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# AQUATIC AND MARSHLAND FLORA OF BHADRAK DISTRICT, ODISHA, INDIA

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Bhadrak district of Odisha, India harbors many water bodies, varying in shape and size, which remain underwater during the rainy season and provide a good habitat to various plant taxa. To assess the status and distribution of aquatic flora, trips were conducted in the intensive study area. A total of 167 plant species were recorded, of which 38 species of hydrophytes (including three pteridophytes) were found in aquatic habitat and 129 species in moist habitat. The most represented plant families were Poaceae (28 sp.) and Cyperaceae (19 sp.). *Alternanthera philoxeroides* (Mart) Griseb., *Alternanthera sessilis* (L.)R.Br.ex DC., *Centella asiatica* (L.) Urb., *Commelina benghalensis* L., *Cyperus alopecuroides* Rottb. Descr., *Eclipta prostrata* (L.) L., *Eichhornia crassipes* Solms, *Hydrilla verticillata* (L.f.) Royle., *Hygrophila auriculata* (Schum.) Heine., *Ipomoea aquatica* Forssk., *Ipomoea carnea* Jacq., *Glinus oppositifolius* (L.) A.DC., *Ludwigia adscendens* (L.) Hara, *Nymphaea pubescens* Willd., *Oxalis corniculata* L., *Pistia stratiotes* L., and *Typha angustata* Bory. & Chaub. were the most common species in all the habitats. Therophytes with 41.9% (70 species) were the highest life form followed by Hydrophytes (22.7%) and Chamaephyte (15%). The status of flora, management and its ecosystem services has been discussed in the paper. In order to conserve the aquatic biodiversity in this region, some strategies and measures are suggested including strengthening scientific research and biodiversity education in the local people, balancing economic development and ecological conservation.

**Keywords:** Aquatic flora, Biological spectrum, Economic uses, Floristic survey, Phytodiversity

## Introduction

India, a mega-biodiversity country with four hotspots hosts a very high diversity of ecosystems and habitats, and encompasses about 8% of the world's biodiversity[1]. Human activities have changed the environment and its components. This has led to the change in species composition and diversity of many plant communities. Phytodiversity is an indispensable component of the ecosystem and is the ultimate for the survival of animals. Loss of plant biodiversity is a major reason behind the loss of genetic and species diversity and it is mainly by the destruction of natural habitats. Freshwater ecosystems are among the most threatened ecosystems around the world than their terrestrial or marine counterparts[2]. Overexploitation, water pollution, flow modification, destruction or degradation of habitats, climatic changes, eutrophication, acidification and exotic species invasions are the major drivers of biodiversity loss in freshwater ecosystems[3, 4]. At a global scale, freshwater is relatively insignificant in terms of area (< 1% global surface), but such habitats support a number of aquatic and marshy flora (~ 10% of all known species) [5] and plays a crucial role in the structure and

the function of this ecosystem[3, 6]. The most imperative ecosystem services of aquatic flora include nutrient rotation, sediment stabilization, and the provision of foods and habitats for a variety of fishes and other animals [3, 7-8]. Moreover, their extensive coverage enhances the transparency of water by favouring the reduction of the resuspension of bottom material[9]. In addition, the excretion of allelopathic substances of submerged plants is responsible for algal growth impairment[10]. Recently, Mustafa and Hayder (2021)[11] stated that aquatic plants have the capacity to absorb excess contaminants such as organic and inorganic, heavy metals, and pharmaceutical pollutants. Research of aquatic flora in India has, in general, received much less attention than that of the terrestrial plants. However, studies by Subrahmanyam (1962)[12] drew some attention to the importance of aquatic flora. Since then a number of reports have appeared on the floristic composition on different water bodies of the country[13- 21]. The aquatic flora from Odisha has been the subject of studies and surveys from the last quarter of the 19th century until the current one[22]. Subhadarsini et al. (2016)[23] provide a list of 102 species under 34 families from Bhubaneswar and the adjoining areas. Panda et al. (2018)[24] have collected 244 macrophyte species that include 182 semi-aquatic and 62 obligatory aquatic macrophytes from Ansupa Lake. Recently, Dalasingh et al. (2019)[25] have assessed the aquatic plants of the Puri district and documented 60 species of hydrophytes under 25 families. Variety of wet habitats ranging from rivers and ponds to land-water margins and shallow water are present in Bhadrak district with rich aquatic flora, but these natural resources have not been given due attention, and thus their potential remains unexplored. No detailed account of aquatic angiosperms for the Bhadrak district is available. The present study is an attempt to open a new avenue in this field and has been investigated mainly for identification, habit, habitat, and aquatic phytodiversity analysis of the Bhadrak district. It is a prerequisite for developing strategies for their conservation.

## Material and Methods

Study site:

Bhadrak district (20°43′–21°13′N and 86°6′–87° E) is located in northeast Odisha and covers an area of 2505 $km^2$, with a population of 1.507 million (2011 Census). It borders the Balasore district in the north, Jajpur in the south, Bay of Bengal and Kendrapara district in the east and Koenjhar in the west . The district accounts for 1.61% of the state's territory and shares 3.62% of the state's population. The climate of the district is warm and humid. The maximum and minimum temperatures range from 37.4°C to 17.7°C, respectively, and the annual average rainfall is approximately 1428mm[26] of which about 71% occurs in the monsoon season. The varying intensities of cyclones, drought and flood are the characteristic feature of the district.

