuing to modify the natural ecosystem throughout the world, native floral and faunal species are continuously decreasing with their diminishing habitat. Therefore, it is important to document the current biodiversity status (diversity, life form, habitat, use values and phenological patterns) and monitor the changes in vegetation pattern over the time. Considering these facts, the present study has been conducted to assess plant diversity within the Doon University campus which would be important to monitor the change in near future and implementation of suitable management plan.

Study area

The present study was conducted in the Doon University campus, situated in the foot hills of Shivalik mountains, lying between 30°15'60"-30°16'10" latitudes and 78°2'36"-78°2'50" longitudes with an altitudinal range of 600 to 630 m asl and covering an area of approximately 0.199 km^2 (Patwal and Naithani, 2014) (Figure 1). It is situated in a mosaic of various habitat types which includes thick deciduous forest, riverine habitat, agricultural fields and human settlements. *Tectona grandis, Shorea robusta*, *Terminalia alata*, *Anogeissus latifolia*, *Mallotus phillippensis* and *Melia azedarach* are major tree species in the forest. The riverine habitat is constituted by river Rispana which flows through eastern side of the campus and further join Song River, a tributary of the River Ganga. The average temperature remains moderate year round ranging from 35 to 40°C in the summers to 15 to 25°C in winter. The average annual rainfall recorded for the area is 2073 mm and most of the rainfall received during the month of June to September. Due to its unique location in the vicinity of different habitat types, the campus consist suitable environmental conditions to supports a variety of floral and faunal species.

MATERIALS AND METHODS

Intensive plant surveys were conducted from August 2014 to December 2015 in different seasons, floral specimens were collected from different locations and identified with the help of relevant floras, book chapters and published literature (Raizada, 1976; Kanjilal, 1979; Raizada and Saxena, 1984; Collet, 1980; Gaur, 1999; Singh and Anand, 2002; Adhikari et al., 2010; Sharma

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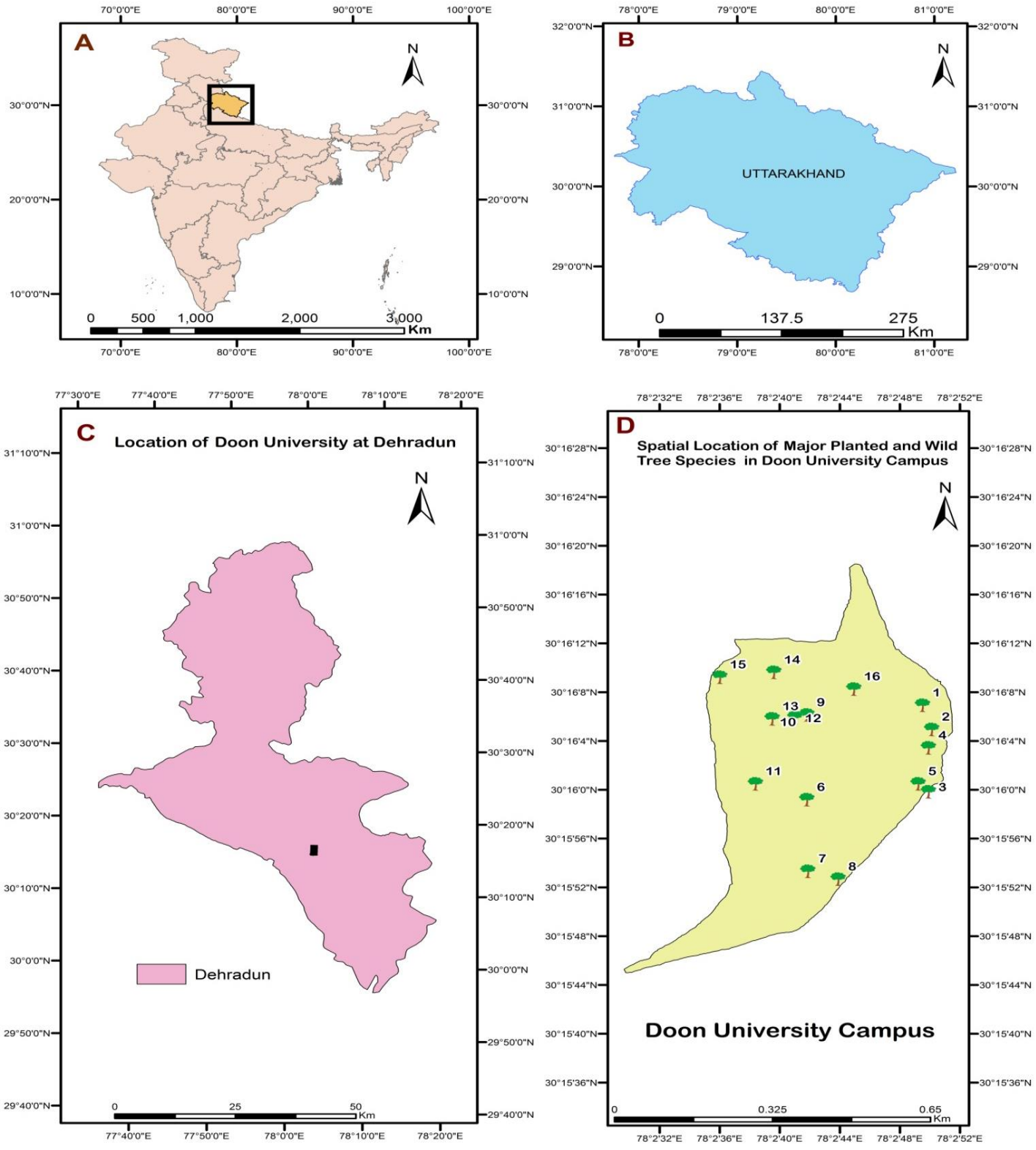

Figure 1. Location map of Doon University. A) India B) Uttarakhand C) Location of Doon University in Dehradun D) Spatial location of major planted and wild tree species in Doon University campus: 1: *Mimusops elengi* (P), 2: *Ficus benjamina* (P), 3: *Lagerstroemia indica* (P), 4: *Bambusa tuldoides* (P), 5: *Chukrasia tabularis* (P), 6: *Nyctanthes arbor-tristis* (P), 7: *Ceiba speciosa* (P), 8: *Ficus semicordata* + *Bauhinia purpurea* (W), 9: *Acacia catechu* (W), 10: *Dalbergia sissoo* + *Acacia catechu* (W), 11: *Melaleuca bracteata* + *Grevillia robusta* + *Putranjiva roxburghii*+*Jacaranda mimosifolia* (P), 12: *Dalbergia sissoo*+*Mallotus philippensis* + *Broussonetia papyrifera* (W), 13: *Erythrina crista-galli* +*Pinus roxbhurghii* (P), 14: *Neolamarckia cadamba* (P), 15: *Ficus religiosa* + *Tecoma castanifolia* + *Grevillia robusta* + *Aurocaria columnaris* (P), 16: *Magnolia champaca* + *Agathis robusta* (P). W- Wild, P- planted.

Table 1. Floristic detail of Doon University Campus.

Groups		F	G	S	T	Sh	H	Cb	G	Fn
Angiosperms	Dicots	63	148	161	39	20	89	13	--	--
	Monocots	7	19	20	2	2	7	1	8	--
Gymnosperms		5	7	8	7	1	--	--	--	--
Pteridophytes		1	2	2	--	--	--	--	--	2
Total		76	176	191	48	23	96	14	8	2

F = family, G = genera, S = species, T = tree, Sh = shrub, H = herb, Cb = climber, G = grass, Fn = fern.

et al., 2011, 2013; Rajendran et al., 2014). For each species, information was collected on local name, altitudinal range, life form, flowering and fruiting periods. Information on economic importance and plant part used was collected through formal discussion with local people working as gardner and wage labour in the campus and from various earlier studies (Nadkarni, 1910; Prajapati et al., 2003; Kumar et al., 2012; Subramanion et al., 2013). In addition, information on ornamental flora was assembled from local plant nurseries and botanical gardens in Dehradun. Additional information such as updated nomenclature of native and exotic plant species was generated through related websites like international plant name index (IPNI, 2015), the plant list (2015), encyclopedia of life (EOL, 2015), tropicos (2016) and the global biodiversity information facility (GBIF, 2015). The nativity of the invasive plants has been recorded from published literatures (Champion and Seth, 1968; Negi and Hajra, 2007; Khuroo et al., 2007; Raizada et al., 2008; Reddy, 2008; Sharma and Raghubanshi, 2008; Weber et al., 2008; Khuroo et al., 2010; Singh et al., 2010; Tewari et al., 2010; Kambhar and Kotresha, 2011; Sekar et al., 2012; Sekar, 2012; Khuroo et al., 2012; Jaryan et al., 2013; Das and Duarah, 2013; Hiremath and Sundaram, 2013; Kaur et al., 2014; Srivastava et al., 2014; Wagh and Jain, 2015; Mishra et al., 2015; Singh and Mohammed, 2015) and further categorized according to their vernacular name, English name, altitudinal range, life forms (herb, shrub, trees, grass, climber and ferns), flowering fruiting periods, plant parts (leave, root, stems, rhizomes, bark, flowers, fruits, seeds and pods). Plants were further categorized according to their economic uses such as medicinal, ornamental, edible, timber, fuel, fodder, condiments and religious. Synonyms of plant species were not included to avoid the taxonomic inflation.

RESULTS AND DISCUSSION

A total of 191 species of vascular plants (Angiosperms, Gymnosperms and Pteridophytes) belonging to 176 genera and 76 families were recorded within the campus. Among these species, 181 species were angiosperms including 161 species of dicotyledons and 20 species of monocotyledons (63 families and 148 genera), 8 gymnosperms and 2 pteridophytes. In terms of habit types, 48 tree species, 96 herb, 23 shrubs, 14 climbers, 8 grasses and rest of 2 species are belonging to ferns were recorded (Table 1). Family Asteraceae (18 genera, 18 species), Fabaceae (16 genera and 18 species), Lamiaceae (8 genera and 9 species), Solonaceae (5 genera and 9 species) were among the dominant families and are followed by Amaranthaceae (7 genera and 8 species), Euphorbiaceae (4 genera and 8 species), Apocynaceae (6 genera and 7 species), Araceae (5 genera and 5 species), Poaceae (5 genera and 5 species), Malvaceae (4 genera and 5 species) and Family Caesalpiniaceae, Verbenaceae, Moraceae, Asparagaceae (4 genera and 4 species in each families) are among the other (Figure 2). In gymnosperms, 8 species from 5 families (Pinaceae, Cycadaceae, Zamiaceae, Araucariaceae and Cupressaceae) were recorded, while 2 species of fern from family pteridaceae were recorded. Maximum flowering and fruiting period was observed in the plants throughout the year (20 species), followed by April to September (11 species), August to November (10 species), July to November (8 species), January to December (7 species), July to October (6 species), April to June (5 species), etc (Figure 3).

Economic importance of the species

Out of the recorded 191 species, all species were found to be used for various economic purpose which includes 111 (58%) medicinal, 43 (23%) ornamental, 8 (4%) medicinal-edible, 8 (4%) fodder, 7 (4%) edible, 2 (1%) medicinal-ornamental, 2 (1%) edible-fodder, 1 (1%) medicinal-timber, 1 (1%) fuel-fodder, 1 (1%) fuel-timber-edible-ornamental, 1 (1%) medicinal-fiber, 1 (1%) medicinal-fuel-fodder-religious, 1 (1%) ornamental-fuel, 1 (1%) ornamental-religious, 1 (1%) condiment uses, while rests of the 2 (1%) species have other uses (Figure 4). In terms of part used for economical and ethno-botanical value, a total of 49% species leaves are used which is followed by root 12%, fruits 12%, bark 7%, seeds 5%, stem 6%, flower 6%, tubers 2% and of 1% pods (Figure 5).

Species of medicinal value

Most of the plant species recorded from the study site are highly medicinal in nature. Some important herbaceous medicinal plants from the study site are *Acyranthus aspera* L., *Centella asiatica* (L.) Urb., *Calotropis procera* (Aiton) Dryand., *Dioscorea bulbifera* L., *Chamaesyce hirta* L., *Asperagus adscendens* Buch.-Ham.ex Roxb.,

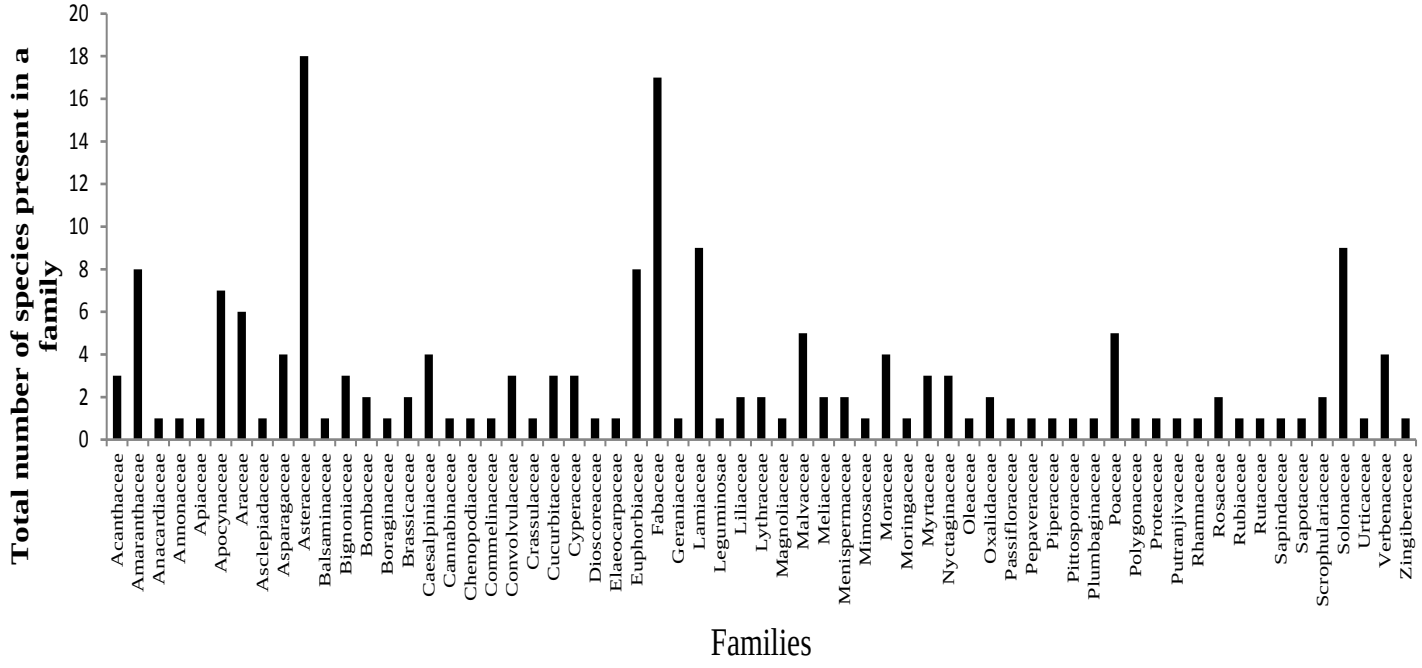

Figure 2. Distribution of vascular plants families in Doon University Campus.

