Diversity of wetland plants used traditionally in China: a literature review

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Abstract

Background: In comparison with terrestrial plants, those growing in wetlands have been rarely studied ethnombotanically, including in China, yet people living in or near wetlands can accumulate much knowledge of the uses of local wetland plants. A characteristic of wetlands, cutting across climatic zones, is that many species are widely distributed, providing opportunities for studying general patterns of knowledge of the uses of plants across extensive areas, in the present case China. There is urgency in undertaking such studies, given the rapid rates of loss of traditional knowledge of wetland plants as is now occurring.

Methods: There have been very few studies specifically on the traditional knowledge of wetland plants in China. However, much information on such knowledge does exist, but dispersed through a wide body of literature that is not specifically ethnobotanical, such as regional Floras. We have undertaken an extensive study of such literature to determine which species of wetland plants have been used traditionally and the main factors influencing patterns shown by such knowledge. Quantitative techniques have been used to evaluate the relative usefulness of different types of wetland plants and regression analyses to determine the extent to which different quantitative indices give similar results.

Results: 350 wetland plant species, belonging to 66 families and 187 genera, were found to have been used traditionally in China for a wide range of purposes. The top ten families used, in terms of numbers of species, were Poaceae, Polygonaceae, Cyperaceae, Lamiaceae, Asteraceae, Ranunculaceae, Hydrocharitaceae, Potamogetonaceae, Fabaceae, and Brassicaceae, in total accounting for 58.6% of all species used. These families often dominate wetland vegetation in China. The three most widely used genera were Polygonum, Potamogeton and Cyperus. The main uses of wetlands plants, in terms of numbers of species, were for medicine, food, and forage. Three different ways of assigning an importance value to species (Relative Frequency of Citation RFC; Cultural Importance CI; Cultural Value Index CV) all gave similar results.

Conclusions: A diverse range of wetland plants, in terms of both taxonomic affiliation and type of use, have been used traditionally in China. Medicine, forage and food are the three most important categories of use, the plants providing basic resources used by local people in their everyday lives. Local availability is the main factor influencing which species are used. Quantitative indexes, especially Cultural Value Index, proved very useful for evaluating the usefulness of plants as recorded in the literature.

Keywords: Wetland plants, Traditional knowledge, Literature study, China
Background

Traditional knowledge of plants has played an important role in people's lives historically and has the potential to continue to contribute much in the future for the sustainable development of societies and economies [1-3]. However, as with biodiversity, traditional knowledge is becoming endangered with the danger of being total loss [4,5]. There are many causes of such endangerment, including changes occurring in the environment [6], urbanization and economic globalization [7,8]. Urbanization is one of the most important factors globally causing loss of traditional knowledge [7,8].

In contrast with terrestrial ecosystems, wetlands have been poorly studied ethnobotanically, even though, for people living in and around wetlands, wild wetland plants play important roles in their daily lives [9-12]. Plants are collected from wetlands for a wide variety of purposes, such as provision of medicine, food and building materials and to sell for cash income [9,11,13]. Wetlands are very susceptible to loss or degradation through urbanization [14-16], which can change their extent and species composition and lead to the loss of biodiversity [17-19]. Traditional knowledge about wetlands is declining along with wetland degradation and alteration [11,12], an inevitable trend given the accelerating rate of urbanization that is now occurring.

Wetlands are widely distributed throughout China, but especially common in the east and south [20], where there are particularly rich traditions of local knowledge about the uses of their plants. There has been little ethnobotanical research specifically on wetland plants, but much information on traditional uses of wetland plants nevertheless does exist, though scattered through regional floras and other types of publication. Like traditional ethnobotanical knowledge generally, that concerned with wetland plants is becoming [11]. Ethnobotanical research on people's knowledge of wetland plants in China is urgently needed.

Currently, most ethnobotanical research concerned with any habitat type (not just wetlands) is conducted on the basis of case studies undertaken at specific field locations. The results of such studies are important for understanding relationships between local people and their environments, including sometimes for providing guidance on the sustainable use of plants and their conservation. However, case studies unavoidably emphasize unique local features of the relationships between people and their environments [21]. There is a role for systematic reviews and meta-analyses on wider regional to international scales to investigate general patterns of knowledge and use relating to plants, including to provide contexts for local-level studies [21-25].

Quantitative methods have been successfully applied in ethnobotanical studies, especially in the evaluation of cultural value or importance of species [11,24,26]. However, most quantitative methods have been developed for the analysis of case studies based on field work. Which of these methods is most suitable for systematic reviews or meta-analyses remains little studied, with little published information available.

In this paper, we aim to answer the following questions through a study of the literature: 1. What are the botanical characteristics of wetland plants traditionally considered useful in China? 2. What are the main factors influencing the patterns of use of wetland plants in China? 3. Which of the available quantitative indexes is most suitable for evaluating traditional knowledge, as determined from the literature?

Methods

Data collection

Two criteria were used to identify the species included in this analysis. First, the species had to be wetland plants; we took the definition of a wetland as that given in the Convention on Wetlands of International Importance especially as Waterfowl Habitat (1971). Second, the species had to have been recorded as having traditional use. In this paper, we only paid attention on vascular plants. There have been very few systematic ethnobotanical studies conducted on wetlands in China. Most of the available ethnobotanical information on wetland plants is scattered sporadically through various publications, such as national and provincial floras, economic floras, and papers published in scientific journals. Our approach has been to identify, so far as we were able, all sources of potential information on wetland plants and then to search through this literature to compile an ethnobotanical inventory of wetland plants. Then we used the scientific names of the plants as key words to search further information on traditional use in the China Science and Technology Journal Database. The total number of principal literature sources studied was 56 [27-82].

Based on records in the literature, we classified uses into 11 groups: medicine, fodder, food, green manure, fiber, ornamental, liquor-making, environmental, industrial raw material, pesticide, and other. The medicine category includes plants used for treating animal as well as human diseases. Fodder refers to plants eaten by domestic animals. Edible plants are those as human food either in a raw or processed state. Green manure refers to plants employed as fertilizer. Fiber plants are those yielding fibers used by people; there are various ways in which they are extracted from the plants. Ornamental plants are those planted deliberately to beautify the environment. Liquor-making plants are those yielding either basic ingredients or supplementary materials used in making traditional liquor. The environmental category refers to plants used in soil conservation or the stabilization of dams. The industrial raw material category includes those plants providing raw materials for industrial production, such as for the manufacture of
essential oils. Although not a typical traditional use, such plants can provide local people with sources of cash income and thus is important category of use for some people. The pesticide category refers to plants used for killing or driving away pests such as insects. Uses other than those in the above ten categories are grouped together in ‘other’.

**Data analysis**

Use Value (UV) is a widely used statistic employed by ethnobotanists to provide a measure of the relative usefulness of plants to people [24,83]. In this paper, we use the formula $UV_i = \sum U_i / n$ to calculate the use value of each species (i), $U_i$ referring to the number of categories of use mentioned for a species in a particular literature source and n the total number of literature sources mentioning the species [23,24,84]. For example, if two literature sources (n = 2) mention species i, with three use categories mentioned in the first source and one in the second, then $UV_i = (3 + 1) / 2 = 2$.

Family Use Value (FUV), a statistic developed by Phillips and Gentry [83], provides a measure of the relative usefulness of plant families. FUV for a particular family (j) is calculated using the formula $FUV_j = \sum (UV_{ij}) / n$, where $UV_{ij}$ is the use value of species i and n is the number of species in the family.

The statistic Relative Frequency of Citation (RFC) is used as a measure of consensus between the information provided by different literature sources. RFC is similar conceptually to that of Utilization Frequency proposed by Ladio and Lozada [85]. RFC for a species is calculated as $RFC_i = FC_i / N$ [24], where $FC_i$ is the number of literature sources mentioning species i and N the total number of literature sources consulted (N = 56 in the present case).

The cultural value (or importance value) of species in a given culture and the comparative importance of species interculturally are receiving growing attention in ethnobotanical studies, especially those concerned with medicinal plants [24,25,86,87]. Here, measures of cultural value for wetland plant in China are provided by the statistics Cultural Importance Index (CI) and Cultural Value Index (CV), based on formulae given in Tardio & Pardo-de-Santayana and Reyes-Garcia et al. [24,26].

Finally, regression analysis has been used to determine the relationships between RFC, CI and CV.

**Results**

**Diversity of the useful wetland plants in China**

A total of 350 wetland plant species (including 5 varieties), belonging to 66 families and 187 genera, were recorded as used in China according to the survey. The average number of species recorded per family was 5.3, with 15 families (22.7% of the total) having more species than the average (Table 1). The ten families (Poaceae, Polygonaceae, Cyperaceae, Lamiaceae, Asteraceae, Ranunculaceae, Hydrocharitaceae, Potamogetonaceae, Fabaceae, and Brassicaceae) contributed 58.6% of all species, the 5 with the highest number of species being Poaceae (46 species; 13.1% of the total), Polygonaceae (9.1%), Cyperaceae (8.3%), Lamiaceae (5.7%), and Asteraceae (5.1%). Twenty-five families (37.9% of the total) were represented by only one useful species each. The remaining 33 families contributed between 2 and 11 species each (0.6-3.1% of the total).