Data collection:

To assess the diversity of aquatic and semi-aquatic angiosperms, the dispersed perennial wetlands of Bhadrak district, in the northeastern Odisha State, India, were selected for botanical surveys. Field surveys (from August 2018 to July 2020) were conducted fortnightly during the monsoon season, when aquatic plants grow most prolifically under seasonally wet conditions and monthly in other seasons (summer and winter). During field visits, plant samples were collected and photographs of plant species were taken from agricultural lands, marshy wastelands, canals, ponds, river banks and other relevant localities to cover almost all the district in a systematic manner. Data regarding the plant species were gathered mostly from local farmers,

elderly and knowledgeable persons through structured questionnaires, complemented by free interviews and informal conversations according to Martin (1995)[27] and Huntington (2000)[28]. Identification was done with the help of available floras [29] and with live specimens on the field itself. During the field study, some of the field characters like habit, habitat, flowering period, and local names if any were collected and recorded from the informants. The economic uses of these species if any were discussed with the local people. The plants were categorized according to their systematic positions following the APG III classification system.

**Results and Discussion**

The intensive floristic survey of aquatic and semi-aquatic angiosperms of Bhadrak district, Odisha from 2018 to 2020, registered 167 species (164 angiosperm and 3 pteridophytes), belonging to 119 genera (116 angiosperm and 3 pteridophytes), distributed over 50 families (48 angiosperm and 2 pteridophytes) (Table 1, fig. 1). The number of species reported in this study can be comparable with the studies of Adhikari and Babu (2008)[13], Mishra (2015)[30], Swamy et al. (2016)[31], Mandal et al. (2017)[32] and Panda et al. (2018)[24]. The most species-rich plant families were Poaceae (28 sp.) and Cyperaceae (19 sp.), followed by Acanthaceae, Amaranthaceae and Asteraceae (7 sp. each). The predominance of these families is also observed in several studies involving aquatic plants[20, 25]. The most frequent taxa were *Alternanthera philoxeroides* (Mart) Griseb., *Alternanthera sessilis* (L.)R.Br.ex DC., *Ammannia baccifera* L., *Aponogeton natans* (L.) Engl. & Krause, *Argemone mexicana* L., *Centella asiatica* (L.) Urb., *Chrysopogon aciculatus* (Retz.) Trin., *Commelina benghalensis* L., *Cyperus alopecuroides* Rottb. Descr., *Eclipta prostrata* (L.) L., *Eichhornia crassipes* Solms, *Hydrilla verticillata* (L.f.) Royle., *Hydrolea zeylanica* (L.) Vahl, *Hygrophila auriculata* (Schum.) Heine., *Ipomoea aquatica* Forssk., *Ipomoea carnea* Jacq., *Glinus oppositifolius* (L.) A.DC., *Limnophila indica* (L.) Druce, *Ludwigia adscendens* (L.) Hara, *Marsilea minuta* L. *Nymphaea nouchali* Burm. f., *Nymphaea pubescens* Willd., *Nymphoides hydrophylla* (Lour.) Kuntze, *Oxalis corniculata* L., *Pistia stratiotes* L., and *Typha angustata* Bory. & Chaub. Percentage of different life forms or biological spectrum was presented in (Fig. 2). Therophytes with 41.9% (70 species) was the highest life form followed by Hydrophytes (22.7%) and Chamaephyte (15%). Comparison of the percentage of life form classes shows that Therophyte is the dominant life form and is much higher as compared with the normal biological spectrum. With respect to life span, annual weeds with 103 species were the most diverse and the remaining were perennials. The results of the interviews revealed that the identified plants are used in various ways of life by the locals as classified in to different categories of applications such as treatment of diseases, food, fodder and other uses. Out of 167, about 32% of the species were used for the treatment of various ailments. In a major way, *Acanthus ilicifolius, Alternanthera sessilis, Argemone mexicana, Bacopa monnieri, Boerhavia diffusa, Centella asiatica, Colocasia esculenta, Cyperus rotundus, Enydra fluctuans, Glinus oppositifolius*, *Hygrophila auriculata, Ipomoea aquatica, Marsilea minuta, Oxalis corniculata, Phyllanthus amarus* were identified with therapeutic importance[33-38].

Local people in this region consumes aquatic plants, viz. *Alternanthera sessilis, Colocasia esculenta, Enydra fluctuans, Glinus oppositifolius, Hygrophila* auriculata *Ipomoea aquatica, Ludwigia adscendens, Marsilea minuta, Nelumbo nucifera,*

*Nymphaea pubescens, Monochoria hastata, Monocharia vaginalis Ottelia alismoides, Trapa natans,* as raw, boiled or fried

**Table 1.** List of aquatic and marshland flora recorded from Bhadrak district, arranged according to the Angiosperm Phylogeny Group Classification III.