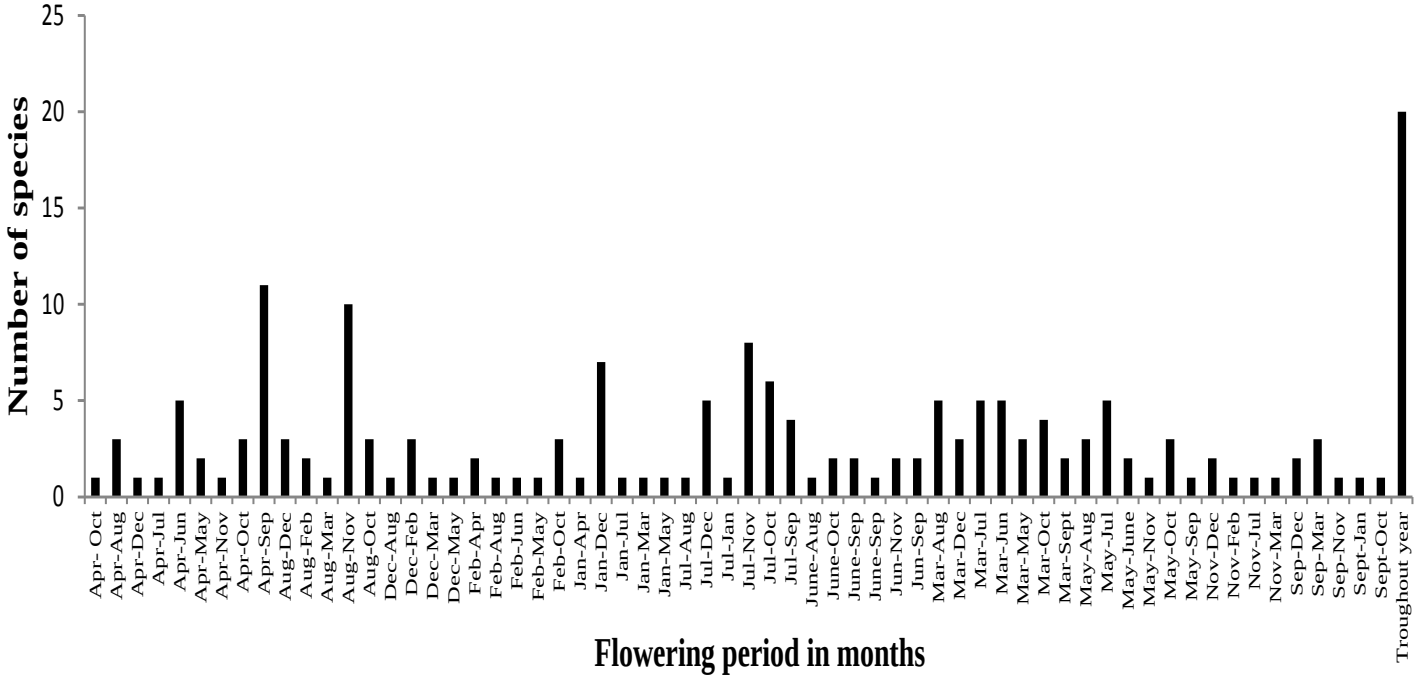

Figure 3. Phenological data on vascular plants in Doon University Campus.

Artemisia nilagrica (C.B.Clarke) Pamp., *Acmella ciliata* (Kunth) cass., *Malvestrum coromendelianum* (L.) Garcke, *Cissampelos pereira* L., *Tinospora cordifolia* (Thunb.) Miers, *Boerhavia diffusa* L., *Plumbago zeylanica* L., *Oxalis latifolia* Kunth, *Murraya koenigii* L. Sprengel, *Cymbopogon citratus* (DC.) Stapf. and *Hellenia speciosa* (J. Koenig) Govaerts. Among the woody plant species *Ficus religiosa* L., *Dalbergia sissoo* Roxb. ex DC.,

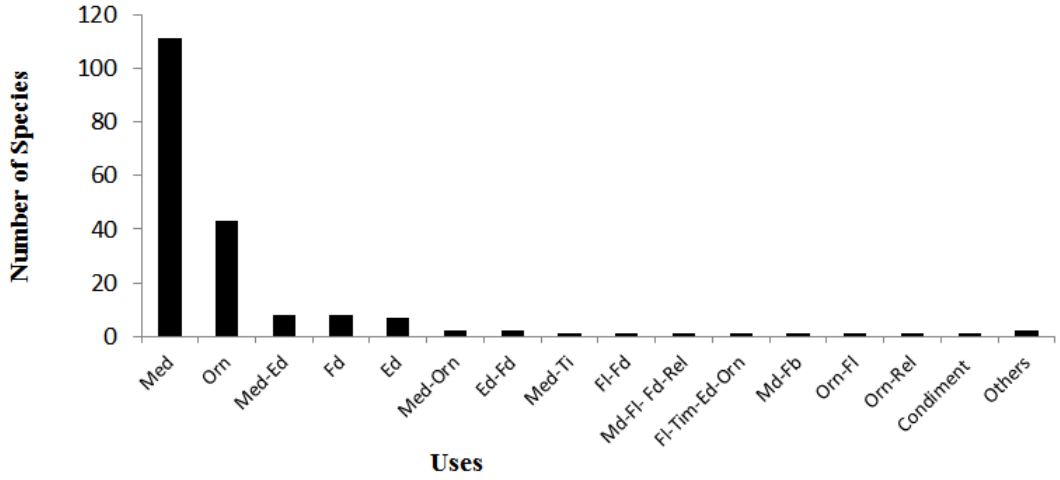

Figure 4. Distribution of different life from the aspect of use value.

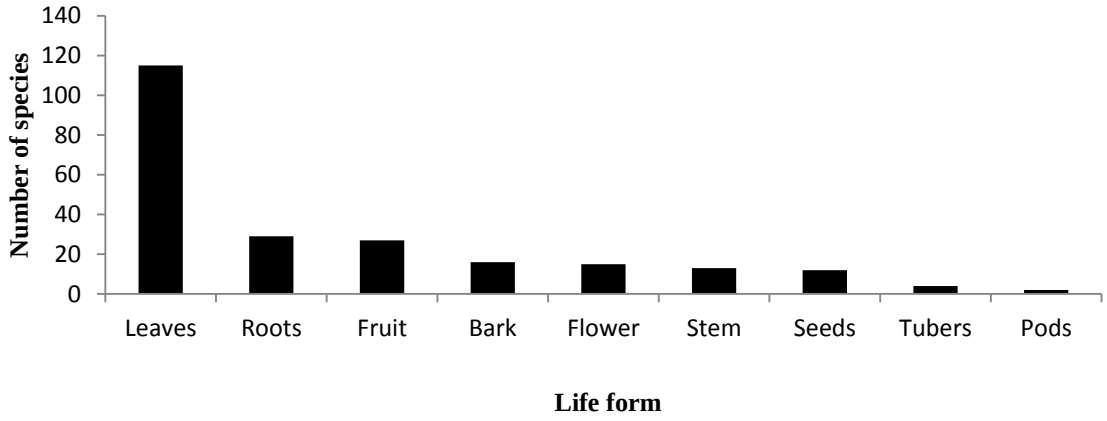

Figure 5. Number of plants species on the basis of use of plant parts.

Erythrina suberosa Roxb., *Ficus palmata* Forssk., *Moringa oleifera* Lam., *Mimusops elengi* L., *Nyctanthes arbor-tristis* L., *Chukrasia tabularis* A. Juss., *Mangifera indica* L., *Cassia fistula* L., *Phyllanthus emblica* L., *Elaeocarpus ganitrus* (Roxb.) and *Bauhinia purpurea* (L.) Benth. are important medicinal plants.

Nativity

Among the 191 recorded species, 70 (36.64%) are native, while 121 (63.35%) are non-natives or exotic species. Thus, the study reveals that the floristic diversity is dominated with exotic species and most of them are planted for ornamental purposes in the campus.

Native plant species

The native species diversity within the University campus are comparatively low. Among these species, *Barleria cristata* L., *Cryptolepis dubia* (Burm.f.) M.R. Almeida, *Cynoglossum glochidiatum* Wall. ex Benth., *Bauhinia purpurea* (L.) Benth., *Cassia fistula* L., *Cycas rumphii* Miq, *Cyperus rotundus* L., *Phyllanthus emblica* L., *Dalbergia sissoo* Roxb. ex DC., *Desmodium concinnum* DC., *Erythrina suberosa* Roxb., *Crotalaria spectabilis* Roth., *Alysicarpus pubescens* Y.W Law, *Elaeocarpus serratus* L., *Leucas cephalotes* (Roth) Spreng., *Anisomeles indica* (Linnaeus) Kuntze, *Ajuga bracteosa* Wall ex Benth., *Perilla frutescens* (L.), *Asparagus adscendens* Buch.-Ham.ex Roxb., *Chukrasia tabularis* A.Juss., *Ficus palmata* Forssk., *Ficus religiosa* L., *Ficus sarmentosa* Buch.-Ham. ex Sm., *Moringa oleifera* Lam., *Nyctanthes arbor-tristis* L., *Cynodon dactylon* (L.) Pers., *Cymbopogon citratus* (DC.) Stapf., *Putranjiva roxbhurghii* Wall., *Murraya Koenigii* L. Sprengel, *Mimusops elengi* L., *Clerodendrum infortunatum* L. and *Hellenia speciosa* (J. Koenig) Govaerts are major native plants.

Invasive plants

Major exotic invasive species include *Lantana camara* L., *Parthenium hysterophorus* L., *Ageratum conyzoides* L., and *Ricinus communis* L. and are dominant throughout the campus. Species like *Chenopodium album* L., *Bidens pilosa* L., *Amaranthus spinosus* L., *Synedrella nodiflora* (L.) Gaertn., *Galinsoga parviflora* Cav., *Sigesbeckia orientalis* L., *Tridax procumbens* L., *Xanthium strumarium* L., *Sonchus asper* (L.) Hill., *Argemone maxicana* L., *Impatiens balsamina* L., *Senna tora* (L.) Roxb., *Ipomoea quamoclit* L., *Cyperus iria* L., *Euphorbia heterophylla* L., *Chamaesyce hirta* L., *Mimosa pudica* L., *Mucuna pruriens* (L.) DC., *Sesbania bispinosa* (Jacq.) W. Wight., *Hyptis suaveolens* (L.) Poit., *Saccharum spontaneum* L., *Solanum nigrum* L., *Solanum viarum* Dunal., *Solanum torvum* Sw., *Vitex negundo* L. were among the other naturally grown exotic species.

Exotic ornamental species

Among the recorded species, 63.35% species are non-natives or exotic. Some of these species are critical to native biodiversity and its ecological and socio-economic framework. Despite the fact, non-native or exotic species generally considered as noxious. However, they also play a significant role in ecological restoration, soil conservation and generating new socio-economic prospects. The field investigation revealed that exotic plants like *Grevillea robusta* A.Cunn. ex R.Br is used for its fuel wood and aesthetic value. Some other species like *Vachellia nilotica* (L.) P.J.H. Hurter & Mabb., *Sesbania bispinosa* (Jacq.) W. Wight, *Pennisetum setaceum* (Forssk.) Chiov and *Trifolium resupinatum* L. are used as fodder species. Tree species like *Polyalthia longifolia* (Sonn.) Thwaites, *Plumeria obtusa* L., *Plumeria alba* L., *Hyophorbe lagenicaulis* (L. H. Bailey) H. E. Moore., *Agathis robusta* (C. Mooreex F. Muell.) F. M. Bailey., *Araucaria columnaris* (G. Forst.) Hook., *Jacaranda mimosifolia* D. Don., *Tecoma castanifolia* (D. Don) Melch., *Delonix regia* (Bojer ex Hook.) Raf., *Platycladus orientalis* (L.) Franco., *Pongamia pinnata* (L.) Pierre., *Magnolia grandiflora* L., *Chukrasia tabularis* A. Juss., *Ficus benjamina* L., *Melaleuca bracteata* F. Muell. and *Zamia furfuracea* L. F. in Aiton contributed to the aesthetic artistry of the university campus.

Origin of invasive species

A total of 11 geographic provinces were recorded in terms of species origin or nativity for the present study. The Tropical America contributed to the maximum percentage of species 61 (31.94%) followed by Asia (excluding Indian sub-continent) 20 (10.47%), Tropical Africa 12 (6.28%), Europe 10 (5.24%), Australia 7 (3.66%), Madagascar 5 (2.62), Eurasia 4 (2.09%), Mediteranean 2 (1.05%), Mascarene Islands 1 (0.52%), New Caledonia 1 (0.52%) and the West Indies 1 (0.52%). American continents have also contributed to majority of invasive species in other parts of India like Doon Valley and Uttarakhand (Negi and Hajra, 2007; Sekar et al., 2012), Indian Himalayan region (Sekar, 2012), Uttar Pradesh (Singh et al., 2010; Srivastava et al., 2014), Himachal Pradesh (Jaryan et al., 2013), Karnataka (Kambhar and Kotresha, 2011), Madhya Pradesh (Wagh and Jain, 2015), South Western Ghats (Aravindhan and Rajendran, 2014), Darjiling Himalaya (Moktan and Das, 2013), Tamil Nadu (Narasimhan and Arisdason, 2009).

The findings from literature and discussions with local inhabitants indicate that several invasive species are also used for various other purposes. For example, leaves of *A. spinosus* are edible and used as fodder while leaves and stem of *G. parviflora* are used for medicinal (anti-itch) as well as fodder purposes while *Tagetes erecta* is considered and used as religious plant species. A total of 67 species were reported to use for medicinal purposes by the local inhabitants and 42 exotic species planted for ornamental purposes within the campus. The economic uses of 3 species namely *Barbarea vulgaris* R.Br., *Ipomoea triloba* L. and *Pteris vittata* L. are not known (Table 2).

The vegetation pattern is crucial for the existence of various faunal species in any habitat. The unique floral diversity within the University campus provides suitable habitat to a number of wild faunal species including mammals (7), avifauna (138), reptiles (8), lepidopteron (41) and other insects (Balodi et al., unpublished). With the modification on the riverine habitat, nesting of species like Red-wattled lapwing *Vanellus indicus* has been affected and cutting of natural stand of *Acacia catechue* (L. f.) Willd. has affected nesting of Baya weaver *Ploceus philippininus*. However, one single *A. catechue* (L. f.) Willd tree holds one of the larget nesting colony (more than 150 nests from last two years) within the Doon Valley (Balodi et al., unpublished). The ornamental plant species like *Hyophorbe lagenicaulis, Jacaranda mimosifolia* D.Don., *Bauhinia purpurea* (L.) Benth., *Delonix regia* (Bojer ex Hook.) Raf., *Vachellia nilotica* (L.) P.J.H. Hurter & Mabb. *Lagerstroemia indica* (L.) Pers., *Bombax ceiba* L. *Ceiba speciosa* (A.St.-Hil.) Ravenna., *Magnolia gradiflora* L., *Grevillea robusta* A. Cunn. ex R.Br., *Putranjiva roxbhurghii* Wall., *Neolamarckia cadamba* (Roxb.) Bosser., *Mimusops elengi L.* and *Zamia furfuracea* L.F. in Aiton provide suitable nesting sites to various aviafaunal species like crows, Asian-pied sterling, kites and some other birds. Ornamental plant like *P. orientalis* (L.) Franco., is observed to be preferred by scaly-breasted munia *Lonchura puctulata* for its nesting. Various frugivorus birds' species can be observed on many ornamental plant species during the fruiting season (Balodi et al., unpublished).

Bird community structure play vital roles in seed dispersal in human-altered landscapes

Table 2. List of vascular plants in Doon University campus.