Some taxa were obviously dominant at the generic level, with 32 genera (17.1% of the total) being represented by 3 or more species. The top scorer was *Polygonum* (24 species), followed by: *Potamogeton* (12); *Cyperus* (10); *Scirpus* and *Rumex* (both 7); *Ranunculus* (6); *Carex*, *Eriocaulon*, *Echinocloa*, *Cardamine*, and *Potentilla* (all 5); *Blyxa*, *Bromus*, *Eleocharis*, *Equisetum*, *Lysimachia*, *Najas*, *Paspalum*, *Stachys*, *Trapa*, and *Typha* (all 4); and then *Alisma*, *Arisaema*, *Clematis*, *Lersia*, *Ludwigia*, *Miscanthus*, *Monochoria*, *Murdannia*, *Oenanthe*, *Plantago*, and *Rorippa* (all 3). The dominant genera belonged to the same families as scored highest at the family level, for example *Polygonaceae*, *Cyperaceae*, *Potamogetonaceae*, *Poaceae*, *Hydrocharitaceae* and *Ranunculaceae*.

Scores for Family Use Value (FUV) fell between 1 (for 14 families and 3.2 (*Cucurbitaceae*) (Table 1). The top 10 families according to this measure (all with FUV >20) were completely different from those scoring highly according to number of species. There was no obvious correlation between FUV and number of species used per family. All top 10 families based on FUV were families with few wetland species (3 or fewer). However, there were also families having few species with low FUV scores.

**Characteristics of traditional use of wetland plants**

Medicine, fodder and food were the main uses made of wetland plants according to number of species (Table 2). Seventy percent of all species were recorded to be of medicinal use, nearly half were employed as forage and somewhat fewer as food. Fewer plants were recorded as employed for green manure, fiber, or as sources of raw materials for industry, but all these were noticeably important types of use. The other five categories of use accounted for only a small proportion of total uses. Twenty-six species (7.4% of all species) provided insecticides and 22 species (6.3%) were employed in the making of liquor. Several plants were sold for cash, such as species of *Polygonum*, among others. The ‘Other’ category included some plants used for skin care, such as *Coix lacryma-jobi* and *Zizania latifolia*, and others in house construction, such as *Arundo donax*, *Miscanthus sacchariflorus*, and *Phragmites australis*. Although few species were included in the construction category, nevertheless wetland plants used in construction can be of major importance to local people.
Different families made very different contribution to different use categories (Figure 1). Over half of the families contributed to the top three categories that were medicine (97% of families), food (62.1%) and forage (59.1%); about one-third contributed to each of green manure, ornamental, and industrial use. However, other categories of use were more obviously concentrated within certain families. For example, fewer than 20% of families contributed to fiber use, pesticides, liquor-making, or environmental use. Nearly half of species providing pesticides were in the Polygonaceae and 54.2% of those used for environmental protection (such as preventing soil erosion and stabilizing dams) in the Poaceae. Species of the Poaceae and Cyperaceae contributed greatly to the fiber group (63.5% of all species so used), while those in the Polygonaceae, Poaceae, and Trapaceae were well represented in liquor-making (54% of species used). Genera showed similar patterns to those shown by families. The results as a whole showed that the top three use categories of medicine, food and forage made

### Table 1 The taxonomic composition of wetland plants used traditionally and family use values (FUV) based on literature research

| Family            | No. of genus (%) | No. of Species (%) | FUV  |
|-------------------|------------------|--------------------|------|
| Poaceae           | 27 (14.4)        | 46 (13.1)          | 1.59 |
| Polygonaceae      | 3 (1.6)          | 32 (9.1)           | 1.57 |
| Cyperaceae        | 6 (3.2)          | 29 (8.3)           | 1.34 |
| Lamiaceae         | 14 (7.5)         | 20 (5.7)           | 1.25 |
| Asteraceae        | 14 (7.5)         | 18 (5.1)           | 1.30 |
| Ranunculaceae     | 6 (3.2)          | 14 (4.0)           | 1.10 |
| Hydrocharitaceae  | 6 (3.2)          | 13 (3.7)           | 1.51 |
| Potamogetonaceae  | 1 (0.5)          | 12 (3.4)           | 1.33 |
| Fabaceae          | 11 (5.9)         | 11 (3.1)           | 1.97 |
| Brassicaceae      | 4 (2.1)          | 10 (2.9)           | 1.81 |
| Apiaceae          | 5 (2.7)          | 7 (2.0)            | 1.38 |
| Arecaceae         | 5 (2.7)          | 7 (2.0)            | 1.19 |
| Rosaceae          | 3 (1.6)          | 7 (2.0)            | 1.56 |
| Scrophulariaceae  | 6 (3.2)          | 7 (2.0)            | 1.05 |
| Aizoaceae         | 3 (1.6)          | 6 (1.7)            | 1.29 |
| Chenopodiaceae    | 3 (1.6)          | 5 (1.4)            | 1.86 |
| Commelinaceae     | 2 (1.1)          | 5 (1.4)            | 1.24 |
| Eriocaulaceae     | 1 (0.5)          | 5 (1.4)            | 1.00 |
| Primulaceae       | 2 (1.1)          | 5 (1.4)            | 1.24 |
| Typhaceae         | 2 (1.1)          | 5 (1.4)            | 1.84 |
| Urticaceae        | 4 (2.1)          | 5 (1.4)            | 1.51 |
| Equisetaceae      | 1 (0.5)          | 4 (1.1)            | 1.21 |
| Lemnaceae         | 3 (1.6)          | 4 (1.1)            | 1.44 |
| Lythraceae        | 3 (1.6)          | 4 (1.1)            | 1.13 |
| Onagraceae        | 2 (1.1)          | 4 (1.1)            | 1.04 |
| Pontederiaceae    | 2 (1.1)          | 4 (1.1)            | 1.83 |
| Trapaceae         | 1 (0.5)          | 4 (1.1)            | 1.75 |
| Acanthaceae       | 3 (1.6)          | 3 (0.9)            | 1.00 |
| Caryophyllaceae   | 3 (1.6)          | 3 (0.9)            | 1.33 |
| Nymphaceae        | 3 (1.6)          | 3 (0.9)            | 2.71 |
| Plantaginaceae    | 1 (0.5)          | 3 (0.9)            | 1.23 |
| Acoraceae         | 1 (0.5)          | 2 (0.6)            | 1.28 |
| Amaranthaceae     | 1 (0.5)          | 2 (0.6)            | 2.82 |
| Cannaceae         | 1 (0.5)          | 2 (0.6)            | 1.42 |
| Haloragaceae      | 1 (0.5)          | 2 (0.6)            | 1.13 |
| Lenticibulariaceae| 1 (0.5)          | 2 (0.6)            | 1.00 |
| Menyanthaceae     | 1 (0.5)          | 2 (0.6)            | 2.06 |
| Solanaceae        | 2 (1.1)          | 2 (0.6)            | 1.50 |
| Valerianaceae     | 1 (0.5)          | 2 (0.6)            | 1.00 |
| Verbenaceae       | 2 (1.1)          | 2 (0.6)            | 1.00 |
| Violaceae         | 1 (0.5)          | 2 (0.6)            | 1.00 |
| Arumylidaceae     | 1 (0.5)          | 1 (0.3)            | 2.50 |

| Family            | No. of genus (%) | No. of Species (%) | FUV  |
|-------------------|------------------|--------------------|------|
| Apocynaceae       | 1 (0.5)          | 1 (0.3)            | 2.67 |
| Azollaceae        | 1 (0.5)          | 1 (0.3)            | 2.22 |
| Butomaceae        | 1 (0.5)          | 1 (0.3)            | 1.50 |
| Cabombaceae       | 1 (0.5)          | 1 (0.3)            | 1.00 |
| Campanulaceae     | 1 (0.5)          | 1 (0.3)            | 1.00 |
| Ceratophyllaceae  | 1 (0.5)          | 1 (0.3)            | 1.71 |
| Cucurbitaceae     | 1 (0.5)          | 1 (0.3)            | 3.20 |
| Euphorbiaceae     | 1 (0.5)          | 1 (0.3)            | 1.00 |
| Gentianaceae      | 1 (0.5)          | 1 (0.3)            | 1.00 |
| Geraniaceae       | 1 (0.5)          | 1 (0.3)            | 1.00 |
| Iridaceae         | 1 (0.5)          | 1 (0.3)            | 1.25 |
| Juncaceae         | 1 (0.5)          | 1 (0.3)            | 1.71 |
| Marsileaceae      | 1 (0.5)          | 1 (0.3)            | 1.71 |
| Menispermacoe     | 1 (0.5)          | 1 (0.3)            | 1.00 |
| Nelumbonaceae     | 1 (0.5)          | 1 (0.3)            | 2.22 |
| Papaveraceae      | 1 (0.5)          | 1 (0.3)            | 1.00 |
| Parkeriaceae      | 1 (0.5)          | 1 (0.3)            | 1.33 |
| Penicillaceae     | 1 (0.5)          | 1 (0.3)            | 2.33 |
| Phytolacaceae     | 1 (0.5)          | 1 (0.3)            | 2.75 |
| Plumbaginaceae    | 1 (0.5)          | 1 (0.3)            | 1.00 |
| Salviniaceae      | 1 (0.5)          | 1 (0.3)            | 1.89 |
| Saururaceae       | 1 (0.5)          | 1 (0.3)            | 1.33 |
| Saxifragaceae     | 1 (0.5)          | 1 (0.3)            | 1.67 |
| Schizaceae        | 1 (0.5)          | 1 (0.3)            | 1.50 |

The family names on the list are arranged in the order of the descending number of species.
use of a broader spectrum of plants taxonomically than other uses.