| Family / Species | Common Name | Habitat | Life Span | Life Form | Uses | Abundance |
|---|---|---|---|---|---|---|
| **Acanthaceae** | | | | | | |
| *Acanthus ilicifolius* L. | Harkanch | Aquatic | P | Hel | Medicinal | ++ |
| *Hemigraphis hirta* (Vahl) T. Anders. | | Semi aquatic | P | Th | Medicinal | +++ |
| *Hygrophila auriculata* (Schum.) Heine. | Koelekha | Semi aquatic | P | Ch | Medicinal | +++ |
| *Hygrophila difformis* Blume | | Semi aquatic | A | Th | Fodder | ++ |
| *Justicia procumbens* L. | | Semi aquatic | A | Ch | Fodder | +++ |
| *Ruellia tuberosa* L. | | Moist loving | P | Th | Medicinal | +++ |
| *Rungia pectinata* (L.) Nees. | | Moist loving | A | Th | Not Known | +++ |
| **Aizoaceae** | | | | | | |
| *Trianthema portulacastrum* L. | Purinisaga | Moist loving | A | Th | Medicinal | +++ |
| **Alismataceae** | | | | | | |
| *Sagittaria sagittifolia* L. | | Aquatic | P | Hyd | Edible | + |
| **Amaranthaceae** | | | | | | |
| *Alternantheraparonychioides* A.St.-Hil | | Moist loving | P | Th | Fodder | ++ |
| *Alternanthera philoxeroides* (Mart) Griseb. | Ghoda-madaranga | Aquatic | P | Hyd | Fodder | +++ |
| *Alternanthera sessilis* (L.)R.Br.ex DC. | Madranga | Moist loving | P | Hyd | Medicinal, edible | +++ |
| *Amaranthus viridis* L. | Kantaneutia | Moist loving | A | Th | Medicinal, edible | +++ |
| *Celosia argentea* L. | Chulia | Moist loving | A | Ch | Medicinal | +++ |
| *Chenopodium album* L. | Bathuasaga | Moist loving | A | Th | Edible | ++ |
| *Gomphrena serrata* L. | | Moist loving | A | Th | Medicinal | +++ |
| **Amaryllidacea**e | | | | | | |
| *Crinum asiaticum* L. | Arsa | Moist loving | P | Cr | Medicinal | +++ |
| *Crinum defixum* | Kondai | Semi aquatic | P | Cr | Medicinal | +++ |
| **Apiaceae** | | | | | | |
| *Centella asiatica* (L.) Urb. | Thalkudi | Semi aquatic | P | Hem | Medicinal, edible | +++ |
| *Hydrocotyle sibthorpioides* Lam. | | Semi aquatic | P | Th | Not Known | +++ |
| **Aponogetonaceae** | | | | | | |
| *Aponogeton natans* (L.) Engl. & Krause | Jhechu | Aquatic | P | Hyd | Edible | +++ |

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| *Aponogeton undulatus* Roxb. | | Aquatic | P | Hyd | Edible | ++ |
| **Araceae** | | | | | | |
| *Alocasia macrorrhizos* (L.) G.Don | Badasaru | Semi aquatic | P | Cr | Edible | +++ |
| *Colocasia esculenta* (L.) Schott | Saru | Semi aquatic | P | Cr | Edible | +++ |
| *Pistia stratiotes* L. | Borajhanji | Aquatic | P | Hyd | Medicinal | +++ |
| *Spirodela polyrhiza* (L.) Schleid. | | Aquatic | P | Hyd | Not Known | +++ |
| *Wolffia globosa* (Roxb.) Hartog & Plas | | Aquatic | A | Hyd | Edible | + |
| **Asteraceae** | | | | | | |
| *Eclipta prostrata* (L.) L. | Bhrungaraj | Moist loving | A | Th | Medicinal | +++ |
| *Emila sonchifolia* (L.) DC. exWight. | Sarkara | Moist loving | A | Ch | Not Known | +++ |
| *Enydra fluctuans*Lour. | Hidmichi | Aquatic | A | Cr | Medicinal | ++ |
| *Grangea maderaspatana* (L.) Poir. | Painjari | Moist loving | A | Ch | Not Known | +++ |
| *Sphaeranthus indicus* L. | Bhuikadamba | Moist loving | A | Th | Not Known | +++ |
| *Spilanthes paniculata* Wall.ex. DC. | | Semi aquatic | A | Ch | Fodder | +++ |
| *Synedrella nodiflora* (L.) Gaertn. | Hemagra puspi | Moist loving | A | Th | Not known | +++ |
| **Boraginaceae** | | | | | | |
| *Heliotropium indicum* L. | Hatisundha | Moist loving | A | Th | Medicine | +++ |
| **Cleomaceae** | | | | | | |
| *Cleome viscosa* L. | Anasorisho | Semi aquatic | A | Th | Medicinal | +++ |
| **Commelinaceae** | | | | | | |
| *Commelina benghalensis* L. | Kansiri | Semi aquatic | A | Ch | Medicinal | +++ |
| *Commelina difusa* Burm.f | | Semi aquatic | A | Ch | Medicinal | +++ |
| *Cyanotis axillaris* (L) Schult. & Schult. f. | | Semi aquatic | A | Ch | Fodder | +++ |
| *Murdannia nudiflora* (L.) Brenan | Kanduli | Semi aquatic | A | Ch | Fodder | +++ |
| **Convolvulaceae** | | | | | | |
| *Ipomoea aquatica* Forssk. | Kalamasaga | Aquatic | A | Hyd | Medicinal, edible | +++ |
| *Ipomoea carnea* Jacq. | Badakalama | Semi aquatic | P | Th | Biofencing | +++ |
| *Evolvulus nummularis* L. | | Moist loving | A | Th | Not Known | ++ |
| *Merremia tridentata* (L.) Hall. f. | | Moist loving | A | Th | Fodder | ++ |
| **Crassulaceae** | | | | | | |
| *Kalanchoe pinnata* (Lam.) Pers. | Amarpoi | Moist loving | P | Th | Medicine | +++ |