Family/Taxa	Vern./Eng. names	Altitudinal range (m)	LF	Blooming period	N/NN	Nativity	Part used	Major uses/effects
Acanthaceae								
Barleria cristata L.	Bajradanti	300-2600	H	Nov-Feb	N	S.Asia	Rt, Sd	Md (Bronchitis, pneumonia, antidote to snake bite)
Justicia procumbens L.	Karambal	700-2500	H	Dec-Mar	NN	Trop. Amer.	Lv, Rt, Sd	Md (Asthama, Cough, Backache, skin)
Dicliptera paniculata (Forssk.) I.Darbysh.	Atrilal	500-2000	H	Jul-Sep	NN	Trop. Afr.	Lv	Md (Hemorrhage)
Amaranthaceae								
Achyranthes aspera L.	Chirchira	300-2200	H	Mar-Dec	N	S.Asia	Rt, Lv	Md (Antimalarial, Dropsy, Bronchitis)
Alternanthera sessilis (L.) R.br ex DC.	Ghandugli	250-1300	H	Feb-Oct	NN	Trop. Amer.	Lv, St	Md (Eye complaints, Diarrhea Vegetables)
Bassia scoparia (L.) A.J.Scoot	Burning bush	100-2600	H	June-Oct	NN	Europe	--	Orn
Celosia argentea L.	Lal-murga	200-1500	H	Nov-Dec	NN	Trop. Amer.	--	Orn
Amaranthus viridis L.	Jungli chaulai	450-1200	H	Jan-Dec	NN	S.Amer	St, Lv	Md (Gastro intestinal disorders, Dermatological and topical diseases)
Amaranthus spinosus L.	Kantili chaulai	400-1200	H	July- Oct	NN	Trop. Amer.	Lv	Ed, Fd
Gomphrena globosa L.	Gul-e-makhmal	900-1500	H	June-Sep	NN	Trop. Amer.	--	Orn
Aerva sanguinolenta (L.) Blume	Safed fulia	400-1500	H	Apr- Oct	NN	Trop. Afr.	Rt , Lv	Md (dysentery)
Anacardiaceae								
Mangifera indica L.	Aam	300-1000	T	Mar-Jul	N	S.Asia	Fr, Lv, Bk	Md, Ed
Annonaceae								
Polyalthia longifolia (Sonn.) Thwaites	Aashupal	500-1500	T	Mar-May	N	S.Asia	--	Orn
Apiaceae								
Centella asiatica (L.) Urb.	Brahmibooti	500-2500	H	Apr-Nov	N	S.Asia	Lv	Md (Brain tonic, Sedative, antibacterial , diuretic and galactogogic activities)
Apocynaceae								
Carissa spinarum L.	Karaunda	300-1600	Sh	Apr-Jun	N	S.Asia	Fr, Rt, Lv	Ed, Fd
Cryptolepis dubia (Burm.f.) M.R.Almeida	Medasinghi	250-1500	Cb	Mar-July	N	S.Asia	Lv, Stem, Rt	Md, Fb

Table 2. Contd.

Tabernaemontana divaricata R.Br. ex Roem. & Schult.	Tagar	300-800	Sh	May-Oct	N	S.Asia	Flw, Rt	Md (Tooth ache)
Plumeria obtusa L.	Gulchin	400-1400	T	May-Aug	NN	Trop. Amer.	--	Orn
Plumeria alba L.	Gulchin	400-1400	T	Mar-Jul	NN	Trop. Amer.	--	Orn
Catharanthus roseus (L.) G.Don	Sadabahar	150-1500	H	Throughout year	NN	Madagascar	Lv, Flw	Md (Leukemia , Cancer, muscle pain, dipression)
Allamanda cathartica L.	Peeli ghanti	0-1000	Cb	May-Aug	NN	Trop. Amer.	--	Orn
Araceae								
Arisaema tortuosum (Wall.) Schott	Bagh-mungri	500-1500	H	Jun-Oct	N	S.Asia	Tb	Md (inflammation)
Colocasia esculenta (L.) Schott	Arbi	200-2200	H	May-Oct	N	S.Asia	Tb, Lv	Ed
Xanthosoma violaceum Schott	Mankand	100-6000	H	May-Nov	NN	Trop. Amer.	Tb, Lv	Ed
Monstera deliciosa Liebm.	Split leaf	50-1500	H	--	NN	Trop. Amer.	--	Orn
Hyophorbe lagenicaulis (L.H Bailey) H.E. Moore	Bottel palm	50-800	T	Mar-Aug	NN	Mascarene Islands	--	Orn
Rhapis excelsa (Thunb.) Henry	Lady palm	500-2500	Sh	Apr-Sep	NN	N.E.Asia	--	Orn
Araucariaceae								
Agathis robusta (C.Moore ex F.Muell.) F.M.Bailey	Kauri pine	400-1900	T	--	NN	Austr.	--	Orn
Araucaria columnaris (G.Forst.) Hook.	Cook's pine	100-1500	T	--	NN	New Caledonia	--	Orn
Asclepiadaceae								
Calotropis procera (Aiton) Dryand.	Aak	300-1400	Sh	Dec-May	NN	Trop. Afr.	Bk, Rt, Lv	Md (Cold, Cough and Asthama)
Asparagaceae								
Ophiopogon jaburan (Siebold) Lodd.	White lily turf	100-1800	H	May-Jul	NN	N.E. Asia	--	Orn
Sansevieria trifasciata Prain	Naagdaman	100-1200	H	Apr-Sep	NN	Trop. Afr.	--	Orn
Agave vivipara L.	Rambans	200-1000	Sh	Jul-Dec	NN	N.Amer.	--	Orn
Dracaena reflexa Lam.	Song of India	100-1500	T	June-Aug	NN	Madagascar	--	Orn

Table 2. Contd.

Asteraceae								
Cosmos sulphureus Cav.	Yello cosmos	300-1350	H	Jul-Oct	NN	N.Amer.	--	Orn
Synedrella nodiflora (L.) Gaertn.	Pig grass	500-2000	H	Apr-Sep	NN	West Indies	Lv	Md (Crushed Leaves used in rheumatism)
Cirsium wallichii DC.	Kandara	500-3000	H	Jul-Nov	N	S.Asia	Lv, Rt, Flw	Md (Dysentry, thrist. Flower extract- Spasmolytic and antiviral)
Acmella ciliata (Kunth) cass.	Beeri	500-1500	H	Aug-Dec	NN	Amer.	Lv , Flw	Md (Toothache and Oral Infections)
Ageratum conyzoides L.	Pudina ghass	900-2500	H	Jan-Dec	NN	Trop. Amer.	Lv	Md (Cancer, Nematicide, Insecticide)
Artemisia nilagirica (C.B.Clarke) Pamp.	Kujja	1500-2400	H	Jul-Dec	N	S.Asia	Lv	Md (Antimicrobial, Antifungal, Asthama, Larvicidal)
Bidens pilosa L. .	Kumar	400-1900	H	Mar-Aug	NN	Trop. Amer.	Lv	Md (Cough, Bronchitis)
Parthenium hysterophorus L.	Gajarghass	300-2000	H	Throughout year	NN	Trop. N. Amer.	Lv	Md (Cause skin allergies)
Galinsoga parviflora Cav.	Maalya	600-1900	H	Apr-Oct	NN	Trop. Amer.	Lv, St	Md (Anti-itch), Fd
Inula cappa (Buch.-Ham. ex D.Don.) DC.	Atthu	100-2500	H	Aug-Feb	N	S.Asia	Rt	Md (supperessed Urination)
Sigesbeckia orientalis L.	Lichkurra	400-2700	H	Jul-Nov	NN	S.E As.	Lv, Flw	Md (Anti-inflammatory, anti cancerous, rheumatic arthritis)
Tagetes erecta L.	Genda	800-2000	H	Throughout year	NN	S. Amer.	Flw, Lv	Md (Antiseptic , Ear pain), Orn
Tridax procumbens L.	Khalmurya	250-1500	H	Jan-Dec	NN	Trop. Amer.	Lv, St	Md (Wound healing, Antiseptic, Hemorrhage from cuts, Bruises and Wound), Ed
Xanthium strumarium L.	Golkurra	250-1600	H	Jul-Dec	NN	Europe	Lv	Md (Headache caused by wind cold ,Arthritis, Sinusitis)
Taraxacum officinale F.H. Wigg.	Dhudhi	650-2000	H	Feb-Oct	NN	Eurasia	Rt, Lv	Md (Migrane , Salads, Lv used as a vegetable, Liver detoxicant)
Sonchus asper (L.) Hill	Peeli dhudhi	300-3000	H	Mar-Sept	NN	Mediterane an	Lv, St	Md (Blood purifier, Wound and cut healing)
Sphagneticola trilobata (L.) Pruski	Cripend daisy	200-1000	H	Throughout year	NN	Trop. Amer.	--	Orn
Silybum marianum (L.) Gaertn.	Dudhpatra	300-1600	H	Mar-Aug	NN	Europe	Rt, Lv	Md (Liver complaints)
Balsaminaceae								
Impatiens balsamina L.	Gulmehandi	300-1100	H	Jul-Oct	NN	Trop. Amer.	Lv, Sd	Condiment
Brassicaceae								
Barbarea vulgaris R.Br.	Bitter cress	100-1600	H	Apr-June	NN	Europe	--	--

Table 2. Contd.

Capsella bursa-pastoris (L.)Medik.	Botlya	600-3500	H	Feb-Oct	NN	Europe	Lv	Md (Anti-haemorrhagic , anti-urtic)
Bignoniaceae								
Tabebuia rosea (Bertol.) Bertero ex DC.	Rosy trumpet tree	100-1200	T	Mar-Oct	NN	N.Amer.	--	Orn
Jacaranda mimosifolia D.Don	Neeli gulmohar	400-1200	T	Apr-May	NN	S. Amer.	--	Orn
Tecoma castanifolia (D.Don) Melch.	Tecoma	100-2200	T	Throughout year	NN	S.Amer.	--	Orn
Boraginaceae								
Cynoglossum glochidiatum Wall. ex Benth.	Lichkurra	700-2000	H	Jul-Nov	NN	E. As.	Rt, Lv, Flw	Md (Dispepsia , digestive disorders)
Caesalpiniaceae								
Bauhinia purpurea (L.) Benth.	Griwal, Kaniyar	400-1200	T	Sep-Mar	N	S.Asia, N.E.Asia	Bk, Lv, Flw	Md (Wounds, stomach, flower buds used for making vegetables and Pickels)
Cassia fistula L.	Amartas	600-1400	T	Feb-Apr	N	S.Asia	Lv , Fr	Md (Blood purifier, cough, epilepsy, dysuria, toothache)
Delonix regia (Bojer ex Hook.) Raf.	Gulmohar	450-1400	T	Apr-Dec	NN	Madagascar	--	Orn
Senna tora (L.) Roxb.	Panwar	500-1500	H	Apr-Sep	NN	Trop. S. Amer.	Lv, Sd	Md (Jaundice, skin disease, bone fracture, wounds, eczema)
Cannabinaceae								
Cannabis sativa L.	Bhaang	600-3000	H	May-Oct	NN	C. As.	Lv, Bk	Md (Astringent, tonic, aphrodisiac, intoxicating, stomachic, analgesic, inflammation, haemorrhoides and abortifacient)
Chenopodiaceae								
Chenopodium album L.	Bathua	300-4200	H	Jan-Dec	NN	Europe	Lv	Md (Oleaginous, digestive, carminative, laxative, anthelmintic, diuretic, aphrodisiac, tonic and seminal weakness)
Commelinaceae								
Commelina benghalensis L.	Kansura	300-2000	H	Jul-Nov	N	S.Asia	Lv, Rt	Md (Liver complaints, Wounds, dysentary, Swellings)
Convolvulaceae								
Ipomoea quamoclit L.	Kaamlata	300-1200	Cb	Jul-Nov	NN	Trop. Amer.	Lv, Flw	Md (Bleeding piles, Ulcers)

Table 2. Contd.

Ipomoea carnae Jacq.	Besharam	250-1000	Sh	Throughout year	NN	N. Amer.	Lv	Md (Cut and Wounds)
Ipomoea triloba L.	Little-bell	100-750	Cb	July- Oct	NN	Trop. Amer.	Lv	--
Crassulaceae								
Bryophyllum pinnatum (Lam.) Oken.	Dardmar	250-1000	H	Nov-Mar	NN	Madagascar	Lv	Md (Swelling, Cuts, Wounds)
Cucurbitaceae								
Bryonia laciniosa L.	Shivlingi	200-1500	Cb	Aug-Oct	N	S.Asia	Fr	Md (Tonic)
Cucumis melo L.	Kachri	250-1000	Cb	Jun-Nov	NN	As.	Fr	Ed
Trichosanthes cucumarina L.	Jungli chachinda	500-1000	Cb	Jul- Oct	NN	Trop. Austr.	Rt, Fr	Md (Maleria, Fever, Jaundice, Stomach problem)
Cupressaceae								
Platycladus orientalis (L.) Franco	Morpankhi	300-3000	T	Mar-Oct	NN	E. As.	--	Orn, Rel
Juniperus communis L.	Jhora	2500-3100	Sh	Sept-Oct	NN	S.E. Europe	--	Orn
Cycadaceae								
Cycas revoluta Thunb.	Kanghi palm	200-1000	T	--	NN	S. Japan	--	Orn
Cycas rumphii Miq	Sago-palm		T	--	N	S.Asia	--	Orn
Cyperaceae								
Kyllinga brevifolia Rottb.	Nirvishi	300-1500	G	Aug-Nov	NN	Afr., Madagascar	Rt	Md (Cold, bronchitis, malaria, intestinal problems)
Cyperus iria L.	Agarmotha	250-1500	G	Sep-Dec	NN	Trop. Amer.	Rt	Md (Rheumatism)
Cyperus rotundus L.	Motha	300-2400	G	July-Dec	N	S.Asia	Lv, Rt	Md (Diaphoretic, astringent)
Dioscoreaceae								
Dioscorea bulbifera L.	Genthi	300-2200	Cb	Jul-Nov	N	S.Asia	Tb	Md (Rheumatism, Asthama, Stomach pain, Body muscle mass, Cough)
Euphorbiaceae								
Phyllanthus emblica L.	Aamla	150-1400	T	Mar-May	N	S.Asia	Fr	Md (Anti aging, cold, diabetes, anti-inflammatory, blood-purifier)
Euphorbia prostrata Aiton	Dhudhi	400-1300	H	Jan-Dec	NN	Trop. Amer.	Lv	Md (Constipation, dysentery)
Euphorbia heterophylla L.	Dhudhi	750-1200	H	Feb-Aug	NN	Trop. Amer.	Lv	Md (Constipation, body pain, fish poison)
Chamaesyce hirta L.	Dhudhi	300-2000	H	Jan-Dec	NN	Trop. Amer.	Lv	Md (Asthama, Lactification, Warts)

Table 2. Contd.

Euphorbia milii Des Moul.	Crown of thorns	200-1800	Sh	Throughout year	NN	Madagascar	--	Orn
Ricinus communis L.	Arandi	300-2500	Sh	Mar-Dec	NN	Trop. Afr.	Sd, Lv and Rt	Md (Skin disease, Constipation, Headache, Burns, Purgative)
Mallotus philippensis (Lam.) Müll.Arg.	Kamala, Raini	300-1800	T	Sep-Nov	N	S.Asia	Fr, Sd, Rt	Md (Rhumatism, Boils , dysentery, Vermifuge, Constipation)
Phyllanthus ninuri L.	Bhoomi amlaki	250-800	H	July-Sep	NN	E. As.	Lv	Md (Hypoglycemi, hypotensive, diuretic, antioxidative, and anti-inflammatory, Jaundice, Kidney ailments)
Fabaceae								
Crotalaria medicaginea Lam.	Van methi	500-1000	H	Apr-Aug	NN	As.	Lv	Md (Scabies, urticaria)
Dalbergia sissoo Roxb. ex DC.	Shisham	400-1500	T	Mar-Jun	N	S.Asia	Lv, St	Md (Leprosy and skin diseases),Fd
Desmodium concinnum DC.	Saakina	900-2200	H	Aug-Nov	N	S.Asia	Lv, St	Fl, Fd
Mimosa pudica L.	Laajwanti	400-1200	H	Jul-Jan	NN	S.Amer.	Lv	Md (Fever, headache, epilepsy, kidney diseases)
Pongamia pinnata (L.) Pierre	Karanj	Upto 1000	T	Apr-May	NN	As.	--	Orn
Vachellia nilotica (L.) P.J.H. Hurter & Mabb.	Kikar	100-2000	T	Jun-Sep	NN	Austr.	Lv	Fd
Acacia catechu (L. f.) Willd.	Khair	200-1400	T	May-Aug	N	S.Asia	Lv, Wd, Bk	Md, Fl, Fd, Rel
Erythrina suberosa Roxb.	Madaru	300-1500	T	Mar-Sept	N	S.Asia	Bk, Lv, St	Md (Gonorrhoea)
Desmodium triflorum (L.) DC.	Motha, Kudaliya	600-2300	H	Jul-Sep	NN	Trop. Amer.	Lv	Md (Body pain, Breast pain, toothache)
Crotalaria spectabilis Roth.	San	200-1200	H	Sep-Mar	N	S.Asia	Lv	Fd
Alysicarpus pubescens Y.W Law	Durangi	20-1200	H	Mar-Aug	N	S.Asia	Lv	Fd
Indigofera astragalina DC.	Ran-methi	800-1500	H	Aug-Nov	NN	Trop. Amer.	Lv , Rt	Md (Skin diseases, insect repellent)
Vigna unguiculata (L.) Walp.	Lobhia	300-1500	Cb	Apr-Aug	NN	Europe	Pods, Sd	Ed
Canavalia ensiformis (L.) DC.	Badi sem	400-1200	Cb	Apr-Oct	NN	S.E. As.	Pods, Sd	Ed
Cicer arietinum L.	Chana	150-1300	H	Feb-Apr	N	S.Asia	Fr, Lv	Md (Use in constipation and nervous disorders)
Mucuna pruriens (L.) DC.	Gauchii	150-1200	Cb	Jul-Nov	N	S.Asia	Lv	Fd
Trifolium resupinatum L.	--	500-2500	H	Mar-May	NN	Eur., As.	Lv	Fd
Melilotus indicus (L.) All.	Banmethi	500-2000	H	Jan-May	NN	Eurasia	Sd , Lv	Md (Bowl complaints and Infentile diarrhoea, also use as insect repellent)
Elaeocarpaceae								
Elaeocarpus ganitrus (Roxb.)	Rudraksha	400-1300	T	Aug-Nov	N	S.Asia	Bk , Lv, Sd	Md (Antihypertensive, antidiabetic, antifungal, antihypertensive, antioxidant, anxiolytic, analgesic and anti-inflammatory)

Table 2. Contd.