Some of the top families contributed greatly to some of the use categories (Table 3). The top ten families contributed about half of all species used medicinally, over 66% of those providing fodder (though lacking any contribution from Ranunculaceae) and nearly fifty percent of those used as food. Seven of the top ten families contributed 52.8% of species used as green manure. The top ten families together contributed 73% of species used for fiber, although actually only three (Poaceae, Cyperaceae, and Fabaceae) made substantial contributions. Similar patterns were apparent in the other use categories. Some top families, such as Lamiaceae, Hydrocharitaceae, Potamogetonaceae, and Brassicaceae, contributed only to certain of the major categories of use, for example Ranunculaceae, Polygonaceae, Lamiaceae, Asteraceae, Runcunculaceae, Hydrocharitaceae and Potamogetonaceae. An uneven distribution of species for RFC, CI, and CV (Figures 2, 3 and 4), once the data had been normalized appropriately. Five of the top ten species according to RFC also appeared in the top ten lists for CI and CV. These species are mentioned frequently in the literature. Glycine soja was second in rank order (UV = 3.5), followed by Zizania latifolia and Rorippa islandica (both UV = 3.33), Actinostemma tenerum (UV = 3.2), Rumex acetosa (UV = 3.17) and Nymphaea tetragona (UV = 3.13). Among species with a UV value of 3.00, Euryale ferox was recorded in ten literature sources, Saccharum spontaneum in three and Oenanthe sinensis in one; all are plants with multiple uses. There were 165 species (about 47% of the total) with the lowest possible score (UV = 1.0). Among these, one hundred and thirty-nine species (84.2%) had only one type of use and twenty-two species (13.3%) had two.

Relative Frequency of Citation (RFC) varied between 0.02 (55 species, nearly 20% of the total) to 0.3 (Table 4). The top three species based on RFC were Polygonum hydropiper (RFC = 0.3), Oenanthe javanica (RFC = 0.25) and Mentha haplocalyx (RFC = 0.21). The next highest score was for Acorus calamus (RFC = 0.20) (Table 4). Many species with high RFC scores were likely to be used over extensive geographical areas, while many of those scoring just 0.02 were likely to be used only very locally.

Cultural Importance scores (CI) ranged between 0.02 (48 species, including Rungia chinensis and A. gramineum) and 0.54 (E. ferox and Z. latifolia) (Table 4), while those for Cultural Value (CV) ranged from 0.00003 (the same 48 species as for CI) and 0.07096 (Polygonum hydropiper) (Table 4). Species with the lowest CI or CV scores had only one kind of use and were mentioned only in one literature source. Significant correlations were found between the scores of species for RFC, CI, and CV (Figures 2, 3 and 4), once the data had been normalized appropriately. Five of the top ten species according to RFC also appeared in the top ten lists for CI and CV. These species are Polygonum hydropiper, P. orientale, Euryale ferox, Zizania latifolia, and Coix lacryma-jobi. The 48 species with the lowest CV scores were also lowest according to UV, RFC and CI.

**Discussion**

**Diversity of wetland useful plant species**

The 350 wetland species recorded as traditionally used in China according to the literature are distributed unevenly across 66 families. The top families are Poaceae, Cyperaceae, Polygononaceae, Lamiaceae, Asteraceae, Rannunculaceae, Hydrocharitaceae and Potamogetonaceae. An uneven
distribution of useful wetland species by plant family has also been found elsewhere in the world [11,88-90], for instance in Manipur (India) where Jain et al. found that Polygonaceae, Araceae, Cyperaceae and Poaceae contributed disproportionately to the list of useful species [11]. Coincidentally, many of the top families found in the Manipur study are also dominant or abundant in wetland plant communities in many parts of China [91-96]. Species scoring highly in our study and which also have wide distributions elsewhere in the world, such as Phragmites australis, Polygonum hydropiper and Zizania latifolia, are always mentioned frequently in the literature from other places. All have high UV, CI and CV values according to our study (Table 4). This suggests that families rich in wetland species are more likely to be used than others, the key factor being the local presence of species potentially available for people’s attention and possible use. This result is similar to those reported for other regions [23]. Moerman et al. have argued in the case of medicinal plants that the characteristics of the local flora have a big influence on people’s knowledge [97]. The more often people come into contact with particular elements of the flora, the more likely they are to find uses for them. Knowledge about the usefulness of such plants will tend to grow disproportionately, as experience is accumulated. Traditional knowledge is always related to local people’s contact with the local environment [23].

The characteristics of usage of wetland useful species
Our results show that wetland plants have been used for multiple purposes in most parts of China. The three most important uses are provision of medicine, food and fodder (Table 2), all required regularly by people as they go about their daily lives [11,13,98,99]. Providing people with sources of green manure is a further noteworthy use made of wetland plants, with 53 species being used. Adding fertility to the soil is a basic necessity in China, which remains fundamentally an agricultural country. Providing people with sources of fiber is another regular use made of wetland plants. People in China have had a long history of using plant fiber for making cloth, rope and other articles and a rich store of knowledge about the use of wetland plants for fiber extraction and use has been accumulated by people living in and around wetlands [100].

Besides providing local people with material necessities for their everyday lives, wetland plants also provide other products used less frequently, as well as a range of services. Some plants are used as ornamentals, such as Polygonum orientale, Phragmites australis, Misanthus sinensis, while others are important for the strengthening of embankments and protecting soil erosion. Twenty-two species provide raw materials for making wine. China has a cornucopia of traditional knowledge relating to liquor-making; our results confirm that a substantial part of this knowledge relates to wetland species, even though much of this knowledge is historical and not known by current generations. Wetlands can be breeding grounds for mosquitoes and other nuisance insects, reducing agricultural production or transmitting disease, so considerable traditional knowledge of wetland plants relating to pesticides may yet prove to be useful in the modern world. There are also some species having important cultural values, for example the flowers of Zantedeschia aethiopica used commonly in sacrificial rites.