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| **Cucurbitaceae** | | | | | | |
| *Mukia maderaspatana* (L.) Roem. | | Moist loving | A | Th | Medicinal | ++ |
| **Cyperaceae** | | | | | | |
| *Cyperus alopecuroides* Rottb. Descr. | Hensuati | Semi aquatic | P | Th | Artifact | +++ |
| *Cyperus brevifolius* (Rottb.) Hassk. | | Semi aquatic | P | Cr | Fodder | ++ |
| *Cyperus castaneus* Willd. | | Semi aquatic | A | Th | Fodder | ++ |
| *Cyperus compressus* L. | | Semi aquatic | A | Hel | Fodder | ++ |
| *Cyperus corymbosus* Rottb. | | Semi aquatic | P | Hel | Not Known | +++ |
| *Cyperus difformis* L. Cent. | Swonli | Semi aquatic | A | Ch | Fodder | ++ |
| *Cyperus distans* L.f. | | Semi aquatic | P | Ch | Not Known | ++ |
| *Cyperus iria* L. | | Semi aquatic | A | Ch | Fodder | +++ |
| *Cyperus rotundus* L. | Mthaghas | Semi aquatic | P | Hem | Medicinal | +++ |
| *Eleocharis acutangula* (Roxb.) Schult.& Schult. | | Semi aquatic | P | Cr | Not known | +++ |
| *Eleocharis dulcis* (Burm.f.) Henschef | | Semi aquatic | A | Cr | Not known | +++ |
| *Fimbristylis dichotoma* (L.) Vahl | | Semi aquatic | A | Ch | Fodder | +++ |
| *Fimbristylis ferruginea* (L.) Vahl | | Semi aquatic | P | Hem | Fodder | +++ |
| *Fimbristylis miliacea*(L.) Vahl | Swanli | Semi aquatic | A | Hem | Fodder | +++ |
| *Fimbristylis ovata* (Burm.f.) JKern. | | Semi aquatic | A | Hem | Fodder | +++ |
| *Fuirena ciliaris* (L.) Roxb. | | Semi aquatic | A | Th | Fodder | ++ |
| *Kylinga nemoralis* (J.R. & G. Forst) Dandy ex Hutch. & Dalz. | | Semi aquatic | P | Th | Not Known | +++ |
| *Scirpus articulatus* L. | Kanri | Semi aquatic | A | Hem | Not Known | +++ |
| *Scirpus grossus* L. | Santara | Semi aquatic | P | Cr | Not Known | +++ |
| **Eriocaulaceae** | | | | | | |
| *Eriocaulon cinereum* R.Br. | | Aquatic | A | Th | Not Known | +++ |
| **Euphorbiaceae** | | | | | | |
| *Chamaesyce hirta* (L.)Millsp. | | Semi aquatic | A | Th | Medicinal | +++ |
| *Euphorbia heterophyla* L. | | Moist loving | A | Th | Not known | +++ |
| **Fabaceae** | | | | | | |
| *Aeschynomene indica* L. | Sola | Aquatic | A | Cr | Not Known | ++ |
| *Aeschynomene aspera* L. | Sola | Aquatic | A | Cr | Artifact | +++ |
| *Alysicarpus monilifer* (L.)DC. | | Semi aquatic | A | Th | Fodder | ++ |
| *Crotalaria prostrata* Rottl. exWilld. | Bishnukarni | Semi aquatic | P | Th | Fodder | +++ |
| *Crotalaria pallida* Aiton | Junjunka | Semi aquatic | P | Th | Medicinal | +++ |

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| *Crotalaria quinquefolia L.* | | Semi aquatic | A | Th | Medicinal | ++ |
| *Desmodium triflorum* (L.) DC. | Kaansisna | Moist loving | A | Th | Fodder | +++ |
| *Melilotus indica* (L.) All | Bana methi | Moist loving | A | Th | Fodder | ++ |
| *Neptunia oleracea* Lour. | | Aquatic | P | Hyd | Edible | ++ |
| **Hydrocharitaceae** | | | | | | |
| *Blyxa echinosperma* (C.B.CL.) Hook.f. | | Aquatic | P | Hyd | Not Known | +++ |
| *Hydrilla verticillata* (L.f.) Royle. | Chingudiadala | Aquatic | P | Hyd | Medicinal | +++ |
| *Najas indica* (Willd.) Cham. | | Aquatic | P; | Hyd | Not Known | +++ |
| *Ottelia alismoides* (L.) Pers. | Panikundri | Aquatic | P | Hyd | Medicinal, edible | ++ |
| *Vallisneria natans* (Lour.) H.Hara | | Aquatic | A | Hyd | Edible | + |
| **Hydroleaceae** | | | | | | |
| *Hydrolea zeylanica* (L.) Vahl | Languliya | Semi aquatic | A | Hyd | Fodder | +++ |
| **Lamiaceae** | | | | | | |
| *Anisomeles indica* (L.) O. Kuntze. | | Moist loving | P | Th | Medicinal | +++ |
| *Leucas aspera* (Willd.) Link. | Gaiso | Moist loving | P | Ch | Medicinal | +++ |
| **Lentiburariaceae** | | | | | | |
| *Urticularia stelaris* L.f. | Bhaturia dala | Aquatic | A | Hyd | Not Known | +++ |
| **Lythraceae** | | | | | | |
| *Ammannia baccifera* L. | Ramdauni | Semi aquatic | A | Th | Fodder | +++ |
| *Ammannia multiflora* Roxb. | | Aquatic | A | Th | Fodder | ++ |
| *Rotala indica* (Willd.) Koehne | | Aquatic | A | Th | Fodder | +++ |
| *Rotala rosea (*Poir.) C.D.K. Cook | | Semi aquatic | A | Th | Fodder | ++ |
| *Trapa natans* L. | | Aquatic | P | Hyd | Edible | + |
| **Malvaceae** | | | | | | |
| *Corchorus aestuans* L. | Bananalita | Moist loving | A | Th | Medicinal | +++ |
| *Corchorus olitorius* L. | | Moist loving | A | Th | Not Known | +++ |
| *Melochia corchorifolia* L. | Telpuri | Moist loving | **A** | Th | Not Known | +++ |
| **Menyanthaceae** | | | | | | |
| *Nymphoides hydrophylla* (Lour.) Kuntze | | Aquatic | P | Hyd | Edible | ++ |
| *Nymphoides indicum* (L.) Kuntze | | Aquatic | P | Hyd | Edible | + |
| **Molluginaceae** | | | | | | |
| *Glinus oppositifolius* (L.) A.DC. | Pitasaga | Moist loving | A | Th | Medicinal, edible | +++ |
| **Nelumbonaceae** | | | | | | |
| *Nelumbo nucifera* Gaertn. | Padma | Aquatic | P | Hyd | Medicinal, edible | ++ |
| **Nyctaginaceae** | | | | | | |
| *Boerhavia diffusa* L. | Puruni | Moist loving | P | Th | Medicina | +++ |