Leguminosae								
Sesbania bispinosa (Jacq.) W.Wight	Dencha	300-1000	H	Sept-Jan	NN	Trop. Amer.	Lv	Fd
Geraniaceae								
Geranium rotundifolium L.	Ratan jot	900-1400	H	Feb-Jun	NN	Europ, As. bor.	Lv	Fd
Leucas cephalotes (Roth) Spreng.	Bishkapru	250-1700	H	Throughout year	N	S.Asia	Lv	Md (Diarrhoea, wounds, sking problems, malaria, cold, cough, infections)
Hyptis suaveolens (L.) Poit.	Jungli tulas	500-2000	H	Aug-Feb	NN	Trop. Amer.	Lv	Md (Anthelmintic)
Anisomeles indica (Linnaeus) Kuntze	Kala-branga	300-2200	H	Aug-Nov	N	S.Asia, S.E. Asia	Lv	Md (Blood purifier, Muscular pain, fever, cuts and wounds)
Mentha arvensis L.	Vilayati pudina	700-2000	H	Apr-June	NN	Europ, As. bor.	Lv	Md (Treating vomiting and digestion)
Ocimum basilicum L.	Marua	250-1500	H	Jul-Dec	N	S.Asia	Lv , St	Md (Cold, Fever, headache, incecticidal, Kidney stones)
Ajuga bracteosa Wall ex Benth.	Neelkanthi	700-1200	H	Apr-Sep	N	S.Asia	Lv	Md (Tonic, astringent , febrifuge , Leaf extract used in malaria)
Ocimum americanum L.	Tulsi	300-2000	H	Throughout year	NN	Trop. Afr.	Lv	Md (Insecticidal properties)
Perilla frutescens (L.)	Bhangjeer	300-3000	H	Jul-Oct	N	S.Asia	Lv , Sd	Md (Flavoring agents, rheumatic arthritis, cough, asthama)
Salvia splendens Sellow ex Schult.	Morokli	300-1800	H	Apr-Sep	NN	S. Amer.	--	Orn
Liliaceae								
Aloe vera (L.)	Ghritkumari	700-1400	H	Sep-Mar	NN	Mediterane an	Lv	Md (Fresh Leaves is use for Wounds and Sores, Plant extract is use for stomachic, purgative, anthelmintic)
Asparagus adscendens Buch.-Ham.ex Roxb.	Shatawar	300-2000	H	Aug-Nov	N	S.Asia	Rt	Md (Aphrodiasic, glactogauge, Dysentry, laxative, diarrhoea, laprosy)
Lythraceae								
Cuphea hissisifolia Kunth	Maxican heather	300-2000	Sh	Apr-Sep	NN	Trop. Amer.	--	Orn
Lagerstroemia indica (L.) Pers.	Saawni	1000-1500	T	May-Aug	N	N.E.Asia	Sd, Bk Rt, Fr	Md (Febrifuge, Narcotic, Stimulant and purgative)
Bombaceae								
Bombax ceiba L.	Semal	400-1600	T	Jan-Mar	N	S.Asia	Flw	Md (Chiken pox, leprosy, anaemia, asthama, digestive disorders)

Table 2. Contd.

Ceiba speciosa (A.St.-Hil.) Ravenna	Resham rui	400-1600	T	Feb-May	NN	N.Amer.	--	Orn
Magnoliaceae								
Magnolia gradiflora L.	Him-champa	60-700	T	May-July	NN	N.Amer.	--	Orn
Malvaceae								
Hibiscus rosa-sinensis L.	Mandar, Gurhal	400-700	H	Throughout year	NN	N.E.Asia	Bk, Flw	Md (Emolient, antifertility, kidney problems, menstrual, fever)
Malvastrum coromandelianum (L.) Garcke	Kharenti	300-1500	H	Throughout year	NN	Trop. Amer.	St, Lv	Md (Dysentery , wounds)
Urena lobata L.	Unga	400-1600	H	Aug-Nov	NN	Trop. Afr.	Lv, Flw, Rt, Bk	Md (Rheumatism, Diarrhoea)
Hibiscus mutabilis L.	Gul-e-ajaib	200-1200	Sh	Aug-Oct	NN	N.E.Asia	--	Orn
Abelmoschus esculentus (L.) Moench	Bhindi	200-1900	H	Jun-Nov	NN	Trop. Afr.	Fr, Sd	Md (Dysentery, fever), Ed
Menispermaceae								
Cissampelos pereira L.	Gindaru	600-3000	Cb	Apr-Sep	N	S. Amer.	Rt, Lv	Md (Cough, dysentery, piles)
Tinospora cardifolia (Thunb.) Miers	Giiloe	600-1600	Cb	Mar-June	N	S.Asia, N.E.Asia	St, Lv	Md (Urinary problems, fever, blood purifier, anti malarial)
Meliaceae								
Toona ciliata M.Roem.	Toon	300-1000	T	Mar-Jul	NN	Austr.	Flw,Bk, Wd	Md (Astringent, tonic,antiperiodic), Tim
Chukrasia tabularis A.Juss.	Chikrasi	400-900	T		N	S.Asia	--	Orn
Mimosaceae								
Calliandra haematocephala Hassk.	Red powder puff	250-1100	T	Apr-Jul	NN	Trop. Amer.	--	Orn
Urticaceae								
Broussonetia papyrifera (L.) L'Hér. ex Vent.	Jungli toot	250-1000	T	Mar-Jun	NN	N.E.Asia	Lv	Md (Liver kidney tonic,blood purifier, impotency, eczema, gonorrhea)
Moraceae								
Ficus benjamina L.	Pukar ped	250-1400	T	Apr-Aug	NN	N.E.Asia	--	Orn
Ficus palmata Forssk.	Bedu	600-2300	T	May-Jun	N	S.Asia	St, Fr	Md (Stomach complaints, sores, constipation)

Table 2. Contd.

Ficus religiosa L.	Peepal	500-1800	T	Apr-Sep	N	S.Asia	Fr, St , Bk	Md (Mouth wash , curing tootache, weak gums, blood purifier, cough, urine problems)
Ficus sarmentosa Buch.-Ham. ex Sm.	Beduli	400-1400	Sh	Feb-May	N	S.Asia, N.E.Asia	Fr,Lv	Md (Fractrue of bones , Lactation)
Moringaceae								
Moringa oleifera Lam.	Senjna	150-1100	T	Jan-Apr	N	S.Asia	Lv, Flw, Fr	Md (Rheumatism and circulatory disorders), Ed
Myrtaceae								
*Melaleuca bracteata*F.Muell.	Golden bottel brush	300-750	T	Apr-Sep	NN	Austr.	--	Orn
Syzygium cumini (L.) Skeels	Jaamun	400-1000	T	Mar-Jul	N	S.Asia	Lv, Fr, Lv, Bk	Md (Digestive problems, cough, dysentery, blood purfier, asthama)
Psidium guajava L.	Amrud	400-1200	T	Apr-June	NN	Trop. Amer.	Fr, Lv	Md (Heart and brain tonic, illusions, abdominal pain, fatigue)
Oleaceae								
Nyctanthes arbor-tristis L.	Harchringar	300-1500	T	Aug-Mar	N	S.Asia	Lv, Bk, Fr	Md (Skin disease, sores, cough, wounds, blood purifier, ulcers)
Nyctaginaceae								
Boerhavia diffusa L.	Punarnarva	600-2000	H	Aug-Dec	N	S.Asia	Rt, Lv	Md (Asthama, high blood pressure, eye ailments, snake bite, Jaundice, urinary disorders), Ed
Mirabilis jalapa L.	Gulabans	460-1800	H	Aug-Dec	NN	S.Amer.	Rt , Lv	Md (Diuretic, purgative, anti-inflammatatory)
Bougainvillea spectabilis Willd.	Bauganvillia	150-2500	Sh	Throughout year	NN	S. Amer.	--	Orn
Oxalidaceae								
Oxalis latifolia Kunth	Khattmeethi	600-2000	H	May-Jul	NN	N.Amer.	Lv	Md (Urinary tract infection, kidney problems, cuts, skin infection , and digestive disorders)
Oxalis corniculata L.	Khattibooti	300-2900	H	Throughout year	NN	Europe	Lv	Md (Insect bites, appetite, diarrhea, piles, fever, skin diseases, stomachache), Ed
Passifloraceae								
Passiflora foetida L.	Gharibel	100-1200	H	Mar-June	NN	S.Amer.	Lv, Sd	Md (cold, cough)
Pepaveraceae								
Argemone maxicana L.	Satyanaashi	300-1700	H	Apr-Oct	NN	S. Amer.	Sd	Md (Malaria)

Table 2. Contd.

Piperaceae								
Peperomia pellucida (L.) Kunth	Toyakand	200-2000	H	Sep-Dec	NN	Trop. S.Amer.	Lv	Md (Headache, fever, eczema, abdominal pain and convulsions)
Pinaceae								
Pinus roxburghii Sarg.	Cheer	1100-2500	T	Mar-Jun	N	S.Asia	Lv,Wd	Fl, Tim, Ed, Orn
Pittosporaceae								
Pittosporum tobira (Thunb.) W.T. Aiton	Piittosporum	-	Sh	Apr-June	NN	N.E.Asia	--	Orn
Plumbaginaceae								
Plumbago zeylanica L.	Chitrak	500-2500	H	Mar-Dec	N	S.Asia	Rt	Md (Skin diseases, wounds, anti fertility, eczema)
Poaceae								
Bambusa tuldoides Munro	Buddha's-belly	Upto 1400	G	--	NN	N.E.Asia	--	Orn
Cynodon dactylon (L.) Pers.	Drub	200 - 2600	G	Jan-Dec	N	S.Asia	Lv	Md (Plant believes as religious, Root juice is taken in fever and internal injury)
Saccharum spontaneum L.	Kaans	200-1700	G	Aug-Nov	N	W. As	Lv, Rt	Md (Astringent, emollient, diuretic, purgative, dyspepsia, burning sensations, respiratory, Tropubles)
Pennisetum setaceum (Forssk.) Chiov.	Fountain-grass	300-2700	G	Aug-Nov	NN	E. Afr.	--	Fd
Cymbopogon citratus (DC.) Stapf.	Lemon-grass	550-2100	G	Jul-Sep	N	S.Asia, N.E.Asia	Lv	Md (carminative, depressant, antibacterial, antifungal, analgesic, stimulant)
Polygonaceae								
Persicaria capitata (Buch.-Ham. ex D.Don.)	Kaaflia	600-2500	H	Jan-Jul	NN	As.	Rt	Md (Boils , Dysentery)
Proteaceae								
*Grevillea robusta*A.Cunn. ex R.Br.	Silver-Oak	760-2000	T	Nov-Dec	NN	Austr.	--	Orn, Fl
Pteridaceae								
Adiantum caudatum L.	Mayur shikha	400-2000	Fn	--	N	S. As.	Lv	Md (Skin ailments, asthama, fever, bronchitis)
Pteris vittata L.	--	500-2600	Fn	--	N	S. As.	Lv	--

Table 2. Contd.

Putranjivaceae								
Putranjiva roxbhurghii Wall.	Putrjeev	400-1500	T	Mar-Aug	N	S.Asia	Bk, Lv, Fr	Md (Rheumatism)
Rosaceae								
Prunus persica (L.)	Aaru	500-2100	T	May-Jul	NN	N.E.Asia	Fr, Bk, Lv	Ed , Md (urinary troubles, cough and cold)
Rosa indica (Linn.)	Gulab	500-3000	Sh	Apr-Sep	N	N.E.Asia	Flw	Orn, Md (Blood purifier, antimicrobial)
Rhamnaceae								
Ziziphus mauritiana Lam.	Ber	300-1300	Sh	Dec-Feb	N	S.Asia	Fr, Bk, Lv	Md (Fever, Abdominal pain and pulmonary ailments)
Rubiaceae								
Neolamarckia cadamba (Roxb.) Bosser	Kadamb	500-1100	T	May-June	N	S.Asia	--	Orn
Rutaceae								
Murraya Koenigii L. Sprengel	Karipatta	300-1600	Sh	Mar-Oct	N	S.Asia	Lv , Rt	Md (Malarial fever, stomach pain, Insecticide), Ed
Sapindaceae								
Cardiospermum halicacabum L.	Kanfudi	400-1500	Cb	Jul-Nov	N	S.Afr.	Rt, Lv, Sd	Md (Antimicrobial, antifungal, anti-inflammatory, anxiolytic, antipyretic, repiratory disorders ,urinogential problems)
Sapotaceae								
Mimusops elengi L.	Maulserri	Upto 1200	T	Dec-Aug	N	S.Asia	--	Orn
Scrophulariaceae								
Mazus pumilus Burm.f.	Mastyar	250-2000	H	Aug-Nov	N	S.Asia	Lv	Md (Burn and Stomach Pains aperients, Emmenagouge, febrifuge and tonic for jaundice)
Verbascum chinensis (Linneaus). Santapau	Gaderi tambaku	100-1300	H	Throughout year	NN	N.E.Asia	Lv	Md (Cuts , wounds, diarrhoea)
Solanaceae								
Solanum nigrum L.	Mokoe	400-1800	H	Throughout year	NN	Trop. Afr.	Lv	Md (Diarrhoea, fever, piles)
Solanum viarum Dunal	Egg-plant	500-2800	H	Throughout year	NN	Trop. Amer.	Lv, Fr, Sd	Md (Mensural disorders, Contraseptive)
Solanum torvum Sw.	Bankatia	300-1600	Sh	Nov-Jul	NN	C. Amer, S.Amer	Lv, Fr	Md (Antifungal, Antibacterial, antiulcer, antidiabetic, analgesic)

Table 2. Contd.