Compared with the uses mentioned above, the use of wetland plants for industrial purpose is comparatively recent. Industrially, wetland plants are mostly used as sources of industrial raw materials. For instance, Scirpus yagara is used as a raw material in the production of ethyl alcohol and glycerol, while Mentha haplocalyx can be a source of volatile oils. These plants can be important source of cash for local people.
| Species                          | UV  | RFC | CI  | CV            | Use                  | Reference(s)                  |
|---------------------------------|-----|-----|-----|---------------|----------------------|-------------------------------|
| Acorus calamus L.               | 1.55| 0.20| 0.30| 0.03795       | ED,ME,FI,FO,PE,OR,ID  | [27-29,45,46,59,63,65,68,62,67]|
| Acorus gramineus Aiton          | 1.00| 0.11| 0.11| 0.00209       | ED,ME                | [27,44,46,59,63,78]          |
| Actinostemma tereum Griff.      | 3.20| 0.09| 0.29| 0.01160       | ED,ME,FO,GR,ID       | [27-29,58,64]                |
| Adenostemma lavenia (L.) Kurtze | 1.00| 0.07| 0.07| 0.00046       | ED                    | [27,29,46,58]                |
| Aeginetia indica L.             | 1.00| 0.05| 0.05| 0.00026       | ME                    | [28,29,46]                   |
| Aeschynomene indica L.          | 2.00| 0.05| 0.11| 0.00157       | ME,GR,FI             | [20,46,58]                   |
| Ageratum coryzoideis L.         | 2.00| 0.05| 0.11| 0.00209       | ME,FO,GR,EN          | [28,29,46]                   |
| Ajuga ciliata Bunge             | 1.00| 0.05| 0.05| 0.00026       | ME                    | [28,29,46]                   |
| Ajuga multiflora Bunge          | 1.00| 0.04| 0.04| 0.00012       | ME                    | [28,29]                      |
| Allisoma canaliculatum A. Braun & C. D. Bouché | 1.50| 0.04| 0.05| 0.00035       | ME,OR                | [29,46]                      |
| Allisoma gramineum Lej.         | 1.00| 0.02| 0.02| 0.00003       | ME                    | [64]                         |
| Allisoma plantago-aquatica L.   | 1.13| 0.14| 0.16| 0.00417       | ME,OR                | [27-29,45,46,59,64,65]       |
| Alternanthera philoxeroides (Mart.) Griseb. | 2.83| 0.11| 0.30| 0.01183       | ME,GR,FO,EN          | [27-29,46,57,58]             |
| Alternanthera sessilis (L.) DC. | 2.80| 0.09| 0.25| 0.00812       | ED,ME,FO,GR          | [27,29,46,58,62]             |
| Amethystea coerulea L.          | 1.00| 0.04| 0.04| 0.00012       | ME                    | [28,29]                      |
| Ammania baccifera L.            | 1.00| 0.04| 0.04| 0.00023       | ME,FO                | [46,62]                      |
| Amphicarpaea trisperma Baker    | 1.00| 0.02| 0.02| 0.00003       | FO                    | [28]                         |
| Anemone hupehensis (Lemoine) Lemoine | 1.67| 0.05| 0.09| 0.00087       | ME,PE                | [28,29,46]                   |
| Apium leptophyllum (Pers.) F. Muell. | 1.00| 0.02| 0.02| 0.00003       | FO                    | [28]                         |
| Apocynum venetum L.             | 2.67| 0.05| 0.14| 0.00278       | ED,ME,FUD            | [28,29,46]                   |
| Arisaema arnurese Maxim.        | 1.00| 0.07| 0.07| 0.00046       | ME                    | [27,28,46,59]                |
| Arisaema du-bois-reymondiae Engl. | 1.00| 0.02| 0.02| 0.00003       | ME                    | [29]                         |
| Arisaema heterophyllum Blume    | 1.00| 0.02| 0.02| 0.00003       | ME                    | [69]                         |
| Artemisia capillaris Thunb.     | 2.20| 0.09| 0.20| 0.00957       | ED,ME,FO,LI,PE,ID    | [27-29,58,67]                |
| Artemisia selengensis Turcz. ex Besser | 1.60| 0.09| 0.14| 0.00348       | ED,ME,FO             | [27,29,46,65,70]             |
| Arthronon hispidus (Thunb.) Makino | 1.50| 0.07| 0.11| 0.00209       | ME,FI,FO             | [28,46,57,67]                |
| Arundinella anomala Steud.      | 2.00| 0.04| 0.07| 0.00046       | Fi,FO                | [28,29]                      |
| Anundo donax L.                 | 2.63| 0.14| 0.38| 0.02922       | ME,FI,FO,OR,EN,OT    | [27-29,36,37,45,46,59]       |
| Anundo donax var. versicolor (Mill.) Stokes | 1.00| 0.04| 0.04| 0.00012       | OR                    | [27,38]                      |
| Astilbe chinensis Franch. & Sav. | 1.67| 0.05| 0.09| 0.00130       | ME,OR,ID             | [28,29,46]                   |
| Astragalus adsurgens Pall.      | 1.67| 0.05| 0.09| 0.00130       | ME,FO,EN             | [28,29,46]                   |
| Atropastrum sinensis Pascher    | 1.67| 0.05| 0.09| 0.00087       | ME,FD                | [28,29,46]                   |
| Azolla imbricata (Rowb.) Nakai  | 2.22| 0.16| 0.36| 0.02087       | ME,FO,GR,PE          | [27-29,31,32,46,58,59,62]    |
| Bacopa monnieri (L.) Wettst.     | 1.00| 0.04| 0.04| 0.00012       | ME                    | [28,29]                      |
| Beckmannia syzigachne (Steud.) Fernald | 1.67| 0.05| 0.09| 0.00130       | ED,ME,FO             | [28,57,68]                   |
| Berteroa incana DC.             | 1.00| 0.02| 0.02| 0.00003       | ID                   | [28]                         |
| Bidens parviflora Willd.        | 1.33| 0.05| 0.07| 0.00070       | ED,ME                | [28,29,46]                   |
| Bidens tripartita L.            | 1.00| 0.05| 0.05| 0.00026       | ME                    | [28,29,46]                   |
| Blyxa uberthii Rich.            | 1.00| 0.02| 0.02| 0.00003       | FO                   | [28]                         |
| Blyxa echinosperma (C. B. Clarke) Hook. f. | 1.00| 0.04| 0.04| 0.00012       | FO                    | [27,28]                      |
| Blyxa japonica Maxim. ex Asch. & Gürke | 1.00| 0.02| 0.02| 0.00003       | FO                    | [28]                         |
| Blyxa leiosperma Koidz.         | 1.00| 0.02| 0.02| 0.00003       | FO                   | [27]                         |
| Boehmeria gracilis C. H. Wright | 1.67| 0.05| 0.09| 0.00130       | ME,FUD               | [28,29,46]                   |
| Brasenia schreberi J. F. Wright | 1.00| 0.05| 0.05| 0.00052       | ED,ME                | [27,29,46]                   |
| Plant Name                              | Density | Height | Reproductive | Economic Value | Notes                                      |
|----------------------------------------|---------|--------|--------------|----------------|--------------------------------------------|
| Bromus catharticus Vahl                | 0.01    | 0.04   | 0.0012       | FO             | [27,29]                                    |
| Bromus inermis Leyss.                  | 2.50    | 0.04   | 0.00087      | ED,FO,EN       | [27,28]                                    |
| Bromus japonicus Thunb.                | 1.83    | 0.11   | 0.00957      | ED,ME,FO,FI,LI | [27,28,45,57,62]                           |
| Bromus remotiflorus (Steud.) Ohwi      | 1.33    | 0.05   | 0.00070      | FI,FO          | [45,57,62]                                 |
| Butomus umbellatus L.                  | 1.50    | 0.04   | 0.00035      | FI,OR          | [28,64]                                    |
| Calamagrostis epigeios (L.) Roth        | 2.60    | 0.09   | 0.00754      | FI,F,O,EN      | [27-29,57,67]                              |
| Calamagrostis pseudophragmites (Hall. f.) Koel. | 2.00 | 0.07   | 0.00186      | FO,EN          | [27-29,57]                                 |
| Caldesia reniformis Makino             | 1.00    | 0.02   | 0.00003      | OR             | [29]                                       |
| Caltha palustris L.                    | 1.33    | 0.05   | 0.00104      | ED,ME,PE       | [29,68,82]                                 |
| Canna indica L.                        | 1.33    | 0.05   | 0.00035      | FI,OR          | [27,29]                                    |
| Capillipedium parviflorum (R. Br.) Stapf | 1.00   | 0.02   | 0.00003      | FO             | [28]                                       |
| Cardamine flouosa With.                | 1.00    | 0.05   | 0.00026      | ME             | [28,59,58]                                 |
| Cardamine impatiens L.                 | 1.75    | 0.13   | 0.00244      | ED,ME,FO       | [27-29,63]                                 |
| Cardamine leucantha (Tausch) O. E. Schulz | 1.25   | 0.07   | 0.00116      | ED,ME          | [28,29,46,70]                              |
| Cardamine lyrata Bunge                 | 1.75    | 0.13   | 0.00162      | ED,ME          | [27-29,46]                                 |
| Cardamine macrophylla Willd.           | 1.67    | 0.09   | 0.00130      | ED,ME,FO       | [29,81,82]                                 |
| Carex baccans Nees                     | 1.00    | 0.04   | 0.00023      | ED,ME          | [28,46]                                    |
| Carex dipalata Boot                    | 1.50    | 0.04   | 0.00035      | FI,FO          | [28,67]                                    |
| Carex leiorhynchica C. A. Mey.         | 1.00    | 0.04   | 0.00012      | FO             | [28,67]                                    |
| Carex scabrinifolia Steud.             | 1.00    | 0.04   | 0.00012      | Fi             | [28,29]                                    |
| Carex tangiana Ohwi                    | 1.50    | 0.04   | 0.00035      | FO,OR          | [28,67]                                    |
| Catabrosa aquatica P. Beauv.           | 1.00    | 0.02   | 0.00003      | FO             | [28,67]                                    |
| Centaurium meyeri Druce                | 1.00    | 0.04   | 0.00012      | ME             | [28,46]                                    |
| Centipeda minima (L.) A. Braun & Asch. | 1.00    | 0.07   | 0.00046      | ME             | [28,29,46,78]                              |
| Ceratophyllum demersum L.               | 1.71    | 0.13   | 0.00487      | ME,FO          | [27-29,46,58,63,64]                        |
| Ceratopteris thalictroides (L.) Brongn. | 1.33    | 0.11   | 0.00278      | ED,ME          | [27-29,46,58,63]                           |
| Chenopodium ambrosioides L.             | 2.20    | 0.09   | 0.00638      | M,ED,PE,ED     | [27-29,46,58]                              |
| Chenopodium serotinum L.                | 1.00    | 0.04   | 0.00023      | ME,FO          | [46,62]                                    |
| Cicuta virosa L.                       | 1.00    | 0.04   | 0.00012      | ME             | [28,46]                                    |
| Clematis cadmia Buch.-Ham. ex Hookf. & Thomson | 1.00   | 0.04   | 0.00012      | ME             | [28,46]                                    |
| Clematis finetiana H. Lév. & Vaniot     | 1.00    | 0.05   | 0.00026      | ME             | [28,29,46]                                 |
| Clematis orientalis L.                  | 1.00    | 0.02   | 0.00003      | ME             | [28]                                       |
| Clinopodium chinense kuntze             | 1.00    | 0.04   | 0.00012      | ME             | [28,46]                                    |
| Clinopodium gracile (Bentham) Matsumura | 1.00   | 0.05   | 0.00026      | ME             | [28,29,46]                                 |
| Cnidium monnieri (L.) Cuss.             | 1.33    | 0.05   | 0.00070      | ME,FO          | [28,29,46]                                 |
| Coix lacryma-jobi L.                    | 2.30    | 0.18   | 0.04000      | ED,ME,FI,FOL,OT | [27,41,42,45,46,59,62,63,65,71]         |
| Colocasia esculenta (L.) Schott         | 1.83    | 0.11   | 0.00574      | ED,ME,FO       | [27,29,46,59,62]                           |
| Commelina benghalensis L.               | 1.00    | 0.07   | 0.00093      | ME,OR          | [27-29,46]                                 |
| Commelina communis L.                   | 1.20    | 0.09   | 0.00261      | ED,ME,FO       | [27-29,46,70]                              |
| Corystis racemosa Pers.                 | 1.00    | 0.07   | 0.00046      | ME             | [28,29,46,58]                              |
| Cryptalaria assamica Benth.             | 2.00    | 0.04   | 0.00093      | ME,FI,FO,GR    | [28,29]                                    |
| Cypripedium aculeata Alton              | 1.50    | 0.04   | 0.00035      | FO,EN          | [28,29]                                    |
| Cyperus compressus L.                   | 1.00    | 0.04   | 0.00012      | FO             | [62,67]                                    |
| Cyperus difformis L.                    | 1.00    | 0.11   | 0.00209      | M,FI           | [28,46,62-64,67]                           |
## Table 4 Ethnobotanical inventory and some quantitative indexes of useful wetland plants in China (Continued)