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|---|---|---|---|---|---|---|
| | | | | | l, edible | |
| **Nymphaeaceae** | | | | | | |
| *Nymphaea nouchali* Burm. f. | NilaKain | Aquatic | P | Hyd | Medicina l, edible | +++ |
| *Nymphaea pubescens* Willd. | Dhalakain | Aquatic | P | Hyd | Edible | +++ |
| *Nymphaea rubra* Roxb.ex Salisb | Nalikain | Aquatic | P | Hyd | Edible | ++ |
| *Euryale ferox* Salisb. | Kantapadma | Aquatic | P | Hyd | Medicina l | + |
| **Onagraceae** | | | | | | |
| *Ludwigia adscendens* (L.) Hara | Jagal | Aquatic | A | Hyd | Medicina l, edible | +++ |
| *Ludwigia hyssopifolia* (G.Don) | | Semi aquatic | A | Hyd | Medicina l, edible | +++ |
| *Ludwigia octovalvis* (Jacq.) Raven | | Semi aquatic | A | Hyd | Medicina l | +++ |
| *Ludwigia perennis* L. | Latkera | Semi aquatic | A | Hyd | Fodder | ++ |
| **Orobanchaceae** | | | | | | |
| *Centranthera tranquebarica* (Spreng.) Merr. | | Semi aquatic | A | Th | Fodder | + |
| **Oxalidaceae** | | | | | | |
| *Oxalis corniculata* L. | Ambiliti | Semi aquatic | P | Cr | Medicina l, edible | +++ |
| **Papaveraceae** | | | | | | |
| *Argemone mexicana* L. | Kanta-kusuma | Semi aquatic | A | Th | Medicina l | +++ |
| **Phyllanthaceae** | | | | | | |
| *Phyllanthus amarus* Schum.&Thonn. | Bhuianla | Moist loving | A | Th | Medicina l | +++ |
| *Phyllanthus urinaria* L. | Bhuiamla | Moist loving | A | Th | Medicina l | +++ |
| **Piperaceae** | | | | | | |
| *Peperomia pellucida* (L.) Kunth | | Moist loving | A | Hem | Medicina l | +++ |
| **Plantaginaceae** | | | | | | |
| *Limnophila heterophylla* (Roxb.) Benth. | | Aquatic | A | Hyd | Fodder | ++ |
| *Limnophila indica* (L.) Druce | | Aquatic | A | Hyd | Fodder | +++ |
| *Mecardonia procumbens* (Mills.) Small | | Moist loving | A | Ch | Not Known | +++ |
| *Scoparia dulcis* L. | Chirarita | Moist loving | P | Ch | Not Known | +++ |
| **Poaceae** | | | | | | |
| *Brachiaria mutica* (Forssk.) Stapf. | | Semi aquatic | P | Th | Fodder | +++ |
| *Brachiaria reptans* (L.) Garde. & Hubb. | | Moist loving | A | Ch | Fodder | +++ |
| *Chrysopogon aciculatus* (Retz.) Trin. | Guguchia | Semi aquatic | P | Cr | Medicina l | +++ |
| *Coix lacryma-jobi* L. | Gargara | Semi aquatic | A | Hyd | Fodder | ++ |
| *Dactyloctenium aegyptium* (L.) P. Beauv. | Kakhuriya | Semi aquatic | A | Hem | Fodder | +++ |
| *Echinochloa colona* (L.) Link | Swanghas | Aquatic | A | Th | Edible | +++ |
| *Echinochloa crusgalli*(L.) P. | Dhera | Semi aquatic | A | Th | Edible, | +++ |