Solanum surattense Burm.	Kateli, Kandara	400-1600	H	Throughout year	N	S. As.	Fr, Lv	Md (Cough, cold, asthma, eye ailments, fish poison)
Datura metel L.	Dhatura	300-2000	Sh	Jul-Dec	N	S.Asia	Lv	Md (Asthma, cough, tuberculosis)
Datura stramonium L.	Dhatura	200-2200	H	May-Sep	NN	C. Amer.	Sd, Lv	Md (Insecticial properties , hair loss)
Lycopersicon esculentum Mill.	Tamatar	250-2000	H	Throughout year	NN	S. Amer.	Fr	Ed
Physalis angulata Linn.	Popati	300-1700	H	May-Jul	NN	Trop. Amer.	Lv, Rt	Md (Anticancer, antibacterial, diabetes, malaria, anemia)
Solanum melongena L.	Baingan	400-1800	H	Jul-Sep	N	S.E. As.	Fr	Ed
Verbenaceae								
Clerodendrum infortunatum L	Bhaant	Upto 1500	Sh	Dec-Feb	N	S.Asia	Lv, Rt	Md (Headache, nausea, skin diseases)
Vitex negundo L.	Nirgundi/Simalu	100-3200	Sh	Mar-Oct	N	S.Asia	St, Lv, Rt, Fr	Md (Antibacterial, anti-feedant, anti-filarial, anti-viral, anti-larval, insecticidal, anti-malarial)
Duranta erecta L.	Pegion berry	200-1600	Sh	Throughout year	NN	N.Amer.	--	Orn
Lantana camara L.	Laaltain ghass	250-2000	Sh	Throughout year	NN	Trop. Amer.	Lv	Md (Skin diseases, Yellow fever, dysentery, malaria, rheumatism, bilious fever, eczema)
Zingiberaceae								
Hellenia speciosa (J. Koenig) Govaerts	Keon	300-1500	H	Aug-Oct	N	S.Asia, S.E. Asia	Lv, Rt	Md (Purgative, astringent bronchitis, cough, constipation, cholera, headache, jaundice. Stimulant)
Zamiaceae								
Zamia furfuracea L.F. in Aiton	Cardboard palm	Upto 1500	T	--	NN	N.Amer.	--	Orn

Nativity = Afr: Africa, Amer: America, Amphig: Amphigaea, As: Asia, Austr: Australia, Geront: Gerontia, Reg Himal: Himalayan region, Ind: Indian, Madag: Madagascar,Cosmop: Cosmopolitan,Or/ Orient: Oriental, Sub Trop: Sub Tropical, Trop: Tropical, Eur: Europe, Ind: Indian, Mex: Mexico, S: South, SE: South East,Eur: Europe, Arct: Arctic,NW: North West, Bor: boreal, Temp: temperate, N: native NN: Non-natives, et: and,-- = unknown. Uses= Orn: ornamental, Md: medicinal, Fl: fuel, Fd: fodder, Ed: edible. Plant parts = Bk: bark, Lt: latex, Flw: flower, St: stem, Rt: roots, Lv: leaves, Flw: flowers Fr: Fruits, Sd: seeds, St: stems, Tb: tubers, Wd: wood. Life forms = H: herb, Sh: shrub, T: tree, G: grass, Fn: fern, Cb: climber.

(Pejchar et al., 2008) as birds are considered best dipersal agents. At a time when natural regeneration of native plant species experience challenges from climate change, land-use change, introduction of invasive species, birds play a vital role in dispersing seeds to suitable sites for regeneration (Gosper et al., 2005; Ruxton and Schaefer, 2012). However, seed dispersal of invasive species through avian communities in the important eco-regions like Shivalik could have adverse ecological consequences on the native flora.

Conclusions

The study provides baseline information on floristic diversity of a modified habitat from riverine and agricultural to concrete jungle and plantation in Shivalik landscape. These finding would be

important in monitoring the changes in vegetation pattern in the near future. At present, the exotic floras dominate the native flora and are important in terms of influencing local environmental condition of the habitat. The flowering period of plants species of different origin would help in prediction of climate change over the years and role of interaction between local environmental conditions as well as their native behavior. Regular monitoring of vegetation and scientific inputs are crucial to promote native species and proper management of floristic diversity is crucial as they provide unique habitat to more than 138 bird species (used for perching, foraging, nesting, breeding, etc) and about 41 lepidopteron species. Further studies on their beneficial uses through phyto-chemical investigation would be important to conserve the important gene flow in a managed landscape to validate and sustain their ethno-medicinal importance.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Developing competence for communities impacted by dam construction

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This paper contributes to the discussion on community competence by focusing on thirteen communities near Bui dam and Bui National Park, Ghana to address the impacts of Bui Dam construction and related resettlements through analysis of community competence. For each of these questions, further analysis was undertaken to assess the role of resettlement, ethnicity, age, livelihood type and gender. Data was gathered through multiple methods. In the design of a survey, administered to 339 respondents across the thirteen communities, document analysis and interviews were conducted to provide inputs for the survey. Community competence for this study was defined to have 4 dimensions: governance training; sustainability training; training to plan and implement; and training for participatory enabling strategies. Overall, respondents indicated low level of support for each aspect of community competence training. Villages not relocated tended to perceive these impacts less negatively, as did people of Nafana ethnicity, and people relying mainly on a farming livelihood. Age and gender had little impact. Further analysis through regression analysis was undertaken to determine the relative influence of each of these predictor variables on community competency. The multiple regression analysis indicated that regarding governance training, only one predictor variable was significant: "livelihood type" (beta = 0.296), and the overall R squared was low (0.080), but significant. Regarding sustainability training, only "livelihood type" was a significant predictor (beta = 0.310), and the overall R squared was low (0.085) but significant. Regarding capacity to plan and implement, two predictor variables were significant: livelihood type (beta=0.167), and relocate (beta=0.213). R squared was low (0.048) but significant. Regarding participatory enabling strategies, only livelihood type was significant (beta=0.070), and the overall R squared was low (0.086) but significant. It is concluded that training opportunities provided for dam impacted communities did not meet the core needs and focus of the impacted communities; because the number of training modules were few; training modules failed to focus on the core skills domains (e.g. governance, sustainability, capacity to plan and implement, and participatory enabling activities). The study showed that people perceive community competence to be decreasing on many spheres, but there is variability between households in the perceived impacts.

Key words: Community, competence, dams, resettlement, gender, age, livelihood, ethnicity, training, stress, shock.

INTRODUCTION

The struggle to address poverty persists in many developing countries (West et al., 2006; International Monetary Fund, 2012; Muruvi and Reid, 2012). However, reducing poverty is a complex undertaking. One critical but not well understood issue is the response of communities to shocks that impact on community livelihoods: such as hunger, drought, floods, and construction of dams and associated resettlements (Bennett et al., 2012). This paper explores these issues through a study of Bui dam, Ghana, and focuses on the impact of the dam on surrounding communities, and the influence of community competence on these processes.

The purpose of the paper is to understand how community competence (influences on ability of different communities to adjust to "shocks" such as dam construction) can provide support to overcome the impacts of dams and associated resettlements on livelihoods of people living near protected areas. The study focused on training because evidence (Environmental Resource Management (ERM), 2007) shows that the perceived challenges from the Bui dam and associated resettlements were new to people within the dam impacted areas. Therefore, providing training in the perceived potential challenges was the alternative for preparing people to overcome the impacts of Bui dam and related resettlements on community livelihoods.

The study covers communities near Bui National Park (BNP), Ghana perceived to be impacted by the Bui dam. BNP was formed to protect riverine vegetation around the Banda gorge, and also protect eighty species of wildlife, including 305 hippopotamus considered red-listed by the International Union for Conservation of Nature (IUCN), and of global conservation concern (GoG, 1961; Ofori-Amanfo, 2005; IUCN, 2010). The park is one of the least developed parks in Ghana and also, the only protected area in Ghana that contains a large component of relatively undisturbed riverine forest associated with wooded savannah (IUCN, 2010). BNP is rated the third largest Protected Area (PA) in Ghana, covers approximately 1812 km^2 (IUCN, 2010), and is located at 8°00´-8°25'N, 2°15'-2°30'W.

In 2007, the government of Ghana established Bui Power authority (BPA) to oversee the construction of Bui dam (Government of Ghana, 2007; Ampratwum-Mensah, 2013). At full capacity, the Bui dam is expected to impact greatly on the nature and content of natural resources; inundate 21% of Bui National Park, destroy 85 km of the bank of the Black Volta River (dammed at Bui), create 36 Islands and a 500 km reservoir shoreline; and destroy 50% of grassland, 20% of savannah woodland and 25% of the water and riverine gallery forest (ERM, 2007; Ghana News Agency, 2012).

The study therefore seeks to provide a better understanding of how community competence might provide support to overcome the impacts of dams and associated resettlements on livelihoods of people living near protected areas. The study focused on training because evidence (ERM, 2007) shows that the perceived challenges from the Bui dam and associated resettlements were new to people within the dam impacted areas. Therefore, providing training in the perceived potential challenges was the alternative for preparing people to overcome the impacts of Bui dam and related resettlements on community livelihoods.

The study therefore addresses the research objectives: i) Examine whether communities near Bui dam perceive the impacts of Bui Dam on community competency; ii) Assess the perceived impacts of Bui Dam on community competency influenced by age, gender, ethnicity, type of livelihood, and whether communities have been relocated; iii) Investigate the impacts of Bui Dam on the relationship between Bui National Park and nearby communities (Figure 1).

METHODOLOGY

The study area is located in the Districts of Banda and Bole in the Brong Ahafo and Northern regions, respectively (Ghana Statistical Service, 2014a; 2014b). Bole town with a population of 61,593 and an area of 4000 sq km is the largest town in the Bole District (Ghana Statistical Service, 2012). The Banda, Bamboi and Bole Paramount Chiefs are responsible for villages within the study area (ERM, 2007). The Banda District Assembly has 45,000 people in 33 communities. The governing systems in the area are government institutions; Chieftaincy systems; and Community Based Organizations (CBOs). CBOs include informal groups such as livelihood and cultural based groups that support socio-cultural networks in the area. But in many of the communities in the two districts, traditional leadership plays important roles in the management of people and to some extent, the regulation of basic livelihoods such as fishing and farming in the communities.

Other stakeholders such as Bui National Park (BNP) and Bui Power Authority (BPA) are responsible for managing Bui National Park and Bui Power Authority, respectively. Communities selected for the study (resettled and non-resettled) are impacted by the dam and also located in the two districts.

Many communities in the region are multi-ethnic but, the dominant people in Bole district are Gonja or Mo, and Mo and Nafana in Tain District (Stahl, 2001). Generally, livelihoods are linked to ethnic groups (Table 1) (Ghana Statistical Service, 2014c; Stahl, 2001). A variety of ethnic groups such as Gonja, Akan,

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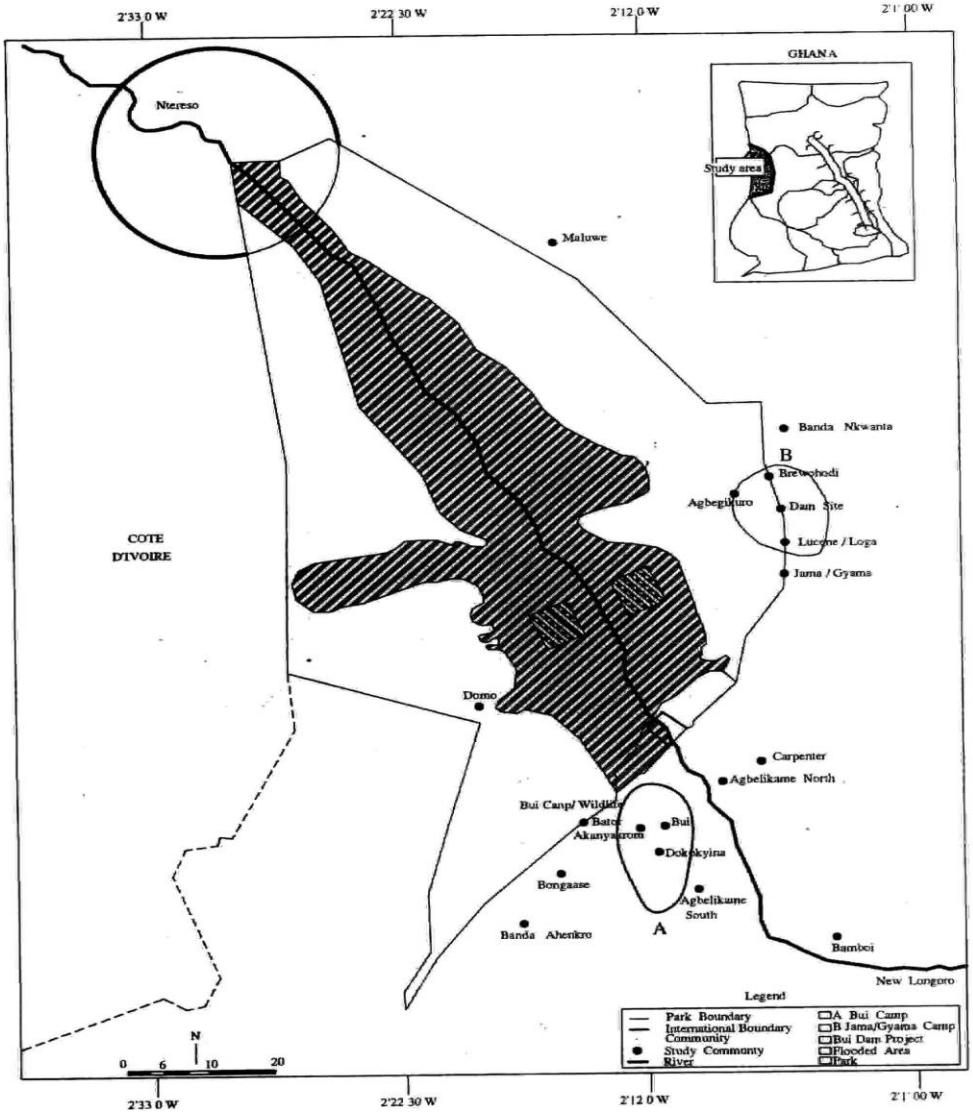

Figure 1. Map of Bui National Park with fringing villages, and inundated areas (ERM, 2007; Town and Country Planning, 2010).

Wala, Dagarti and Lobi persist in the study area (ERM, 2007; Tain District Assembly, 2012). The study placed much emphasis on the majority, that is, Ewe, Nafana, and Mo. Community livelihoods include subsistence farming, fishing, hunting, wild produce collection, charcoal burning, wage labour, processing of cassava into garri for sale, and trading but, a few (Bator, Bui, Banda Nkwanta, Tainaboi, Mempeasem and Agbelikame North and South) historically engaged in active fishing (ERM, 2007).

Thirteen communities (Table 1) were selected for the study. Seven have been displaced by the Bui dam. The other six communities will not be relocated except, Bui Camp (Wildlife village) that is currently in the process of relocation. The resettled communities are located in two camps Bui camp (containing Bator, Bui and Dokokyina), and Gyama camp (containing Dam site, Lucene, Brewohodi and Agbegikro). The resettlement created a mix of adverse negative implications such as poor compensation for lands for farming and fishing, loss of social and economic forms of livelihood available for the people in the communities nearby BNP.

Selection of these villages was shaped by the need to compare the experiences of those villages that have been relocated with the experiences of villages that have not been relocated. For example, an impact assessment has indicated that Bui dam will impact the Wildlife community; through the loss of some livelihoods such as fishing, charcoal burning, trading, and farming; loss of social facilities such as a church, clinic and school; and the loss of traditional leadership (ERM, 2007). The inclusion of the Bui Camp, Bongaase, Jama, Banda Ahenkro, Agbelikame North and South Wildlife villages in the sample was critical, because the selected will allow for a comparison with the relocated communities. Many of the communities in the study area have weak educational systems, and weak foundations in community competence such as, skills and competences to overcome stress in their livelihoods (ERM, 2007)

Table 1. List of villages around BNP inundated or isolated by the Bui dam (Stahl, 2001; ERM, 2007; Ghana Statistical Service, 2012).

Tain District						
Village	**Ethnicity**	**Major Livelihood**	**Resettled**	**Population**	**Total households**	**Sampled household**
Bui	Mo/Nafana	Farming	Yes	297	42	25
Bator	Ewe	Fishing	Yes	437	63	35
Dokokyina	Mo	Farming	Yes	165	36	20
Wildlife	Multi-ethnic	Mixed (fishing, farming, employed by BNP)	No	100	36	20
Dam site	Ewe	Fishing	Yes	36	6	5
Brewohodi	Dagarti	Farming	Yes	48	10	5
Bole District						
Lucene/Loga	Dagarti	Farming	Yes	26	4	4
Agbegikro	Ewe	Fishing	Yes	107	22	15
Jama	Mo	Farming	No	1500	154	50
Banda Ahenkro	Nafana	Farming	No	3323	unknown	50
Bongaase	Nafana		No	2797	347	50
Agbelikame North	Ewe	Fishing	No	702	70	35
Agbelikame South	Ewe	Fishing	No	209	26	15
Total	-	-	-	9,627	816	329

Literature review and theoretical framework

Dams are constructed across streams, block river flow and triggers the formation of lakes (Gilman, 2008). Dams construction have in recent past shifted from the industrialized world to developing countries (Khagram, 2004: p.270; Fearnside, 2015). Incidence of recorded cases of dams was over 37,641 of not less than 15 m height by 2015, with 8,689 being either wholly or partially for the purpose of hydropower (ICOLD, 2014). Dam construction can contribute to socio-economic development in many developing countries (WCD, 2000; Cernea, 2003; Nusser, 2014). For example, dams can increase energy access (OECD/IEA, 2003; Bakis, 2007), control floods, and increase infrastructural development (Galipean et al., 2013; Nusser, 2014). Generally, hydropower is the major source of over 97% of all electricity generated by renewable sources, prevent the burning of 22 billion gallons of oil and 120 million tons of coal annually, and serves as the most efficient way (0.85 cents per kwh) to generate electricity (Kaygusuz, 2004; Rakis, 2007). Dams such as the construction of the Akosombo dam resulted in improved income from the fishing industry, including a 90% increase in total fish harvested (73,000-82,000 metric tonnes, values at US$ 2.4 million) from inland waters (FAO, 1991: 1995; Braimah, 2001).