| Species                          | FI   | FO   | FI/FO   | ME/FO/GR/LI |
|----------------------------------|------|------|---------|-------------|
| **Cyperus exaltatus Retz.**      | 1.00 | 0.07 | 0.07    | 0.00093     |
| **Cyperus glomeratus L.**        | 1.60 | 0.09 | 0.14    | 0.00464     |
| **Cyperus imbricatus Retz.**     | 1.00 | 0.04 | 0.04    | 0.00012     |
| **Cyperus iria L.**              | 1.00 | 0.05 | 0.05    | 0.00052     |
| **Cyperus michelianus (L.) Link**| 1.00 | 0.02 | 0.02    | 0.00003     |
| **Cyperus microstachyus Steud.** | 1.00 | 0.02 | 0.02    | 0.00003     |
| **Cyperus pilosus Vahl**         | 1.00 | 0.07 | 0.07    | 0.00139     |
| **Dichrocephala auriculata Druce**| 1.00 | 0.05 | 0.05    | 0.00026     |
| **Dichrocephala benthamii C. B. Clarke**| 1.00 | 0.05 | 0.05    | 0.00026     |
| **Dicliptera chinensis (L.) Juss.**| 1.00 | 0.05 | 0.05    | 0.00026     |
| **Duchesnea indica (Andrews) Focke**| 1.00 | 0.02 | 0.02    | 0.00003     |
| **Echinochloa caudata Roshev.**  | 1.00 | 0.02 | 0.02    | 0.00003     |
| **Echinochloa crus-galli (L.) P. Beauv.**| 2.40 | 0.09 | 0.21    | 0.01044     |
| **Echinochloa crus-galli var. mitis (Pursh) Peterm.**| 1.00 | 0.02 | 0.02    | 0.00003     |
| **Echinochloa crus-galli var. zelayensis (Kunth) Hitchc.**| 1.00 | 0.02 | 0.02    | 0.00003     |
| **Echinochloa crus-pavonis (Kunth) Schult.**| 1.00 | 0.02 | 0.02    | 0.00003     |
| **Eichhornia crassipes (Mart.) Solms**| 2.67 | 0.11 | 0.29    | 0.01670     |
| **Eleocharis dulcis Trin. ex Henschel.**| 2.00 | 0.11 | 0.21    | 0.00626     |
| **Eleocharis plantagineiformis Tang & F. T. Wang**| 1.00 | 0.02 | 0.02    | 0.00003     |
| **Eleocharis valleculosa Ohwi**   | 1.33 | 0.05 | 0.07    | 0.00070     |
| **Eleocharis yokusensis (Franch. & Savat.) Tang & F. T. Wang**| 1.00 | 0.02 | 0.02    | 0.00003     |
| **Elytrigia kachinensis Prain**   | 1.40 | 0.09 | 0.13    | 0.00304     |
| **Equisetum debile Roxb. ex Vaucher**| 1.50 | 0.07 | 0.11    | 0.00139     |
| **Equisetum hyemale L.**         | 1.33 | 0.05 | 0.07    | 0.00070     |
| **Equisetum pratense Ehrh.**     | 1.00 | 0.04 | 0.04    | 0.00012     |
| **Equisetum ramosissimum Desf.** | 1.00 | 0.05 | 0.05    | 0.00026     |
| **Eriocaulon australe R. Br.**    | 1.00 | 0.04 | 0.04    | 0.00012     |
| **Eriocaulon buergerianum Körn.**| 1.00 | 0.11 | 0.11    | 0.00104     |
| **Eriocaulon cinereum R. Br.**    | 1.00 | 0.04 | 0.04    | 0.00012     |
| **Eriocaulon decemflorum Maxim.**| 1.00 | 0.02 | 0.02    | 0.00003     |
| **Eriocaulon robustius Makino**   | 1.00 | 0.02 | 0.02    | 0.00003     |
| **Euphorbia thymifolia L.**      | 1.00 | 0.07 | 0.07    | 0.00046     |
| **Euryale ferox Salisb.**         | 3.00 | 0.18 | 0.54    | 0.00688     |
| **Fimbristylis miliacea (L.) Vahl**| 1.67 | 0.05 | 0.09    | 0.00130     |
| **Geranium sibiricum L.**        | 1.00 | 0.04 | 0.04    | 0.00012     |
| **Geum aleppicum Jacq.**          | 1.75 | 0.07 | 0.13    | 0.00244     |
| **Gloxina maritima L.**           | 1.00 | 0.04 | 0.04    | 0.00012     |
| **Glegeoma longituoba (Nakai) Kuprian.**| 1.00 | 0.07 | 0.07    | 0.00046     |
| **Glycine soja Siebold & Zucc.**  | 3.50 | 0.07 | 0.25    | 0.00974     |
| **Glycyrrhiza pallidiflora Maxim.**| 1.00 | 0.05 | 0.05    | 0.00078     |
| **Halerpestes symbalaria Greene** | 1.00 | 0.02 | 0.02    | 0.00003     |
| **Halerpestes ruderens (Jacq.) Ovcz.**| 1.00 | 0.02 | 0.02    | 0.00003     |
| **Hemarthria altissima (Poir.) Stapf & C. E. Hubb.**| 1.50 | 0.04 | 0.05    | 0.00035     |
| **Hemarthria compressa (L. f.) R. Br.**| 1.00 | 0.02 | 0.02    | 0.00003     |