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|---|---|---|---|---|---|---|
| Beauv. | | | | | fodder | |
| *Echinochloa stagnina* (Retz) P. Beauv. | Jhipa | Aquatic | A | Th | Fodder | +++ |
| *Eleusine indica* (L.) Gaertn. | Anamandia | Semi aquatic | A | Hem | Fodder | +++ |
| *Eragrostis ciliata* (Roxb)Nees. | | Semi aquatic | P | Cr | Fodder | +++ |
| *Eragrostis gangetica* (Roxb.) Steud. | Kankra chare | Semi aquatic | A | Cr | Fodder | +++ |
| *Heteropogon contortus* (L.) P. Beauv. | Dauria | Semi aquatic | P | Cr | Fodder | +++ |
| *Imperata cylindrica* (L.) Raeusch. | Chhana ghas | Semi aquatic | P | Hem | Fodder | +++ |
| *Isachne globosa* (Thunb.) Kuntze | | Semi aquatic | A | Th | Fodder | +++ |
| *Ischaemum rugosum* Salisb. | Tuli | Semi aquatic | A | Hem | Fodder | +++ |
| *Leptochloa chinensis* (L.) Nees. | Bhuru | Semi aquatic | A | Hem | Fodder | +++ |
| *Myriostachya wightiana* (Nees ex Steud.) Hook.f. | | Semi aquatic | P | Hel | Fodder | ++ |
| *Oryza rufipogon* Griff. | Balunga | Semi aquatic | P | Th | Fodder | +++ |
| *Panicum psilopodium* Trin. | | Moist loving | A | Th | Fodder | +++ |
| *Panicum repens* L. | Reda | Semi aquatic | P | Th | Fodder | +++ |
| *Paspalum distichum* L. | | Semi aquatic | P | Th | Fodder | +++ |
| *Phragmites karka* (Retz.) Trin.ex Steud. | Noto | Aquatic | A | Th | Fodder | +++ |
| *Saccharum spontaneum* L. | Kashatundi | Semi aquatic | P | Hel | Fodder | +++ |
| *Setaria intermedia* Roem. & Schult. | | Semi aquatic | A | Th | Fodder | ++ |
| *Setaria pumila* (Poir.) Roem. & Schult. | Sial legunda | Moist loving | A | Th | Fodder | +++ |
| *Setaria verticillata* (L.) P. Beauv. | | Moist loving | A | Th | Fodder | +++ |
| *Sporobolus indicus* (L.) R. Br. | Kankra chara | Semi aquatic | P | Th | Not Known | +++ |
| *Chrysopogon zizanioides* (L.) Roberty [=*Vetiveria zizanioides* (L.) Nash] | Bena | Semi aquatic | P | Th | Artifact | +++ |
| **Polygonaceae** | | | | | | |
| *Polygonum barbatum* L. | Nara | Semi aquatic | A | Th | Edible | +++ |
| *Polygonum glabrum* (Willd.) M.Gomez | | Semi aquatic | A | Th | Edible | +++ |
| *Polygonum plebeium* R.Br. | Muthisaga | Semi aquatic | A | Th | Medicinal, edible | +++ |
| **Pontederiaceae** | | | | | | |
| *Eichhornia crassipes* Solms | Bilatidala | Aquatic | P | Hyd | Not Known | +++ |
| *Monocharia hastata* Solm-Laub. | | Aquatic | A | Hyd | Edible | + |
| *Monocharia vaginalis* (Burm. f.) C. Presl. | | Aquatic | A | Hyd | Edible | + |
| **Portulacaceae** | | | | | | |
| *Portulaca oleracea* L. | Badabalbaula | Semi aquatic | A | Ch | Medicinal, edible | +++ |
| *Portulaca quadrifida* L. | Balbaula | Semi aquatic | A | Ch | Edible | ++ |
| **Rubiaceae** | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Dentella repens* (L.) J.R. &Forst. | | Semi aquatic | A | Th | Fodder | +++ |
| *Hedyotis corymbosa* (L.) Lam. | Jarjati | Moist loving | A | Ch | Medicinal | +++ |
| *Spermacoce articularis* L.f. | Solaganthi | Moist loving | A | Ch | Fodder | +++ |
| **Scrophulariaceae** | | | | | | |
| *Bacopa monnieri* (L.) Pennell. | Brahmi | Moist loving | A | Ch | Medicinal | +++ |
| *Lindernia antipoda* (L) Alston. | | Moist loving | A | Th | Fodder | +++ |
| *Lindernia crustacea* (L.)F.v.Muell. | | Moist loving | A | Th | Not Known | +++ |
| **Sphenocleaceae** | | | | | | |
| *Sphenoclea zeylanica* Gaerntn. | Panimircho | Semi aquatic | A | Hyd | Fodder | ++ |
| **Typhaceae** | | | | | | |
| *Typha angustata* Bory. & Chaub | Hangla | Aquatic | P | Ph | Medicinal | +++ |
| **Verbenaceae** | | | | | | |
| *Phyla nudiflora* (L.) Greene | | Moist loving | A | Th | Fodder | +++ |
| *Lippia javanica* (Burn.f)Spreng | Naguari | Moist loving | P | Ch | Medicinal | +++ |
| **Violaceae** | | | | | | |
| *Hybanthus enneaspermus* (L.) F. v. Muell. | Madan mastak | Semi aquatic | A | Ch | Medicinal | +++ |
| **Xyridaceae** | | | | | | |
| *Xyris indica* L. | | Semi aquatic | A | Th | Fodder | ++ |
| **Pteridophyte** | | | | | | |
| *Azolla pinnata* R.Br. Salviniaceae | | Aquatic | A | Hyd | Not known | ++ |
| *Marsilea minuta* L. Marsileaceae | Sunsunia | Aquatic | P | Hyd | Edible, medicinal | +++ |
| *Salvinia molesta* D.Mitch. Salviniaceae | | Aquatic | A | Hyd | Not Known | ++ |