However, dams can undermine the social and ecological integrity of community resources, displace and destabilize communities, and fracture relationships and social systems that form the foundation for effective governance arrangements (Hussein, 2002; Bennett et al., 2012; International Rivers, 2013; Peter, 2013). Dams can also adversely affect livelihoods and the socio-economic wellbeing of people whose assets are acquired, as well as the communities they live in (The World Bank, 2004). For example, the construction of Arase dam, Japan disrupted feeding routes of fish and diminished fish catch (Jovais, 2014). The Don Sahong Dam in Cambodia jeopardized migratory routes of fish, undermined food security and livelihoods of millions of people (Ross, 2014).

Dam related resettlements can have positive impacts such as improved housing and provision of better schools. However, resettlement often has led to loss of land, legal authority over land, community support for members, and cultural and traditional healing systems (Teemacane Trust, 2002; Ferraro et al., 2011; UNDP, 2011; Bennett and McDowell, 2012: p. 97; International Rivers, 2013). For example, between 40-80 million people have been displaced by hydro dams worldwide (Ligon et al., 1985; WCD, 2000: p.16; Cernea, 2003; Cornea, 2005; Krueger, 2009). Ghana's case is not different as the construction of the Akosombo and Bui dams led to the displacement of some 80,000 people from 740 villages and over 1200 people from seven villages, respectively (Kalitsi, 2004; ERM, 2007; Ghana News Agency, 2010). Dams and resettlements have impacted governance in nearby communities. For example, the application of international laws over indigenous rights resulted in the loss of the voice of the people of San Kaputura (a resettlement communities near Etosha National Park), and led to a dependence on the government (le Roux and White, 2004; Bennett and McDowell, 2012: p. 98). In the cases of dam impacted communities, the voices of the displaced are rarely heard (Bennett and McDowell, 2012). Community competence (CC) can support community adaptive capacity to cope with socio-ecological changes such as dams and associated resettlements through; improvement in knowledge about hazard impacts, skills training and development, livelihood enhancement programmes, and development and improvements in community assets (Paton, 2003; Paton et al., 2006;West et al., 2006; Dzodzi, 2006). Wallerstein (1992) argues that skill training is central to community empowerment as well as addressing the challenges of powerlessness among people. Providing training in community interventions areas such as community health care can result in substantial reductions in child mortality through the management of ill children in Ghana (Haines et al., 2007). Similarly, skills training in indigenous conservation practices were shown to support effective hunter-gather traditions for resettled communities in NyaeNyae Conservancy, Botswana (Bennett and McDowell, 2012: p.98). However, knowledge of hazards and consequences alone does not exercise significant influence on preparedness (Gregg et al., 2004; Lasker, 2004). The ability to make the right decisions; and a person's ability to make, and act on, his or her own decisions has provided some important hallmark for developing the competence

of some communities whose livelihoods have been undermined by shocks (Kopelman, 1990: p. 327; Silberfeld, 1990: 37; Wicclair, 1993; Silberfeld et al., 1994: p. 6). For example, the application of proper decision making that involve local level management with a collaborative governmental support is important for addressing conflicts in fisheries in the long term (Bennett et al., 2001). But, in some cases of dam impacts, the approach to lessening the potential impacts have been diverse as a result of its effectiveness in bettering the lot for people whose livelihoods are impacted by the dam. In some literature, it is found that developing community competence can support community efforts to develop adaptive capacities to overcome the impacts of dam and related resettlement. Community competence (CC) is the capacity and effectiveness of communities to: undertake community action (such as conflict resolution); mobilize resources; make decisions; exhibit critical reflection; solve problems; and, develop technical expertise (Reid and Muruvi, 2011).

CC embraces strategies such as, gender equality, social cohesion and inclusiveness (Krishna, 2004; Norris and Stevens, 2006). Further, CC is noted to encourage community participation; promote collaboration and partnership; and engage traditional leadership, local governance institutions, researchers, and livelihood groupings in livelihood development activities (Kopelman, 1990: p. 327; Carney, 1997; Norris and Stevens, 2006; Mochizuki and Fadeeva, 2010; Possardt and Reid, 2010; Hout et al., 2011; Reid and Muruvi, 2011). For example, building community capacity to plan, and implement community projects such as farms and their related organizations is effective in enabling tomato farmers to develop greater roles and improve their position in tomato chain management, and also effective in building the competences of tomato farmers in the Northern region of Ghana (Clottey et al., 2008).

CC approaches have been applied by different organizations (international development partners, NGOs, governments and researchers) to address a wide variety of issues including resettlement issues, livelihood studies, poverty reduction and park governance (Carney, 1996; Brooks, 2003; Norris and Steven, 2006; Paton et al., 2006; Smith and Wandel, 2006; West et al., 2006; Smith and Mireles, 2011). For purposes of this study, Reid and Muruvi (2011) provides some critical domains of CC that support livelihood development in rural communities in Ghana. These domains are:

1) Governance,
2) Capacity to plan and implement community projects,
3) Participatory enabling activities, and
4) Sustainability of community projects.

Governance refers to how power is obtained, exercised and monitored, as well as serving as evidence of a system for accountability (Reid and Muruvi, 2011). Governance domains are evident in a community leadership structure, available systems of checks and balances, the execution of legitimate authority, processes for resolving conflicts, and processes for delegating power (Dudley, 2008; Nelson and Agrawal, 2008; Reid and Muruvi, 2011). Similarly, governance as a competence domain is also measured through the practice of local traditional belief systems, and traditional authority in managing communities.

Capacity to plan and implement community projects refers to planning organizational infrastructure, evidence of implemented community programmes and resource mobilization (Reid and Muruvi, 2011). A community's capacity to plan and implement community projects is measured through the level of technical expertise applied in community project implementation, experience in planning and implementing projects in the community, and community demonstrated competence, and community mobilization (Labonte and Laverack, 2001). The ability and level of linkages formed also indicates a community's capacity to plan and implement community activities.

Participatory enabling activities refer to evidence of inclusiveness or openness to all members of community, participations in activities, as well as how members are included in decision making (Eng and Parker, 1994; Reid and Muruvi, 2011). In measuring community participatory enabling strategies issues of community reach, level of gender equity, process and effectiveness of decision making, level of social cohesion and inclusiveness, and community history of sharing are taken into consideration. In many cases of CC in Ghana, participatory enabling activities such as community involvement in skills training provides important solutions to address un/underemployment leading to improved livelihoods and poverty reduction for many rural communities (Palmer, 2007). Sustainability of community projects refers to evidence of continuity within the community, including whether the group is transient or saves a permanent function in the community (Labonte and Laverack, 2001). Sustainability as a competence domain is measured by the level of community utility of activities and whether those activities project the concept of longevity, taking into cognisance the need to plan and implement projects that suit the needs of the present and the future members of the community.

The sustainability of education for all, including people in rural communities is linked to the development of community capacity to address challenges in livelihoods. Palmer (2007) argues that provision of technical and vocational education, including the widening of opportunities for lifelong learning and sustainability is critical in creating enabling environment for skills utilization through skills development, sustainable employment and sustained growth in Ghana.

However, community efforts to develop and improve competence are sometimes undermined by poor social and economic infrastructure, poor social mechanisms for knowledge transfer and skills development, and the development of socio-economic projects such as dams (WCD, 2000; West et al., 2006; Krueger, 2009; Nelson, 2010). For example, in Ghana, aggravated traditional stratification of society inherited from the colonial governance structures, led to class domination in exploitation of the mass of the people (Donkor, 2002: p. 212). The weakness in Word Bank development policies such as funding for Plan of Action to Mitigate the Social Cost of Adjustment (PAMSCAD), a social and economic development policy, was unable to empower people to mitigate poverty in late 90s in Ghana (Donkor, 2004: p. 228). A number of factors are thought to mitigate the effects of dams on communities. These additional factors include: gender, ethnicity, age and type of livelihood.

Gender can shape development planning in that women can effectively apply knowledge (plants and medicinal herbs, and irrigation) in subsistence farming, water harvesting, and wise use of natural resources (Enarson and Morrow, 1998; Anderson, 2009; Enarson and Chakrabarti, 2009; Harcourt, 2012). For example in Kumasi, Ghana women are marginalized in accessing land particularly amongst the older generation due to old age, physical weakness or the loss of land after the death of husband (Ashong and Smith, 2001, p.14), Again, women especially the elderly are more vulnerable to shocks such as economic risks and vulnerability that culminate into an increase in migration, illiteracy rates, poverty, and limited land rights (Amuzu et al., 2010, p.39) Accordingly, gender can impact agricultural productivity, health and nutrition (Krishna, 2004; Eysenbach, 2011, p. 193; FAO, 2014).

Greenburg et al. (1999) argue that boys are more responsive to negative influences of the neighbourhood, and therefore more vulnerable to their environment. Gender and social skills measured by performance on a role play, shows that being male in the United States is identified as risk factors for maladjustment during

childhood (Patterson et al., 1990). Men use more problem-focused coping than women at work and in situations having to be accepted and requiring more information but, not for emotion-focused coping (Folkman and Lazarus, 1980). Abukari and Laser (2013) argues that the Ghanaian youth often experience minimal early learning opportunities but, females are more negatively impacted through sex discrimination, and other forms of discrimination in education. In many cases, such discrimination comparatively predispose females to significant risks for dropping out of school and reduces their chances to attain postsecondary education. Other studies have indicated that gender contributes significantly to explaining the competence of people who act as activists in communities (Zanbar and Itzhaky, 2013). For example, there is the argument that men are characterized by higher levels of abilities associated with community activity.

Similarly, ethnicity is noted to mediate the effects of dams and resettlement on communities. Studies conducted in Wenchi, Ghana reveals that historical, ethnic and gender dimensions of diversity provide additional insights into livelihood patterns and soil fertility management and importantly in negotiating alternative land tenure arrangements for people (Agyei-Nsiah et al., 2007). Ethnicity can influence social struggle for power, resources and identities, and plays key roles in most conflicts in sub-Saharan Africa (Aluned, 2000; Braathen et al., 2000). For example, in places such as Angola, Congo-Brazaville, D R Congo, Liberia, Mozambique, Rwanda, Sierra Leone and Somalia ethnic affiliations was perceived to be a key factor in the prolonged conflicts that occurred in many communities (Horowittz, 1985).

Ethnicity is an important factor that explains why black children in the United States are more likely than white children to live in low-income homes (Patterson et al., 1990). Dei (2004) argues that for effectiveness in inclusive schooling in Ghana, educators and students should emphasize ways that people respond to ethnicity, gender and other forms of social difference, because such factors implicate the wider educational experience for the youth. Experience in working with various different cultural groups according to PhD graduates in counselling and clinical psychologists, is important in predicting competence (Allison et al., 1996). Ethnicity is argued to moderate joint and unilateral decision making for 14-16 year olds in the United States (Lamborn et al., 1996). For example, for joint and unilateral youth decision making, variations in decision making had a stronger impact on ethnically mixed than in predominantly white communities (for Hispanic-American youth and for African-American youth). The negative impact of unilateral youth decision making was stronger in predominantly white communities. Similarly, ethnicity is a weak predictor of dropout, utilization and level of functioning among some ethnic groups in the United States (Maramba and Hall, 2002). For example, ethnicity's effect on dropout and utilization has a larger effect on minority groups than Caucasian Americans.

Age affects access to human, physical, natural and financial capitals, livelihood portfolios (Scoones, 1998; De Shebinin et al., 2008; Mabala, 2011), and household labour supply which, in turn affects natural resource use (Paumgarten, 2005). Similarly, age has significant influence on the ability to reduce shocks in enterprises, and improve livelihoods for women in Tolon/Kumbungu, Ghana (Zakaria, 2009). Age can influence discrimination between low prospect of livelihood sustainability. Relatively young women are more likely to have a higher prospect of livelihood sustainability than older women, in a study conducted in Tolon/Kumbungu, Ghana. Older Ghanaian have a lower propensity to sustain themselves through the use of saving and assets due to the prolonged periods of living under worsening economic strain such as un- and underemployment, increasing costs of living and low earnings, and worsening weather and flooding that worsen agricultural fortunes (Ogwumike and Aboderin, 2005, p.9, 12).

Age is argued to mediate children's pre-academic skills and behaviour and is often considered the basis for placement and programming decisions (La Paro and Pianta, 2000). Age of a child affects what measures are possible to support the development of social competence (Clikeman-Semrud, 2007, p.50). At preschool level for example, observation is argued to provide the best effect for developing social competence. Liberman (1975) holds the view that the aged as compared to the younger population, are more successful in developing adaptive strategies to address life stresses. Younger populations are more vulnerable to threat and loss of management strategies to deal with stresses in life (Lieberman, 1975).

Some researchers have argued that livelihoods strategies applied by households and individuals in rural communities are highly dependent on resource availability (Mutenje et al., 2010). As a result, overcoming challenges or shocks in livelihoods can be successful through the application of diversified livelihoods (Ellis, 1998; Bryceson, 2002; Aasoglenang and Bonye, 2013). Diversification of individual or community livelihoods is greatly influenced by assets portfolios and the economic shocks that households face (Freeman and Ellis, 2005). The success of a diversified livelihood is influenced by improvements in risk management capacities of individuals and households, as well as targeting areas where shocks are minimal (Ellis, 1998; Mutenje et al., 2010). During the construction of the Akosombo dam in Ghana, communities resettled nearby the dam were able to overcome dam impacts through the practice of multiple livelihoods such as farming, fishing, fish mongering and trading.

Data and methods

The study is a case study illustrating how Bui dam has impacted on nearby communities. Case study is an empirical inquiry that investigates a contemporary phenomenon within its real life context, especially if the intention is to provide clarity of phenomenon and context (Woodside, 2010). This study adopted a triangulation approach involving document analysis interviews with key informants, and a household survey. This paper addresses the following research questions:

How do communities near Bui dam perceive the impacts of Bui Dam on community competency?
Are perceived impacts of Bui Dam on community competency influenced by age, gender, ethnicity, type of livelihood, and whether communities have been relocated?

This study used the PAPR "Community Poverty Scan and Assets based Approach to Poverty Reduction" that developed a competence domain for assessing livelihood development in rural communities in Ghana (Reid and Muruvi, 2011). The competence domains of the model include:

1) Governance- how power is obtained, exercised and monitored as evidence of a system of accountability;
2) Capacity to Plan and Implement- planning the organizational infrastructure, evidence of implemented community development programmes and resource mobilization;
3) Participatory enabling strategies- evidence of inclusiveness or openness to all members of community, participation in activities, and how members are included in decision making; and
4) Sustainability- evidence of continuity within the community to show that community project ensures development that meets the needs of the present generation of people in the community. Such activities should also lay foundation for the future generation to continue to benefit from community projects as well as provide

Table 2. List of key informants for the study.