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| Plant Name                  | Frequency | flowers | fruit | seed | Index   | Reference(s)  |
|---------------------------|-----------|---------|-------|------|---------|---------------|
| Hydrilla verticillata     | 2.00      | 0.05    | 0.11  | 0.00104 | FO,GR  | [27,28,64]    |
| Hydrocharis dubia         | 1.67      | 0.05    | 0.09  | 0.00130 | ED,FO,GR | [27-29]       |
| Hygrophila salicifolia    | 1.00      | 0.04    | 0.04  | 0.00012 | ME      | [28,46]       |
| Iris tectorum             | 1.25      | 0.07    | 0.09  | 0.00116 | ME,OR   | [27,29,46,59] |
| Ixeris polycephala        | 1.00      | 0.02    | 0.02  | 0.00003 | ME      | [29]          |
| Juncus effusus            | 1.71      | 0.13    | 0.21  | 0.00731 | ME,OT   | [27-29,64,65,67] |
| Kyllinga colorata         | 1.00      | 0.02    | 0.02  | 0.00003 | ED      | [28]          |
| Lactuca tatarica          | 2.00      | 0.02    | 0.04  | 0.00012 | ED,FO   | [28]          |
| Lavedium sibiricum        | 1.00      | 0.02    | 0.02  | 0.00003 | ED      | [70]          |
| Lapsana apogonoides       | 1.00      | 0.05    | 0.05  | 0.00052 | FO      | [28,29,57]    |
| Leersia hexandra          | 1.50      | 0.04    | 0.05  | 0.00052 | ME,FO,JD| [28,46]       |
| Leersia japonica          | 1.00      | 0.02    | 0.02  | 0.00003 | ME      | [46]          |
| Leersia oryzoides         | 1.00      | 0.02    | 0.02  | 0.00003 | FO      | [28]          |
| Lemna minor               | 1.75      | 0.07    | 0.13  | 0.00244 | ME,FO,GR| [28,48,59,62]|
| Lemna trisulca            | 1.00      | 0.02    | 0.02  | 0.00003 | FO      | [28]          |
| Leptochloa chinensis      | 1.00      | 0.05    | 0.05  | 0.00026 | FO      | [27,29,62]    |
| Limonium sinense          | 1.00      | 0.05    | 0.05  | 0.00026 | ME      | [28,29,46]    |
| Lobelia chinesis          | 1.00      | 0.07    | 0.07  | 0.00046 | ME      | [28,29,46,58]|
| Lotus tenuis Waldst. & Kit. ex Willd. | 1.00 | 0.04 | 0.04 | 0.00012 | ME | [28,46] |
| Ludwigia adscendens       | 1.17      | 0.11    | 0.13  | 0.00244 | ME,FO   | [27-29,46,58,62] |
| Ludwigia hyssopifolia     | 1.00      | 0.05    | 0.05  | 0.00026 | ME      | [28,29,46]    |
| Ludwigia prostrata        | 1.00      | 0.05    | 0.05  | 0.00052 | ME,FO   | [27,46,62]    |
| Lycopus lucidus Turcz.    | 1.20      | 0.09    | 0.11  | 0.00174 | ED,ME   | [28,29,46,69,70] |
| Lythrum salicaria         | 2.50      | 0.07    | 0.18  | 0.00812 | ED,ME,PELL,FO,OTJD | [27-29,46] |
| Lygodium japonicum        | 1.50      | 0.07    | 0.11  | 0.00209 | ME,PE,ED | [28,29,46,77] |
| Lysimachia christinae      | 1.00      | 0.09    | 0.09  | 0.00072 | ME      | [27-29,46,58]|
| Lysimachia congestiflora  | 1.00      | 0.07    | 0.07  | 0.00046 | ME      | [27-29,46]    |
| Lysimachia fortunei       | 1.20      | 0.09    | 0.11  | 0.00174 | ME,FO   | [27-29,46,58]|
| Lysimachia heterogena     | 2.00      | 0.02    | 0.04  | 0.00012 | ME,GR   | [28]          |
| Lymnium salicaria         | 1.50      | 0.14    | 0.21  | 0.01113 | ME,OR,FO,JD | [27-29,46,58,62,64,65] |
| Marsilea quadrifolia      | 1.71      | 0.13    | 0.21  | 0.00974 | ED,ME,FO,GR | [27-29,46,58,59] |
| Mazus japonicus           | 1.00      | 0.04    | 0.04  | 0.00012 | ME      | [27,46]       |
| Mellotus indicus           | 2.33      | 0.05    | 0.13  | 0.00244 | ME,FO,GREN | [28,46,77] |
| Mentha haplocalyx Briq.   | 1.67      | 0.21    | 0.36  | 0.02087 | ED,MEJD | [27-29,45,46,58,59,65,67,70,78,77] |
| Microstegium ciliatum      | 1.50      | 0.04    | 0.05  | 0.00035 | FI,FO   | [28,29]       |
| Mimulus tenellus           | 1.00      | 0.05    | 0.05  | 0.00052 | ED,ME   | [28,29,46]    |
| Miscanthus floridulus Warb. ex K. Schum. & Lauterb. | 1.83 | 0.11 | 0.20 | 0.00765 | ME,FO,EN | [27-29,46,57,62] |
| Miscanthus sacchariflorus  | 2.00      | 0.09    | 0.18  | 0.00435 | FI,FO,EN | [27,28,45,57,62] |
| Miscanthus sinensis       | 2.00      | 0.11    | 0.21  | 0.00835 | ME,FO,EN | [27-29,45,46,62] |
| Monochoria hastata        | 1.00      | 0.04    | 0.04  | 0.00012 | ED      | [28,56]       |
| Plant Name                                      | Value 1 | Value 2 | Value 3 | Value 4 | Value 5 | Value 6 | Value 7 | Value 8 |
|------------------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| Monochoria korshakowii Regel & Maack           | 2.00    | 0.14    | 0.29    | 0.01855 | ED,ME,FO,OR,GR | [27-29,46,56,57,62,64] |
| Monochoria vaginalis (Burm. f.) C. Presl ex Kunth | 1.67    | 0.11    | 0.18    | 0.00696 | ED,ME,FO,GR | [27,46,56,57,62,70] |
| Mosla diandra (Buch.-Ham. ex Roxb.) Maxim.      | 1.33    | 0.05    | 0.07    | 0.00070 | ME,PE | [28,29,46] |
| Murdannia keisak (Hassk.) Hand.-Mazz.           | 1.00    | 0.02    | 0.02    | 0.00003 | FO | [28] |
| Murdannia nudiflora (L.) Brenan                 | 1.00    | 0.04    | 0.04    | 0.00012 | ME | [28,29] |
| Murdannia tripetra (B. Bruckn.                 | 2.00    | 0.07    | 0.14    | 0.00278 | ME,ED,FO | [27,29,46,49] |
| Myosoton aquaticum Moench                      | 2.00    | 0.05    | 0.11    | 0.00696 | ME,ED,FO | [28,29,46] |
| Myriophyllum spicatum L.                       | 1.25    | 0.07    | 0.09    | 0.00116 | ME,FO | [27-29,64] |
| Myriophyllum verticillatum L.                   | 1.00    | 0.05    | 0.05    | 0.00026 | FO | [27,28,64] |
| Najas foceolata A. Braun ex Magnus              | 2.00    | 0.02    | 0.04    | 0.00012 | FO,GR | [28] |
| Najas graminea                                 | 2.00    | 0.04    | 0.07    | 0.00046 | FO,GR | [28,29] |
| Najas marina L.                                | 1.50    | 0.07    | 0.11    | 0.00139 | FO,GR | [27,28,62,64] |
| Najas minor All.                               | 1.50    | 0.07    | 0.11    | 0.00139 | FO,GR | [27,28,62,64] |
| Nanocnide japonica Blume                       | 1.00    | 0.05    | 0.05    | 0.00026 | ME | [27,28,46] |
| Nanocnide lobata Wedd.                         | 1.33    | 0.05    | 0.07    | 0.00070 | ME,GR | [28,29,46] |
| Nasturtium officinale R. Br.                   | 2.25    | 0.07    | 0.16    | 0.00417 | ED,ME,OR,ID | [28,46,58,65] |
| Nelumbo nucifera Gaertn.                       | 2.22    | 0.16    | 0.36    | 0.02087 | ED,ME,OR,FO | [27,29,45,58,59,62,65,66] |
| Nepeta catania L.                              | 1.50    | 0.07    | 0.11    | 0.00139 | ME,JD | [28,29,46,66] |
| Nuphar pumila (Timm.) DC.                      | 2.00    | 0.13    | 0.25    | 0.01136 | ME,ED,OR,FO | [27,29,46,54,58,59,62] |
| Nymphoides indica (L.) Kuntze                  | 2.13    | 0.14    | 0.30    | 0.01971 | ME,FO,GR,OR,ED | [27-29,46,58,59,62,70] |
| Oenanthe benghalensis Benth. & Hook.f.         | 1.00    | 0.04    | 0.04    | 0.00012 | ME | [28,46] |
| Oenanthe javanica DC.                          | 1.36    | 0.25    | 0.34    | 0.02313 | ED,ME,FO | [27-29,45,58,59,62,64,66] |
| Oenanthe sinensis Dunn                         | 3.00    | 0.02    | 0.05    | 0.00026 | ED,ME,FO | [28] |
| Oenothera rosea Aston                          | 1.00    | 0.04    | 0.04    | 0.00012 | ME | [28,29] |
| Origanum vulgare L.                            | 2.00    | 0.05    | 0.11    | 0.00157 | ME,JD,LI | [28,29,46] |
| Ottelia acuminate (Gagnep.) Dandy              | 1.00    | 0.04    | 0.04    | 0.00023 | ED,ME | [65,75] |
| Ottelia allioides (L.) Pers.                   | 2.60    | 0.09    | 0.23    | 0.00942 | ED,ME,OR,GR,FO | [27-29,46,59] |
| Panicum paludosum Roxb.                        | 1.00    | 0.02    | 0.02    | 0.00003 | FO | [28] |
| Paspalum dilatatum Poir.                       | 1.00    | 0.05    | 0.05    | 0.00026 | FO,EN | [29,40,62] |
| Paspalum distichum L.                          | 1.00    | 0.04    | 0.04    | 0.00023 | FO,EN | [27,62] |
| Paspalum pashaloides Scribn.                   | 2.00    | 0.02    | 0.04    | 0.00012 | FO,EN | [28] |
| Paspalum thunbergii Kunthi ex Steud.           | 1.00    | 0.04    | 0.04    | 0.00012 | FO | [57,62] |
| Penthorum chinense Pursh.                      | 2.33    | 0.05    | 0.13    | 0.00244 | ED,ME,FO,GR | [28,29,46] |
| Phalaris arundinacea L.                        | 2.00    | 0.05    | 0.11    | 0.00014 | FO,FI | [27-29] |
| Phragmites australis Trin. ex Steud.           | 3.71    | 0.13    | 0.46    | 0.03693 | ED,ME,EN,OT,OR | [27,29,45,46,62,64,65] |
| Phragmites karka (Retz.) Trin. ex Steud.       | 2.00    | 0.04    | 0.07    | 0.00070 | ME,EN | [28,46] |
| Phyla nodiflora (L.) Greene                    | 1.00    | 0.05    | 0.05    | 0.00026 | ME | [28,29,46] |
| Phyllotaxis acinosa Roxb.                      | 2.75    | 0.07    | 0.20    | 0.00510 | ED,ME,PE,ID | [27-29,69] |