Abbreviations: A: Annual, P: Perennial, Ch: Chamephyte, Cr: Cryptophyte, Hem: Hemicryptophyte, Ph: Phanerophyte, Hel: Helophytes, Hyd: Hydrophyte, Th: Therophyte, + rare, ++ common, +++ abundant.

vegetables. Similar observations were made from habitual uses of the wetlands of South Odisha (Mishra et al. 2012)[39]. People of Zeiling tribe of Nagaland have been reported to consume *Centella asiatica, Colocasia esculenta* as a vegetable[40]. The most significant fodder species were *Echinochloa crus-galli, Echinochloa stagnina* and *Alternanthera. philoxeroides*. *E. crus-galli* and *E. stagnina* are considered as a source of protein as well as additives to the fodder for animals[41]. The use of *Alternanthera philoxeroides* as forage for animals is also reported[42]. Plant species such as *Aeschynomene aspera* L., *Vetiveria zizanioides* (L.) Nash. and *Cyperus alopecuroides* Rottb. Descr. are utilized by the artisans to produce artifact items. Similar observations have also been made in earlier studies [43, 44].

Some of the reported wild edible plant species such as *Colocasia esculenta* (L.) Schott., *Glinus oppositifolius* (L.) A.DC., *Ipomea aquatica* Forssk., *Marsilea minuta* L. and *Trapa natans* (L.) Roxb. are found to be sold in the local markets (Fig. 3 and 4) particularly by poor and economically marginalised families, thereby generating a supplementary income to their household economy. The selling prices varied with