Respondent's number	Town	Key Characteristics	Respondent's number	Town	Key Characteristics	Case Study
V001	Bui	Male	L013	Bator	Fishing, Male, Youth	√
V002	Bator	Male, Elder	L014	Bator	Fishmonger, Female, Youth	
V003	Dokokyina	Male, Elder	L015	Dokokyina	Farmer, Male, Elder	√
V004	Wildlife	Male, Leader	L016	Bator	Trader, Female, Youth	
V005	Dam site	Female, Elder	S017	Bator	Teacher, Male, Elder	
V006	Brewohodi	Male, Elder	S018	Bator	Catechist, Male, Elder	
V007	Lucene,	Male, Elder	S019	Bongaase		√
V008	Agbegikro	Male, Chief	G020	Wildlife	BNP, Male, Head	√
L009	Bator	Fisherman, Male, Youth	G021	BPA camp	BPA, Male, Resettlement Officer	
L010	Bator	Fish monger, Female, Youth	G022	Bator	Assemblyman, Male, Youth	
L011	Dokokyina	Farmer, Male, Elder	R023	Sunyani	Researcher A, Male, Lecturer/Planning Officer	
L012	Bator	Trader, Female, Youth	R024	Sunyani	Researcher B, Female, Lecturer (with years of research experience in communities near BNP)	

Source: Field Work, 2014.

the needed platform without compromising the ability of future generations, to benefit from existing projects or develop their own activities to support their generation. Data was collected through a survey questionnaire (n=329), and through key informant interviews (n=24).

The study forms part of a larger research project focusing on a multi-dimensional Canada-Africa Research and Learning Alliance seeking to address the challenges of reducing rural poverty and ensuring environmental sustainability through a focus on protected areas and adjacent communities in Canada, Tanzania and Ghana (Protected Areas and Poverty Reduction, 2010). This study explores processes to reduce shock in community competence, with a focus on dam and resettlement impacts on Community Competence in communities around Bui National Park (BNP). The study involved key informant interviews, document analysis and household survey. Traingulation is critical to research; because it emphasises the confirmation of findings as well as complements findings (Redfem and Norman, 1994); and has the potential to produce a more comprehensive and insightful data (Halcomb and Andrews, 2005; Casey and Murphy, 2009). The study uses traingultion to help in achieving the best of each method, inceasing confidence of results, and a potential of creating new methods, and opportunity in enriching the explanation of the research problem (Jick, 1979) while also helping to overcome the shortcomings of each method (Denzin, 1978).

Key informant interviews

Key informants for the study involved a total of twenty four (24) people purposively selected from different groups; women, young adults, volunteers, aged, and researchers who have some experience such as having undertaken some form of studies in the resettled communities around BNP. A key informant interview (use of a semi-structured interview) was preferred as an effective and flexible method, because it is an effective tool to probe for more information about the topic (Robson, 2011; Creswell, 2007). Interviewees included eight traditional leaders and elders of the resettled communities, four from the livelihood groups (that is, traders, fishermen, fishmongers and farmers), and representatives of BNP, BPA, school, church, District Assembly and researchers (Table 2).

Key informant interviews provided information on (1) the impact of Bui Dam construction and resettlement on CC. Responses were used as primary data, and also to inform the development of a household survey outlined below.

Questions asked included how the people made a living before and after the Bui dam, and aspects of community competence that has been changed by the Bui dam. Key informant interviews served to complement survey findings, and also guide the presentation and interpretation of the results for the study. Key informants were selected based on the specific roles they play in the society, and who were perceived to have some level of knowledge on issues being investigated (Creswell, 2007; Robson, 2011). In many other cases, snowballing was handy in identifying other relevant respondents (Henslin, 1972; Biernacki and Waldorf, 1981). Efforts were made to reduce the potential biases in snowballing such as obtaining a sizeable sample, using other indirect sources to source respondents, and reaching isolated groups such as women and the youth (Atkinson and Flint, 2001; Faugier and Sargeant, 1997).

Household survey

The survey questionnaire was developed from a literature review and the key informant interviews. Questionnaire items focused the impact of Bui Dam construction and resettlement on CC. The questionnaire on CC is limited to these four broad domains; governance, capacity to plan and implement community projects, participatory enabling activities, and sustainability. The domains were in reference to Reid and Muruvi's work on "The Community Poverty Scan and Assets Based Approach to Poverty Reduction"

Table 3. Institution providing training opportunities before and after the construction of Bui Dam.

Institution	Percent Responding Yes Before Bui Dam	Percent Responding Yes After Bui Dam
Bui National Park (BNP)	39.8	29.5
Bui Power Authority (BPA)	22.2	13.4
Tain District Assembly (TDA)	1.5	0.0
Banda Ahenkro District Assembly (BADA)	2.4	3.6
Cooperatives	4.0	8.5
Bole Bamboi District Assembly (BBDA)	4.3	3.6
Environmental Protection Agency (EPA)	0.9	0.0
Non-Governmental Organization (NGOs)	1.5	0.3
Students	7.0	7.6
No training provided	23.4	33.4

Source: Field Work, 2014.

on how to access CC on the context of Ghana (Reid and Muruvi, 2011). The domains have been successfully applied to study livelihoods, capital assets and CC in the Ghanaian context.

A pilot study involving six researchers from academia; and ten people of at least one from each of the eight resettled communities around BNP were used for the study. Respondents reviewed the questions, and also helped to provide clarity and relevance of questions to the intended participants in the communities. Pre-test information was used to modify the household questionnaire to ensure that respondents easily understood the questions, and provided the required information. All statements were translated through the help of a translator, into the Akan language, a common language of the resettled communities.

The sample involved participants representing households, randomly selected from an openly available village register that indicated housing units, and members of households (Groves et al., 2006; Robson, 2011). Households for the study represented people forming domestic social units sharing resources, specifically each of the following criteria: (1) share a meal a day, (2) share accommodation, and (3) share expenditure (Bender, 1967; Yanagisago, 1979; Wilk and Miller, 1997; Davenport et al., 2000, p.901; Casimir and Tobi, 2011). The sample was comprised of 339 people (with 100% response rate), including adult male and female representatives of households (Table 1). Each household selected a representative to lead the household in providing responses to the questionnaire. The result is a sizeable number of females who responded to the questionnaire. In some cases as well, households were headed by single parents of whom a large number were females. Data was collected between 2013 and 2014. The selection of sample size was based on the number of households available in each community; at least 50% (Krejcie and Morgan, 1970; Nwana, 1981) of the total number of households in each resettled community around BNP (Table 1).

Four trained Ghanaian research assistants who had at least a diploma level education in research methodology, conducted the surveys as well as the pilot study. In this research, a number of independent variables were examined for their impact on each type of community competence. In order to understand the relative impact of each independent variable (relocated, livelihood and ethnicity), multiple regression was used.

First, a total score was computed for each community competence, by summing the mean scores reported in each item in the table. For example, a total score for governance was computed by summing the mean responses of each of the items reported. This total score for governance was the dependent variable used in the multiple regression analysis reported in the first row of Table 11.

RESULTS AND DISCUSSION

Institutions providing training

In the resettlement plan, training was to be provided by many stakeholders but, coordinated by Bui Power Authority. Institutions that provided most of the training before and after the construction of the Bui dam (Table 3) were Bui National Park (BNP), followed by the Bui Power Authority (BPA). A substantial number of respondents (23%) indicated that no training was provided before the dam construction. The district assemblies were among institutions that provided the least training before the dam. Students from institutions such as Sunyani Polytechnic, and University of Ghana, Legon also provided some forms of training for households before the dam. The situation of training was not different after the dam, since BNP gave the highest number of training modules and followed by BPA. It was noted that cooperatives and students also led a number of training for households after the construction of Bui dam.

Some key informants (e.g. V005) noted that other institutions such as the Ministry of Food and Agriculture (MOFA) provided some training opportunities before and after the Bui dam. A senior official of BPA (G016) noted that it is now important for institutions such as health, education and district assemblies to provide some forms of institutional support for the resettled communities.

Further, he added that it is now the responsibility of some state institutions to resource these facilities and also ensure their functionality for the resettled communities. For example, the resourcing and functioning of the school is the responsibility of the Ministry of education, the clinic for the Ministry of Health, and the market for the District Assembly (G016).

The impacts of Bui Dam were examined with respect to training in the four aspects of CC: governance, sustainability, capacity to plan and implement community projects, and participatory enabling strategies. These findings are outlined in the following sections.

Impacts of Bui Dam on governance training

The governance aspect of CC refers to how power is obtained, exercised and monitored as evidence of a system accountability. Training in governance was examined with 6 questionnaire items outlined in Table 4, where respondents indicated their level of agreement on a 5 point scale from “strongly disagree” to “strongly agree”. The responses showed that the majority of respondents disagreed with each statement that training in governance was provided for households.

Responses for communities who had been relocated were not significantly different as compared to the responses of communities who had not been relocated (t-test findings). Comparing mean scores for these governance items by ethnicity, suggests some differences (ANOVA and Scheffe findings in Table 4):

1. Nafana mean responses higher that Ewe for 3 items
2. Nafana mean responses higher than Mo for 2 items
3. No differences in mean responses when comparing Mo and Ewe.

Table 4 examines the influence of livelihood type on governance training. Mean scores for livelihood by governance training range between the highest 2.49 and 2.32. Mean scores for livelihood was highest for farming for all aspects of governance training, followed by fishing, and lastly mixed livelihoods. This meant that farmers responded better to the training provided to support livelihood changes.

ANOVA test scores were significant for livelihoods under all items of governance training. Scheffe test scores for livelihood also showed significance for all aspects of governance training, except fishing by mixed livelihoods under governance training in how to lead, direct, and support community activity and training on how to share authority and responsibility.

There were no significant differences when responses were compared by gender or by age groupings. This study provided further support to the findings of Roux and White (2004) and Bennett and McDowell (2012: p. 98) that dams and related resettlements can lead to the loss of voice (an aspect of community governance) for resettled people and create a dependence tendency for communities near dams. This study also corroborates the findings of Dzodzi (2006), Kraan (2009) p.296) and Norris and Steven (2006) that advocates for the need to motivate people to formulate decisions in their governance such as negotiating livelihood space to provide preparedness to reduce risk that may invariably be caused by dams.

Impacts of Bui Dam on sustainability training

The sustainability aspect of CC refers to evidence of continuity within the community, that is, whether the group or community activity provides for functional continuity for the present people in the community as well as for future generations. Scores for impact of dam and resettlement on sustainability showed that the majority of respondents disagree that training in sustainability has been provided. Mean scores comparing relocated versus not relocated communities did not show significance (Table 5). Only one difference was noted when comparing ethnic groups (between Nafana and Mo).

The results of the Bui study further buttresses the findings of Teemacane Trust (2002), and Bennett and McDowell (2012) that indicated that dam related resettlements can lead to the loss of land and ruling of land, community support for members, cultural and traditional healing systems, and especially governance mechanisms that support the survival of many communities.

Training by relocation and ethnicity

When responses were compared by ethnicity, just one relationship was significant: Nafana scored higher than Mo for “training in how to ensure that community groups and organizations continue to function and adjust to changes”. This indicated that Nafana is better placed to apply CC to overcome stresses in their livelihoods such as the effects of dams and related resettlement. Table 6 provides information on how livelihood type influences sustainability training for people impacted by dam and resettlement.

Mean scores on how livelihood influences sustainability training was highest for farming livelihoods for all aspects of sustainability. This implied that people in farming livelihoods are better in terms of being able to overcome the impacts of dam and associated resettlement on their livelihood. But, mean scores were lowest for mixed livelihoods for all aspects of sustainability training. For F at (19.385 and 18.880), ANOVA scores were significant for all items under sustainability training. Scheffe test

Table 4. Impacts of Bui Dam on governance training by relocation and ethnicity.

Governance	Comparing mean responses for relocated vs. not relocated communities						Comparing mean responses by ethnicity				
	Percent that agree	Percent that disagree	Mean*	Relocated	Not relocated	t-test, significant	Nafana (N)	Mo (M)	Ewe (E)	ANOVA F, Signif	Scheffe Test**
Training in how to lead, direct and support community activity,	21.2	56.9	2.32	2.22	2.37	T=-0.977 P=0.329	2.61	2.22	2.13	F=3.826 P=0.023	N– M=0.097 N - E=0.047 M - E=0.907
Training in how to share authority and responsibility	20.9	54.7	2.33	2.12	2.42	T=-1.855 P=0.065	2.71	2.18	2.01	F=7.067 P=0.001	N-M=0.019 N - E=0.003 M - E=0.737
Training in how the whole community can be involved and represented in dealing with issues fairly	26.5	53.2	2.38	2.23	2.45	T=-1.351 P=0.178	2.79	2.15	2.13	F=8.168 P=<0.001	N - M=0.003 N - E=0.004 M - E=0.998
Training in how to use the proper ways/authority (e.g. legal, institutional, etc) to get things done	26.1	52.0	2.49	2.43	2.51	T=-0.490 P=0.625	2.79	2.35	2.30	F=3.402 P=0.035	N – M=0.100 N – E=0.080 M - E=0.973
Training in how to manage conflicts and disagreements in the community	26.1	52.0	2.44	2.47	2.43	T=0.240 P=0.811	2.71	2.33	2.36	F=2.969 P=0.053	N – M=0.153 N - E=0.098 M - E=0.964
training in how to use traditional knowledge and skills to govern people's behaviour, relationships and the environment	17.3	53.8	2.37	2.45	2.33	T=0.737 P=0.462	2.63	2.19	2.25	F=3.396 P=0.035	N –M=0.059 N-E=0.146 M - E=0.967

Source: Field Work, 2014

Table 5. Impacts of Bui Dam on sustainability.

Sustainability	Percent that agree	Percent that disagree	Mean*	Comparing mean responses for relocated vs not relocated communities			Comparing mean responses by ethnicity				
				Relocated	Not relocated	t-test, signif	Nafana (N)	Mo (M)	Ewe (E)	ANOVA F, significant	Scheffe test**
Training in the usefulness of local institutions or organization such as chieftaincy, police, clans, families to provide leadership for community initiatives	27.9	51.1	2.5	2.58	2.44	T=0.821 P=0.412	2.71	2.38	2.34	F=2.0336 P=0.133	N – M=0.245 N - E=0.226 M - E=0.989
You and your family received training in how to ensure that community groups and organizations continue to function and adjust to changes	19.4	51.7	2.4	2.43	2.34	T=-0.626 P=0.532	2.69	2.21	2.22	F=4.479 P=0.012	N-M=0.031 N - E=0.058 M - E=0.997

Source: Field Work, 2014.

scores for livelihood type were significant for all aspects of sustainability training. There was no significant relationship between sustainability and gender, or age.

Impacts of Bui dam on ability to plan and implement

Capacity to plan and implement refers to planning the organizational infrastructure, evidence of implemented community development programmes and resource mobilization. The majority of respondents agree that training has not been provided in capacity to plan and implement community activities (Table 7). Mean scores for relocated communities were worse for three of four aspects (statistically different as measured by Students T-Test). Analysis by ethnicity revealed a number of significant differences (ANOVA and Scheffe tests):

1) Nafana responses were higher than Mo for 3 of 4 items meaning Nafana ethnic groups are better in applying CC after the dam, to overcome stresses in their livelihoods;
2) Nafana responses were greater than Ewe for 3 of 4 items;
3) There was no difference between Mo and Ewe for any items.

There were no significant relationships when comparing responses by age or by gender. The Bui study contributes to knowledge and is supported by Jovais (2014) because the Bui study suggests that construction of dams and resettlement can disrupt community efforts to promote livelihoods, including the influx of migrants to compete for the available livelihoods.

Table 8 shows scores for the influence of livelihood type on ability to plan and implement community activities. Mean scores for livelihood type ranged between the highest of 2.31 and lowest of 2.06. Farming livelihood scored the highest mean (better in terms of using CC to overcome dam impacts) for all aspects of capacity to plan, followed by fishing, and then mixed livelihoods. ANOVA test scores were significant for all aspects of capacity to plan and implement except for training and opportunities in strategies to facilitate the promotion of community engagement, allow community voices to be heard, and make collective decisions. Analysis by livelihoods revealed significant results

Table 6. Influence of livelihood type on how governance training is perceived.