| Pilea notata C. H. Wright                      | 1.20    | 0.09    | 0.11    | 0.00174 | ME,FO | [27-29,58,46] |
| Pistia stratiotes L.                           | 1.50    | 0.14    | 0.21    | 0.00835 | ME,FO,GR | [27-29,46,58,57,59,62] |
| Plantago asiatica L.                           | 1.20    | 0.09    | 0.11    | 0.00261 | ME,FO,ED | [28,46,57,65,70] |
| Plantago lanceolata L.                         | 1.50    | 0.04    | 0.05    | 0.00035 | ME,FO | [28,46] |
| Plantago major L.                              | 1.00    | 0.09    | 0.09    | 0.00145 | ME,ED | [28,46,69,70,76] |
| Plant Name | EO | SE | TE | Index | Environments |
|------------|----|----|----|-------|--------------|
| Pluchea indica (L.) Less. | 1.33 | 0.05 | 0.07 | 0.00070 | ED, ME |
| Poa acroleuca Steud. | 1.00 | 0.02 | 0.02 | 0.00003 | FO |
| Pogonatherum crinitum Kunth | 1.33 | 0.05 | 0.07 | 0.00070 | ME, FO |
| Polygonum amphibium L. | 1.00 | 0.05 | 0.05 | 0.00026 | ME |
| Polygonum aviculare L. | 1.50 | 0.14 | 0.21 | 0.01391 | ED, ME, FO, JD, PE |
| Polygonum barbatum L. | 1.00 | 0.04 | 0.04 | 0.00012 | ME |
| Polygonum capitatum Buch.-Ham. ex D. Don | 1.00 | 0.07 | 0.07 | 0.00046 | ME |
| Polygonum chinense L. | 1.00 | 0.05 | 0.05 | 0.00026 | ME |
| Polygonum excurrens Steward | 1.00 | 0.02 | 0.02 | 0.00003 | ME |
| Polygonum hydropiper L. | 1.41 | 0.30 | 0.43 | 0.07096 | ME, ED, FO, OT, PE, ID |
| Polygonum japonicum Meisn. | 1.17 | 0.11 | 0.13 | 0.00244 | ME, PE |
| Polygonum jucundum Meisn. | 1.00 | 0.04 | 0.04 | 0.00023 | ME, PE |
| Polygonum kawageanum Makino | 1.00 | 0.02 | 0.02 | 0.00003 | ME |
| Polygonum lathophyllum L. | 2.13 | 0.14 | 0.30 | 0.03154 | ED, ME, FO, PE, LI, ID, EN, GR |
| Polygonum lathophyllum var. salicifolium Sibth. | 2.50 | 0.04 | 0.09 | 0.00116 | ME, PE, JD |
| Polygonum longisetum var. rotundatum A. J. Li | 1.25 | 0.07 | 0.09 | 0.00116 | ME, JD |
| Polygonum nepalense Meisn. | 1.00 | 0.05 | 0.05 | 0.00026 | ME |
| Polygonum orientale L. | 2.60 | 0.18 | 0.46 | 0.05276 | ED, ME, FO, PE, LI, JD |
| Polygonum perfoliatum L. | 2.50 | 0.07 | 0.18 | 0.00348 | ME, PE, JD |
| Polygonum persicaria L. | 1.33 | 0.05 | 0.07 | 0.00104 | ME, FO, PE |
| Polygonum posumbu Buch.-Ham. ex D. Don | 1.00 | 0.02 | 0.02 | 0.00003 | ME |
| Polygonum sibiricum Laxm. | 2.00 | 0.02 | 0.04 | 0.00012 | ME, FO |
| Polygonum sieboldii Meisn. | 1.00 | 0.05 | 0.05 | 0.00026 | ME |
| Polygonum taquetii H. Lév. | 1.00 | 0.02 | 0.02 | 0.00003 | ME |
| Polygonum thunbergii Siebold & Zucc. | 2.00 | 0.05 | 0.11 | 0.00209 | ED, ME, FO, JD |
| Polygonum viscosum Buch.-Ham. ex D. Don | 1.67 | 0.05 | 0.09 | 0.00130 | ED, ME, JD |
| Potamogeton crispus L. | 2.00 | 0.11 | 0.21 | 0.00835 | ED, ME, FO, GR |
| Potamogeton cristatus Regel & Maack | 1.00 | 0.04 | 0.04 | 0.00023 | ME, FO |
| Potamogeton distinctus A. Benn. | 1.33 | 0.05 | 0.07 | 0.00070 | FO, GR |
| Potamogeton lucens L. | 1.00 | 0.04 | 0.04 | 0.00012 | GR |
| Potamogeton maackianus A. Benn. | 1.00 | 0.02 | 0.02 | 0.00003 | FO |
| Potamogeton malaianus Miq. | 2.00 | 0.05 | 0.11 | 0.00104 | FO, GR |
| Potamogeton natans L. | 1.00 | 0.05 | 0.05 | 0.00078 | ME, FO, GR |
| Potamogeton octandrus Poir. | 1.00 | 0.02 | 0.02 | 0.00003 | FO |
| Potamogeton oxyphyllus Miq. | 1.00 | 0.02 | 0.02 | 0.00003 | FO |
| Potamogeton pectinatus L. | 1.66 | 0.09 | 0.14 | 0.00348 | ME, FO, GR |
| Potamogeton perfoliatus L. | 1.00 | 0.02 | 0.02 | 0.00003 | ME |
| Potamogeton pusillus L. | 2.00 | 0.04 | 0.07 | 0.00046 | FO, GR |
| Potentilla anserina L. | 2.17 | 0.11 | 0.23 | 0.01357 | ED, ME, FO, JD, OT, LI |
| Potentilla discolor Bunge | 1.33 | 0.05 | 0.07 | 0.00070 | ED, ME |
| Potentilla frageliana D. F. K. Schltdl. | 2.00 | 0.04 | 0.07 | 0.00093 | ED, ME, FO, GR |
| Potentilla kleiniana Wight & Arn. | 1.00 | 0.05 | 0.05 | 0.00026 | ME |
| Potentilla reptans L. | 1.50 | 0.04 | 0.05 | 0.00035 | ED, ME |
| Prunella vulgaris L. | 1.00 | 0.05 | 0.05 | 0.00026 | ME |
| Scientific Name | Common Name | Value 1 | Value 2 | Value 3 | Value 4 | Reference 1 | Reference 2 |
|----------------|-------------|---------|---------|---------|---------|-------------|-------------|
| Pseudoraphis sordida | (Thwaites) S. M. Phillips & S. L. Chen | 1.00 | 0.04 | 0.04 | 0.00012 | FO | [27,29] |
| Ranunculus cantoniensis DC. | | 1.00 | 0.07 | 0.07 | 0.00046 | ME | [28,29,46,58] |
| Ranunculus chinensis Bunge | | 1.17 | 0.11 | 0.13 | 0.00244 | ME,PE | [27-29,46,58,68] |
| Ranunculus japonicus Thunb. | | 1.17 | 0.11 | 0.13 | 0.00244 | ME,PE | [27-29,46,58,74] |
| Ranunculus sceleratus L. | | 1.00 | 0.09 | 0.09 | 0.00072 | ME | [28,29,46,58,59] |
| Ranunculus sieboldii Miq. | | 1.00 | 0.07 | 0.07 | 0.00046 | ME | [27-29,46] |
| Ranunculus ternatus Thunb. | | 1.00 | 0.09 | 0.09 | 0.00072 | ME | [27-29,46,58] |
| Reynoutria japonica Houtt. | | 2.50 | 0.04 | 0.09 | 0.00116 | ED,ME,PE,ID | [28,46] |
| Roegneria ciliaris (Trin.) Nevski | | 1.00 | 0.05 | 0.05 | 0.00026 | FO | [28,29,57] |
| Rorippa dubia (Pers.) Hara | | 2.50 | 0.04 | 0.09 | 0.00116 | ED,ME,FO,ID | [28,29] |
| Rorippa globosa (Turcz.) Hayek | | 3.33 | 0.05 | 0.18 | 0.00348 | ED,FO,ID | [27,28,45] |
| Rorippa islandica (Oeder) Borbás | | 2.57 | 0.13 | 0.32 | 0.01826 | ME,FI,FO,ID,LI | [27,28,45,46,59,62,64] |
| Rotala indica Koehne | | 1.00 | 0.07 | 0.07 | 0.00139 | ED,ME,FO | [27,28,63,62] |
| Rotala rotundifolia (Buch.-Ham. ex Roxb.) Koehne | | 1.00 | 0.07 | 0.07 | 0.00093 | ME,FO | [29,46,75,29,62] |
| Rumex acetosa L. | | 3.17 | 0.11 | 0.34 | 0.01652 | ED,ME,FO,PE,ID | [27-29,46,58,65] |
| Rumex crispus L. | | 1.00 | 0.09 | 0.09 | 0.00145 | ED,ME | [28,30,46,67,79] |
| Rumex dentatus L. | | 1.75 | 0.07 | 0.13 | 0.00244 | ME,FO,PE | [27,28,46,62] |
| Rumex japonicus Houtt. | | 2.60 | 0.09 | 0.23 | 0.00942 | ED,ME,FO,ID,LI | [28,29,46,57,58] |
| Rumex maritimus L. | | 1.33 | 0.05 | 0.07 | 0.00070 | ME,FO | [28,29,63] |
| Rumex nepalensis Spreng. | | 1.25 | 0.07 | 0.09 | 0.00116 | ME,ID | [28,29,46,68] |
| Rumex patientia L. | | 2.50 | 0.04 | 0.09 | 0.00116 | ED,ME,ID,LI | [28,46] |
| Rungia chinensis Benth. | | 1.00 | 0.02 | 0.02 | 0.00003 | ME | [28] |
| Saccharum spontaneum L. | | 3.00 | 0.05 | 0.16 | 0.00313 | FI,FO,OT,EN | [27-29] |
| Sacciolepis indica (L.) Chase | | 1.00 | 0.04 | 0.04 | 0.00012 | FO | [27-28] |
| Sacciolepis myosuroides (R. Br.) A.Camus | | 1.00 | 0.04 | 0.04 | 0.00012 | FO | [28,29] |
| Sagittaria pygmaea Miq. | | 1.25 | 0.07 | 0.09 | 0.00174 | ME,FO,GR | [27-29,46] |
| Sagittaria trifolia L. | | 1.88 | 0.14 | 0.27 | 0.01739 | ED,ME,FOL,OR | [27-29,45,46,63,65,64] |
| Salicornia europaea L. | | 2.50 | 0.04 | 0.09 | 0.00087 | ME,ID,EN | [27-28] |
| Salvia plebeia R. Br. | | 1.00 | 0.07 | 0.07 | 0.00046 | ME | [27-29,46] |
| Salvinia natans (L.) All. | | 1.89 | 0.16 | 0.30 | 0.01331 | ME,FO,GR | [27-30,46,57,58,62,64] |
| Saururus chinensis Hort. ex Loudon | | 1.33 | 0.05 | 0.07 | 0.00070 | ME,GR | [28,29,46] |
| Scirpus juncoides Roxb. | | 1.50 | 0.04 | 0.05 | 0.00035 | ME,FI | [28,46] |
| Scirpus planiculmis F.Schmidt | | 2.75 | 0.07 | 0.20 | 0.00765 | ED,ME,FOL,EN | [28,57,62,67] |
| Scirpus tabernaemontani Salzm. ex Ball | | 2.50 | 0.11 | 0.27 | 0.01304 | ME,FO,EN,OR | [27,28,45,57,64,65] |
| Scirpus triangulatus Roxb. | | 1.40 | 0.09 | 0.13 | 0.00304 | ME,FO,FI | [28,29,45,46,67] |
| Scirpus triqueter L. | | 1.43 | 0.13 | 0.18 | 0.00406 | FI,FO | [27-29,45,57,62,64] |
| Scirpus wallichii Nees | | 1.00 | 0.02 | 0.02 | 0.00003 | ME | [28] |
| Scirpus yagara Ohwi | | 2.57 | 0.13 | 0.32 | 0.01826 | ME,FO,JO,DJ | [27,28,45,46,59,62,64] |
| Scrophularia ningpoensis Hemsl. | | 1.00 | 0.05 | 0.05 | 0.00026 | ME | [28,29,46] |
| Sesbania cannabina (Retz.) Poir. | | 2.67 | 0.05 | 0.14 | 0.00417 | ME,FO,GREN,JD | [28,29,46] |
| Sinoecmio oldhamianus (Maxim.) B. Nord. | | 2.00 | 0.04 | 0.07 | 0.00046 | FO,GR | [28,57] |
| Sium suave Walter | | 1.00 | 0.07 | 0.07 | 0.00093 | ME,FO | [28,29,46,64] |
| Solanum torvum Sw. | | 1.33 | 0.05 | 0.07 | 0.00070 | ED,ME | [28,29,46] |
| Sparganium stoloniferum (Graebn.) Buch.-Ham. ex Juz. | | 1.78 | 0.16 | 0.29 | 0.02505 | ME,OR,FO,FI,GR,OT | [27-29,45,46,57,59,62,64] |
Wetland plants provide people with many types of products valuable for subsistence living. The wealth of traditional knowledge that has accumulated about the uses of wetland plants is a reflection of the close relationships traditionally existing between people and their local environments, in this case specifically relating to wetlands. Much of this knowledge is disappearing today along with the loss of traditional lifestyles and retreat of wetlands. Systematic ethnobotanical surveys of traditional knowledge relating to wetlands are therefore needed, while such knowledge still exists.