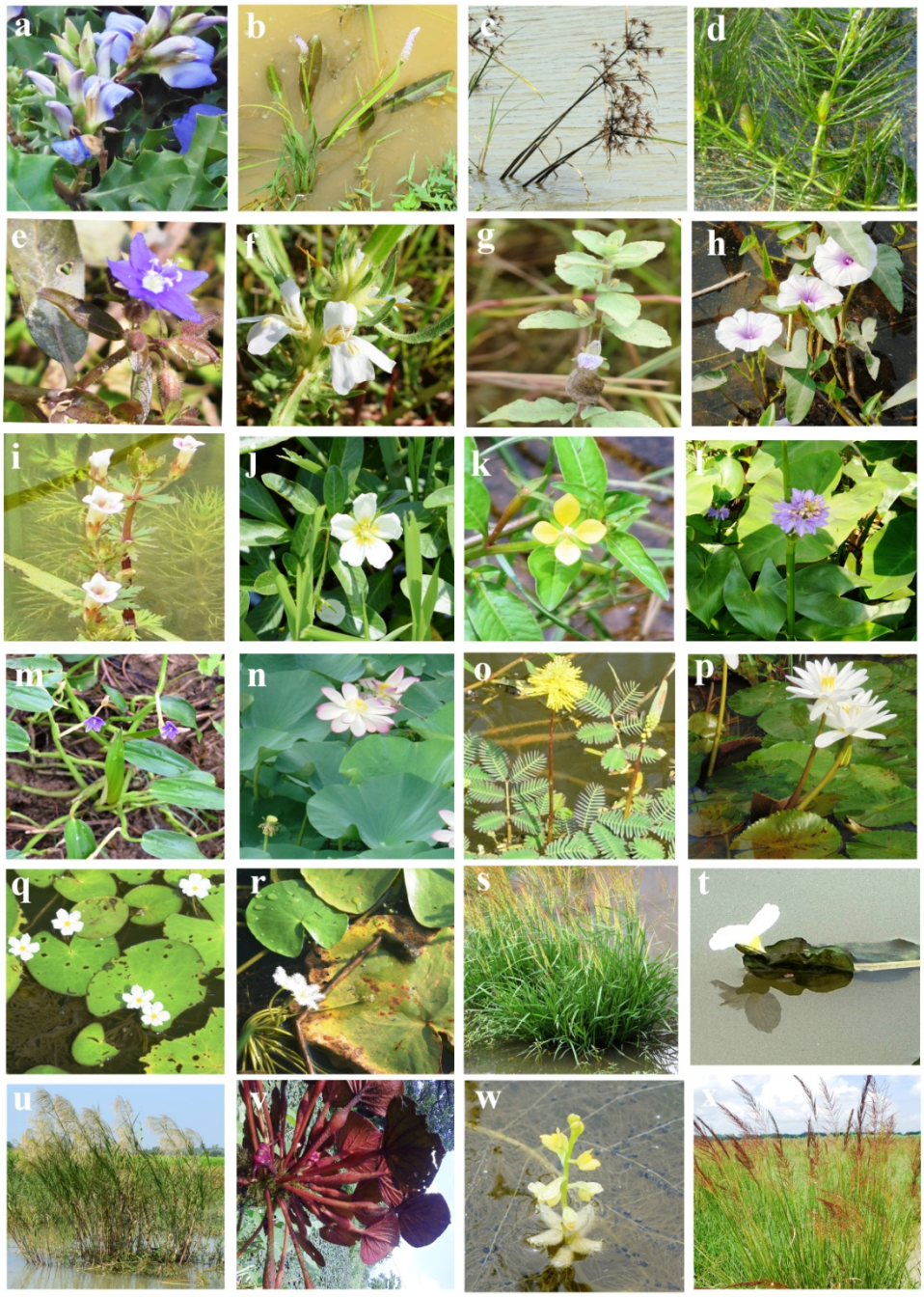


**Figure 1. a.** *Acanthus ilicifolius* L. **b.** *Aponogeton natans* (L.) Engl. & Krause **c.** *Cyperus alopecuroides* Rottb. Descr. **d.** *Hydrilla verticillata* (L.f.) Royle. **e.** *Hydrolea zeylanica* (L.) Vahl **f.** *Hygrophila auriculata* (Schum.) Heine. **g.** *Hygrophila difformis* Blume **h.** *Ipomoea aquatica* Forssk **i.** *Limnophila heterophylla* (Roxb.) Benth. **j.** *Ludwigia adscendens* (L.) Hara **k.** *Ludwigia perennis* L. **l**. *Monocharia hastata* Solm-Laub. **m.** *Monocharia vaginalis* (Burm. f.) C. Presl **n.** *Nelumbo nucifera* Gaertn. **o.** *Neptunia oleracea* Lour. **p.** *Nymphaea pubescens* Willd. **q.** *Nymphoides hydrophylla* (Lour.) Kuntze **r.** *Nymphoides indicum* (L.) Kuntze **s.** *Oryza rufipogon* Griff. **t.** *Ottelia alismoides* (L.) Pers. **u.** *Phragmites karka* (Retz.) Trin. ex Steud. **v.** *Trapa natans* L. **w**. *Urticularia stelaris* L.f. **x.** *Vetiveria zizanioides* (L.) Nash.

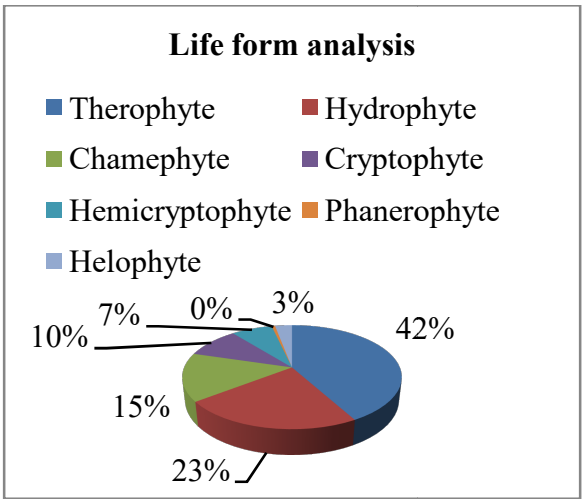


**Figure 2.** Distribution of life-form in Bhadrak district

**Figure 3.** Selling of *Glinus oppositifolius* (L.) A.DC. in local market

**Figure 4.** Selling of *Marsilea minuta* L. in local market

species, with season and market to market. The selling of *Glinus oppositifolius, Ipomoea aquatica* and *Marsilea minuta* in the local markets was also reported by

**Figure 5.** *Eichhornia crassipes* Solms an alien invasive weed spreading expansively in a pond

**Figure 6.** *Ipomoea carnea* Jacq. an alien invasive weed spreading in a canal

**Figure 7.** *Pistia stratiotes* L. an alien invasive, aggressive weed covering the pond

Srivastava et al. (2018)[45]. The author also observed people are collecting wild food plants notably during their growing season, and travels on foot between villages for its sell. It is worth noting that several young adults among the settled population do not

have familiarity with wild plants whereas most adults and old people do. They still remember plant names and their use in local diet. So this knowledge may get lost forever in the near future, not being passed on to the new generations, who have changed their way of living and do not need any more to know about the natural environment and its resources.

Presence of *Eichhornia crassipes*, *Ipomoea carnea* and *Pistia stratiotes* indicated a clear sign of invasion of alien species in the studied area (Fig. 5-7). Quantitative and qualitative floristic survey, constant monitoring and protection of aquatic ecosystems are the need of the hour in order to save the native biota, to maintain the quality of drinking water, and disqualify the efforts of alien species to invade. To control the proliferation of *Ipomoea*, stems may be cut randomly after a gap of two months, which will not affect the ecosystem. The method of control of expansive alien species in the present study is manual removal. This method is still practiced in developing countries[46]. Moreover, this method of control is effective only for small infestations, as it is labour-intensive and offers only a short-term solution because the long-lived seeds are able to germinate and hence reinflux occurs rapidly [47].

Local aquatic plants diversity can be influenced by many factors such as hydrological alteration, habitat loss, over-grazing, high human population pressure, global climate change, an inappropriate economic development policy. Among them, the largest threat to aquatic plants biodiversity may be habitat loss due to hydrological alteration. Many ponds of the study area are converted to homestead land. Several studies have highlighted high rates of land-use change in the last 50 years which has been associated with human population growth and processes such as urbanization and residential and commercial development that have directly and indirectly affected the freshwater habitats, as well as their structure and functions[48, 49]. There is a consensus among many scientists that the earth's climate is changing and will continue to change at an increasingly rapid pace[50]. Evidence of the damaging effects is already clear and likely to increase in both direct and indirect ways causing changes in species, phenology, range, and community composition [51-53].

**Conclusion**

There is a rich and diversified flora of aquatic plants in Bhadrak district, evidenced by the number of recorded taxa and variety of life forms. In order to conserve the aquatic plants biological resources and biodiversity in this region, some strategies and measures must be suggested including strengthening scientific research and biodiversity education in the local people, balancing economic development and ecological conservation.

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