Governance Training	Comparing Mean Responses by Livelihood					
	Mean	Farming	Fishing	Mixed	ANOVA F, Signif.	Scheffe Test
Training in how to lead, direct and support community activity,	2.32	2.59	1.96	1.30	F=16.084 P=<0.001	Fa-Fi=<0.001 Fa-M=<0.001 Fi-M=0.095
Training in how to share authority and responsibility.	2.33	2.67	1.89	1.20	F=19.876 P=<0.001	Fa-Fi=<0.001 Fa-M=<0.001 Fi-M=0.103
Training in how the whole community can be involved and represented in dealing with issues fairly	2.38	2.69	2.01	1.20	F=18.192 P=<0.001	Fa-Fi=<0.001 Fa-M=<0.001 Fi-M=0.040
Training in how to use the proper ways/authority (e.g. legal, institutional, etc) to get things done	2.49	2.81	2.11	1.20	F=18.339 P=<0.001	Fa-Fi=<0.001 Fa-M=<0.001 Fi-M=0.028
Training in how to manage conflicts and disagreements in the community	2.44	2.75	2.08	1.20	F=18.283 P=<0.001	Fa-Fi=<0.001 Fa-M=<0.001 Fi-M=0.027
training in how to use traditional knowledge and skills to govern people's behaviour, relationships and the environment	2.37	2.68	1.99	1.20	F=19.656 P=<0.001	Fa-Fi=<0.001 Fa-M=<0.001 Fi-M=0.027

(Scheffe test):

1) Farming by fishing was significant for 3 aspects (meaning people who practice a mixed farming and fishing livelihoods are better able to use CC to overcome the impacts of Bui dam and related resettlement on their livelihoods);
2) Farming by mixed was significant for 3 aspects;
3) Fishing by mixed did not show any significant score.

Impacts of Bui Dam on development of participatory enabling strategies

Participatory enabling strategies refers to evidence of inclusiveness or openness to all members of community, participation in activities, and how members are included in decision making. Responses on training in participatory enabling activities show that the majority of respondents are of the opinion that training was not provided for households in all aspects of participatory enabling activities (Table 9).

Mean scores did not show significance differences when comparing relocated communities to not relocated communities. When responses were compared by ethnicity, the following pattern emerged (ANOVA and Scheffe results):

1) Nafana responses were higher than Mo responses for 3 of 5 items;
2) Nafana responses were higher than Ewe responses for 5 of 5 items;
3) Mo responses were not different than Ewe responses.

There were no significant relationships when comparing responses by age or gender. Mean scores for

Table 7. Impacts of Bui Dam on ability to plan and implement by relocation and ethnicity.

Capacity to plan and implement	Percent that agree	Percent that disagree	Mean*	Comparing mean responses for relocated vs. not relocated communities			Comparing mean responses by ethnicity				
				Relocated	Not relocated	t-test, signif	Nafana (N)	Mo (M)	Ewe (E)	ANOVA F, Significance	Scheffe Test**
Training and opportunities in how to come together to discuss, plan or implement issues of interest to the community.	20.9	56.0	2.31	2.01	2.46	T=-2.791 P=0.006	2.65	2.15	2.04	F=5.687 P=0.004	N – M=0.030 N - E=0.011 M - E=0.879
Training and opportunities in strategies to facilitate the promotion of community engagement, allow community voices to be heard, and make collective decisions	13.4	63.5	2.19	2.01	2.29	T=10.741.53 6 P=0.459	2.51	1.84	2.32	F=1.022 P=0.361	N-M=0.373 N - E=0.930 M - E=0.665
Training and opportunities in how to set and work towards specific goals that can be used to assess progress.	14.0	63.5	2.06	1.51	2.32	T=-5.375 P=<0.001	2.40	1.99	1.66	F=7.518 P=0.001	N-M=0.080 N - E=0.001 M - E=0.259
Training and opportunities in how to partner, collaborate, or contact external or internal groups to work together on issues that benefit the community	18.2	60.8	2.18	1.69	2.42	T=-4.3637 P=<0.001	2.55	2.03	1.88	F=6.581 P=0.002	N-M=0.024 N - E=0.004 M - E=0.769

Source: Field Work, 2014.

livelihood range between highest of 2.42 and lowest of 2.25 for participatory enabling strategies (PES). Mean scores for livelihood type was highest for farming for all aspects of PES. People practicing farming livelihoods and the dam impacted area are better in using CC to address the changes in their livelihoods caused by the Bui dam and related resettlement (Figure 10). Mean scores for mixed livelihoods were lowest for all aspects of PES. When responses (ANOVA and Scheffe) were compared for livelihoods, the following pattern emerged. ANOVA scores were significant for all aspects (meaning that PES have a better impact of the ability of the communities to address their livelihood changes in the phase of the Bui dam and its impacts)

1) Farming by fishing was significant for 5 aspects
2) Farming by mixed was significant for 5 aspects
3) Fishing by mixed was significant for 4 aspects.

The study adds to literature (Hussein, 2002; Palmer, 2007; Bennett, 2012), because the Bui study suggests; dams can impact family involvement in decision making as well as the effectiveness of communities to participate in community activities to address changes in their livelihoods.

Multiple regression analysis

In each case, the R squared scores were low, but significant. The relative effect of each

Table 8. Influence of livelihood type on how ability to plan and implement is perceived.

Capacity to Plan and Implement Training	Comparing Mean Responses by Livelihood					
	Mean	Farming	Fishing	Mixed	ANOVA F, Significance	Scheffe Test
Training and opportunities in how to come together to discuss, plan or implement issues of interest to the community.	2.31	2.61	1.94	1.20	F=16.404 P=<0.001	Fa-Fi=<0.001 Fa-M=<0.001 Fi-M=0.073
Training and opportunities in strategies to facilitate the promotion of community engagement, allow community voices to be heard, and make collective decisions	2.19	2.34	2.11	1.20	F=1.210 P=0.300	Fa-Fi=0.843 Fa-M=0.316 Fi-M=0.503
Training and opportunities in how to set and work towards specific goals that can be used to assess progress.	2.06	2.34	1.66	1.20	F=14.466 P=<0.001	Fa-Fi=<0.001 Fa-M=0.001 Fi-M=0.350
Training and opportunities in how to partner, collaborate, or contact external or internal groups to work together on issues that benefit the community	2.18	2.45	1.86	1.20	F=12.653 P=<0.001	Fa-Fi=0.001 Fa-M=<0.001 Fi-M=0.129

Source: Field Work, 2014.

independent variable differed in each analysis (Figure 11):

1) For governance, only livelihood was significant;
2) For sustainability, only livelihood was significant;
3) For capacity to plan and implement, relocate and livelihood were significant;
4) For participatory enabling activities, only livelihood was significant.

DISCUSSION

Dams and resettlement negatively impact governance. In resettled communities nearby parks dam has worsened governance. Aspects of governance worsened include how to lead, direct and support community activity, and how to share authority and responsibility. This study provided further support to the findings of Roux and White (2004) and Bennett and McDowell (2012, p. 98) that dams and related resettlements can lead to the loss of voice for resettled people and create a dependence tendency for communities near dams. This study also corroborates the findings of Dzodzi (2006), Kraan (2009, p.296), and Norris and Steven (2006) that advocates for the need to motivate people to formulate decisions such as negotiating livelihood space to provide preparedness to reduce risk that may invariably be caused by dams.

Community competence in the form of sustainability of communities such as training in the usefulness of local institutions- chieftaincy, police, and clans as well as ensuing that community groups and organization continue to function and adjust to changes are adversely impacted by dams. The impact of dams on sustainability is rather worse for communities not relocated, but nearby dams. The results of the Bui study further buttresses the findings of Teemacane (2002) and Bennett and McDowell (2012) that indicated that dam related settlements can lead to the loss of land and ruling of land, community support for members, cultural and traditional healing systems, and especially governance mechanisms that support the survival of many communities. The study is therefore important as it provides further backing for the measures to address impact on the sustainability of education for all, including people in rural communities (Palmer, 2007).

The community's capacity to plan and implement projects is also negatively impacted by dams and

Table 9. Impacts of Bui Dam on participatory enabling strategies by relocation and ethnicity.

Participatory Enabling Strategies	Percent that agree	Percent that disagree	Mean*	Comparing mean responses for relocated vs not relocated communities			Comparing mean responses by ethnicity				
				Relocated	Not relocated	T-test, signif	Nafana (N)	Mo (M)	Ewe (E)	ANOVA F, Signif	Scheffe Test**
Training in the use of people or community groups to implement community development 17.3 programmes/projects	20.9	52.6	2.4	2.34	2.46	T=-0.749 P=0.454	2.72	2.29	2.21	F=4.357 P=0.014	N – M=0.064 N - E=0.034 M - E=0.923
Training in strategies for participation, (including assessing decision making, who makes decisions, and influence community in final decision that are made.)	17.3	57.2	2.3	2.07	2.34	T=-1.794 P=0.074	2.59	2.22	1.86	F=7.574 P=0.001	N-M=0.116 N - E=0.001 M - E=0.182
Training in how to target inclusion of women or marginalized gender in planning, implementation and other decision making process.	17.0	54.4	2.3	2.21	2.34	T=-0.895 P=0.372	2.69	2.12	1.97	F=8.216 P=<0.001	N-M=0.016 N - E=0.001 M - E=0.577
Training in community solidarity, and helping each other materially (e.g. food and clothing) and socially (during funerals, naming ceremonies, etc.)	17.6	55.3	2.3	2.24	2.29	T=-0.221 P=0.825	2.68	2.14	2.05	F=6.999 P=0.001	N-M=0.011 N - E=0.005 M - E=0.916
Training in how to be open in activities and processes in the community	16.1	56.2	2.3	2.2	2.3	T=-0.362 P=0.718	2.66	2.07	2.07	F=7.772 P=0.001	N-M=0.003 N - E=0.006 M - E=0.999

Source: Field Work, 2014.

associated resettlements. In general, the community capacity to come together to discuss, plan or implement issues of interest to the community, develop strategies to facilitate the promotion of community engagement, and allow community voices to be heard are worsened in communities displaced by dams. The adverse impacts of dams are worse for relocated communities. This assertion is similar to the findings of Bennett and McDowell (2012) and Donkor (2002, p.212) that argued that in dam impacted communities, the voices of the displaced

Table 10. Influence of livelihood type on participatory enabling strategies.

Participatory enabling strategies training	Comparing mean responses by livelihood					
	Mean	Farming	Fishing	Mixed	ANOVA F, Signif.	Scheffe Test
Training in the use of people or community groups to implement community development programmes/projects	2.42	2.73	2.04	1.20	F=20.013 P=<0.001	Fa-Fi=<0.001 Fa-M=<0.001 Fi-M=0.027
Training in strategies for participation, (including assessing decision making, who makes decisions, and influence community in final decision that are made.)	2.25	2.60	1.77	1.20	F=23.474 P=<0.001	Fa-Fi=<0.001 Fa-M=<0.001 Fi-M=0.167
Training in how to target inclusion of women or marginalized gender in planning, implementation and other decision making process.	2.29	2.62	1.89	1.20	F=20.892 P=<0.001	Fa-Fi=<0.001 Fa-M=<0.001 Fi-M=0.074
Training in community solidarity, and helping each other materially (e.g. food and clothing) and socially (during funerals, naming ceremonies, etc.)	2.31	2.63	1.91	1.20	F=20.017 P=<0.001	Fa-Fi=<0.001 Fa-M=<0.001 Fi-M=0.072
Training in how to be open in activities and processes in the community	2.28	2.57	1.92	1.20	F=18.269 P=<0.001	Fa-Fi=<0.001 Fa-M=<0.001 Fi-M=0.051

Source: Field Work, 2014.

Table 11. Influence of three predictor variables: relocate, livelihood and ethnicity on community competence.

	Relative strength of prediction of each independent variables			Overall strength of prediction	
	Relocate	Livelihood	Ethnicity	R, sig	R squared
Governance	B=0.009 Signif=0.889	B=-0.296 Signif= <0.001	B=0.028 Signif=0.722	R=0.282 P=<0.001	0.080
Sustainability	B=-0.077 Signif = 0.249	B=-0.310 Signif=<0.001	B=0.037 Signif=0.637	R=0.291 P=<0.001	0.085
Capacity to plan and implement	B=0.167 Signif = 0.014	B=-0.213 Signif=0.003	B=0.087 Signif=0.279	R=0.058 P=0.001	0.048
Participatory enabling activities	B=-0.017 Signif=0.793	B=-0.282 Signif=<0.001	B=-0.026 Signif=0.743	R=0.294 P=<0.001	0.086

Source: Field Work, 2014.

are rarely heard, and class division that suppress the voices of the masses are created. In a similar vein, the Bui study contributes to knowledge and is supported by Jovais (2014) because the Bui study suggests that construction of dams and resettlement can disrupt community efforts to promote livelihoods, including the influx of migrant to compete for the available livelihoods.

Community participatory enabling strategies are negatively affected by dams. The capacity to use people or community groups to implement community development programmes/projects, target inclusion of women or marginalized gender in planning is worsened by dams. The impact of dams on participatory enabling strategies is worse for relocated communities. The study adds to literature (Palmer, 2007; Hussein, 2002; Bennett, 2012), because the Bui study suggests; dams can impact

family involvement in decision making as well as the effectiveness of traditional leaders to mobilize people for communal activities.

Ethnicity and relocation were weak predictors of the variability in dam impacts and related resettlement for the different types of community competence. The Bui study is similar to others (Patterson et al., 1990; Allison et al., 1996; Lamborn et al., 1996; Maramba and Hall, 2002; Dei, 2004) becuase the Bui's study that suggested ethnicity and relocate as perceived weak predictors for CC in communities impacted through dam construction and resettlement.

The Bui study showed that gender and age do not appear to influence community competence for communities impacted by dam and associated resettlements. The results of the study differs from literature (Patterson et al., 1990; Laser, 2013); since the Bui study indicated that gender is not perceived to mediate CC for communities impacted by dams and associated resettlements. It also differs from studies by Liberman (1975), La Paro and Pianta (2000), and Clikeman-Semrud (2007, p.50), because for the Bui study the age of person is not perceived to influence CC available for people to overcome the impacts of dams and resettlements.

CONCLUSION AND RECOMMENDATIONS

This paper examines the impacts of "shocks" (Bui dam construction and resettlement) on a number of phenomena which include community competence. Within each of these research questions, a number of intervening variables were examined, including resettlement, ethnicity, livelihood, age and gender, the impacts of "shocks" (Bui dam construction and resettlement) on community competence. The study is unique because it is one of only a few studies to examine dam impacts on community competence, and governance mechanisms available to resettled communities around Bui National Park. The study is undertaken with reference to Reid and Muruvi's work on "The Community Poverty Scan and Assets Based Approach to Poverty Reduction" on how to access community competence from the Ghana's perspective (Reid andMuruvi, 2011). The CC domains (governance, sustainability, capacity to plan and implement, and participatory enabling activities) (Reid and Muruvi, 2011) were arrived at after a successful application in the study of CC, livelihoods and capital assets in the Ghanaian context.

When each aspect of community competence was examined, it was apparent that perceived training was low (low mean), although some variability was apparent. Most of this variability appears to be explained by livelihood, rather than by relocation, ethnicity, age or gender. However, the multiple regression analysis indicates that R squared values were low, suggesting that other factors (not explored in this study) contribute to variability in responses.

Training opportunities provided for dam impacted communities did not meet the core needs and focus of the impacted communities; because the number of training modules were few; training modules failed to focus on the core skills domains (e.g. governance, sustainability, capacity to plan and implement, and participatory enabling activities) (Reid and Muruvi, 2011) needed to overcome dam impacts. Training opportunities provided for the households impacted by the dam fell short in areas such as the necessary inputs and funds to explore opportunities in areas such as livelihoods. It is therefore relevant that policy implementers such as the government through the District Assemblies, Bui Power Authority, Bui National Park, and Community Base Organizations such as livelihood groups are empowered and provided with the necessary tools to carry out extensive campaigns relating to the development and sustenance of community competence activities.

The study showed that people perceive community competence to be decreasing on many spheres, but there is variability between households in the perceived impacts. The predictors of variability were relocate and ethnicity. The trend in community competence is a wakeup call for all stakeholders involved in issues that relate to community competence and ultimately the livelihoods of people living near the Bui National Park. The call to address the declining community competence is appropriate because issues of community competence have critical roles to play in the development, improvements, and sustenance of livelihoods on which communities such as those near Bui National Park subsist.

CONFLICT OF INTERESTS

The author will like to declare that there was no conflict of interests associated with any of the process(es) leading to the completion of this research work.

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