Comparison of some quantitative indexes
An increasing number of papers have appeared over recent years discussing the use of quantitative methods in ethnobotanical research [101,102]. In particular, many new parameters have been suggested for evaluating the cultural importance or significance of plants and...
determine information consensus between informants [24-26,103]. The use of such indexes can not only advance the development of ethnobotany, but can also make it possible to compare results between different regions or cultural groups, as well as undertaking meta-analyses.

Use Value (UV) is one of the most frequently used indexes for evaluating ‘the relative usefulness of plants to people’ [23,24,83,84]. It has been successfully applied in many contexts [104-108]. With respect to an analysis of the literature, such as that here, UV reflects not only the number of uses made of a plant as well as the number of literature sources mentioning it. So a plant with high UV value does not necessarily mean that it has multiple uses nor that it is necessarily mentioned in many publications, as we have discussed in an earlier paper [109]. To illustrate this point, three species (Najas graminea, Potamogeton pusillus and Monochoria korsakowii) were all found to have UV = 2 in the present study, but actually the first two of these are only mentioned in two literature sources with two uses in each case, while the third is mentioned in 8 sources but only for one type of use. Among those plants with UV = 1, they have the same total numbers of different uses recorded in the literature and the numbers of literature recording these uses. Although their UV values are the lowest, it does not mean that they have few uses. However, some plants with higher UV values are indeed versatile, such as P. australis, Z. latifolia, and N. tetragona. These plants have a common feature: mentioned by a higher number of literature. So the UV value in a literature study may give us a bias. When using UV index to evaluate a plant, we should use the number of the literature recorded it for reference.

According the formula used for calculating FUV, we can find that FUV depends on the UV of species in a family. So FUV has a similar shortcoming to UV. Compared with UV, RFC, CI and CV have considered more factors that may lead to a bias. RFC is as same as %P designed in one of our previous papers [109]. Although it has considered the number of the literature which mentions a given species and the total number of literature concerned in the study, it does not take into account the number of uses mentioned in the literature. It just reflects the frequency of a species mentioned by the literature. There are significantly positive correlations between RFC and CI (R² = 0.767, p < 0.001) and CV (R² = 0.841, p < 0.001), respectively (Figure 2 and 3). Because RFC does not consider the number of uses, it will not show the difference of the importance and use values between species. Compared with RFC, CI and CV are two more comprehensive indexes. They consider not only the frequency cited by the literature, but also the number of uses recorded in the literature. There is a significant correlation between CI and CV (R² = 0.980, p < 0.001). The species with higher CI values often have higher CV, such as P. hydropiper and Z. latifolia. Compared with CI, CV is more sensitive to the information recorded in the literature and is more effective to show the differences of use value and frequency being cited in the literature between species.

In fact, many indexes used in quantitative ethnobotany are related to the use categories. The method of use type
classification will affect greatly the calculation results. However, it is often very difficult to produce a perfect scheme of use categories which could be closer to the truth. What can we do is to try our best to make the use categories more reasonable.

Conclusion

The wide distribution of many species of wetland plants [110,111] makes it possible to gain a general picture of the uses made of such plants on a macro-scale. A principal conclusion from the present study is that the biggest uses of wetland species, in terms of the number of citations in the literature, are for medicine, food and fodder. We conclude that it is whether or not particular species are growing locally that is a major determinant over whether people actually use them. Cultural Value (CV) and Cultural Importance (CI) are judged to be the most useful quantitative indices for providing measures of the relative importance and usefulness of wetland species, based on analyses of citations in literature that is not specifically ethnobotanical. However, such publications cannot provide detailed information about relationships between wetland plants and people, such as details of the ways in which people use and manage them. China is rich in both wetlands and traditional knowledge of wetland plants, but both wetlands and traditional knowledge are rapidly being lost. Traditional knowledge about wetland plants has much to offer for modern needs, such as the sustainable use of wetland plants, conservation and industrial development. We therefore conclude that there is a great need for detailed systematic ethnobotanical studies on wetland plants to be undertaken as a matter of urgency.

Competing interests

The authors declare that they have no competing interests.

Authors’ contributions

YZ and HH conceived of the study, participated in its design, data collection and analysis, and helped to draft the manuscript. HLX participated in data analysis and enrichment of manuscript. HC and FW participated in data collection, analysis and revision of the manuscript. All authors read and approved the final manuscript.

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