Potential Growth Of Aquatic Plants In The Republic Of The Philippines And Projected Methods Of Control

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ABSTRACT

Waterhyacinth, waterlettuce, and ottelia were the most widely observed aquatic plants. Frequently, watermorning-glory and waterprimrose grow intermingled with these species and make the problem of aquatic plant control more difficult. When these aquatic plant growths are permitted to become established in quantity, original design characteristics are changed and the storage, drainage and/or navigation capacity become uncertain. Maintenance operations are required to prevent the problem situation from becoming acute. Mechanical methods, or herbicides, or both of these control measures are available and should be implemented concurrently with the development of a project. Biological methods should be researched in the Philippines for practical long-term vegetative management.

INTRODUCTION

During the post World War II period various efforts to provide technical assistance have been extended to nations of the Far East by the United Nations Economic Commission for Asia and the Far East (ECAFE). As a provisional part of that program, U. S. Agency for International Development, (USAID/Philippines) requested a survey of aquatic plant problems related to water resource projects under study in the Philippines. A three-man team was assembled by the Corps of Engineers to review aquatic plant problems and to make a limited survey of different areas of Asia (1,3,4,5,6,8).

RIVER BASIN DEVELOPMENT

Serious flood losses in central Luzon in 1960 dramatized the need for control and regulation of the river systems to insure stability of future agricultural and industrial development. With the endorsement of the Philippine National Economic Council, the USAID/Philippines submitted a project proposal covering seven river systems. Subsequently, a Participating Agency Agreement was executed under which the U.S. Bureau of Reclamation made a survey of water resources (14,15,16,17,18,19,20). See Figure 1.

Central Luzon. This area consists of the Agno River Basin and the Pampanga River Basin. The area covers about 18,000 km^2 in Central Luzon. It is bounded on the south by Manila Bay, on the east by the Sierra Madre Mountains, on the northeast by the Caraballo Mountains, on the north by the Cordillera Central Mountains, on the northwest by Lingayan Gulf, and on the west by the Zambales Mountains. The terrain is relatively flat. It is extensively cultivated and has long been known as the rice bowl of the Philippines. Aquatic weed problems in this area are related to rice culture.

Upper Pampanga River. This project area is located in the Province of Luzon on the upper reaches of the Pampanga River Basin. It is planned as a multipurpose project which would furnish year-round water for irrigation of 80,000 ha of land, 30,000 kw of power, control of flood flows originating above the Pantabangan Damsite, furnish municipal water for the area, and provide facilities for fish conservation and recreation. Aquatic weed problems in this project are related to water storage, irrigation, and fish culture.

Cagayan Valley. This basin is located in the northern portion of the Island of Luzon and encompasses part of Isabella, Cagayan, Mountain, Nueva Vizcaya, and Quezon Provinces. It covers an area of approximately 28,000 km.^{2} The Cagayan River is the principal drainageway, flowing in a northerly direction from its headwaters in Nueva Province. The principal land forms are the Sierra Madre Mountains on the east, the Cordillera Central Mountain Range on the west, and the Caraballo Mountains on the south. The river valley is a broad fertile alluvial plain, subject to periodic flooding during high water flows. Marshes and swampland are found along the lower reaches at the mouth of the river. Numerous potential dam and reservoir sites available along the watercourse. Aquatic weed problems are related to flood control.

Bicol Penninsula. The basin is situated on the lower part of the Island of Luzon and encompasses the Bicol River in the Provinces of Carmarine Norte and Arby. It is an elongated flat plain bordered by mountains and volcanos on the eastern side and highlands and low hills on the western side. It covers an area of about 312,000 ha. The main drainage is to the northeast through the Bicol River and its tributaries which ultimately drain into San Miguel Bay. There are three natural lakes in the basin, Lake Buhi, Lake Bato, and Lake Baao. There is only limited opportunity for large scale hydroelectric power development. The most pressing need is for the expansion of irrigation storage reservoirs. Aquatic weed problems are related to water storage.

Negros Island. The Ilog-Hilabangan River Basin is located in the southern part of the Island, bounded on the north by the Panay Gulf, on the south by Tolong Bay, and on the east by Tonon Strait. The Ilog River, the principal drainageway, discharges into the Panay Gulf. The Hilabangan River originates in the eastern most part of the Island and flows in a westerly direction into the Ilog River,

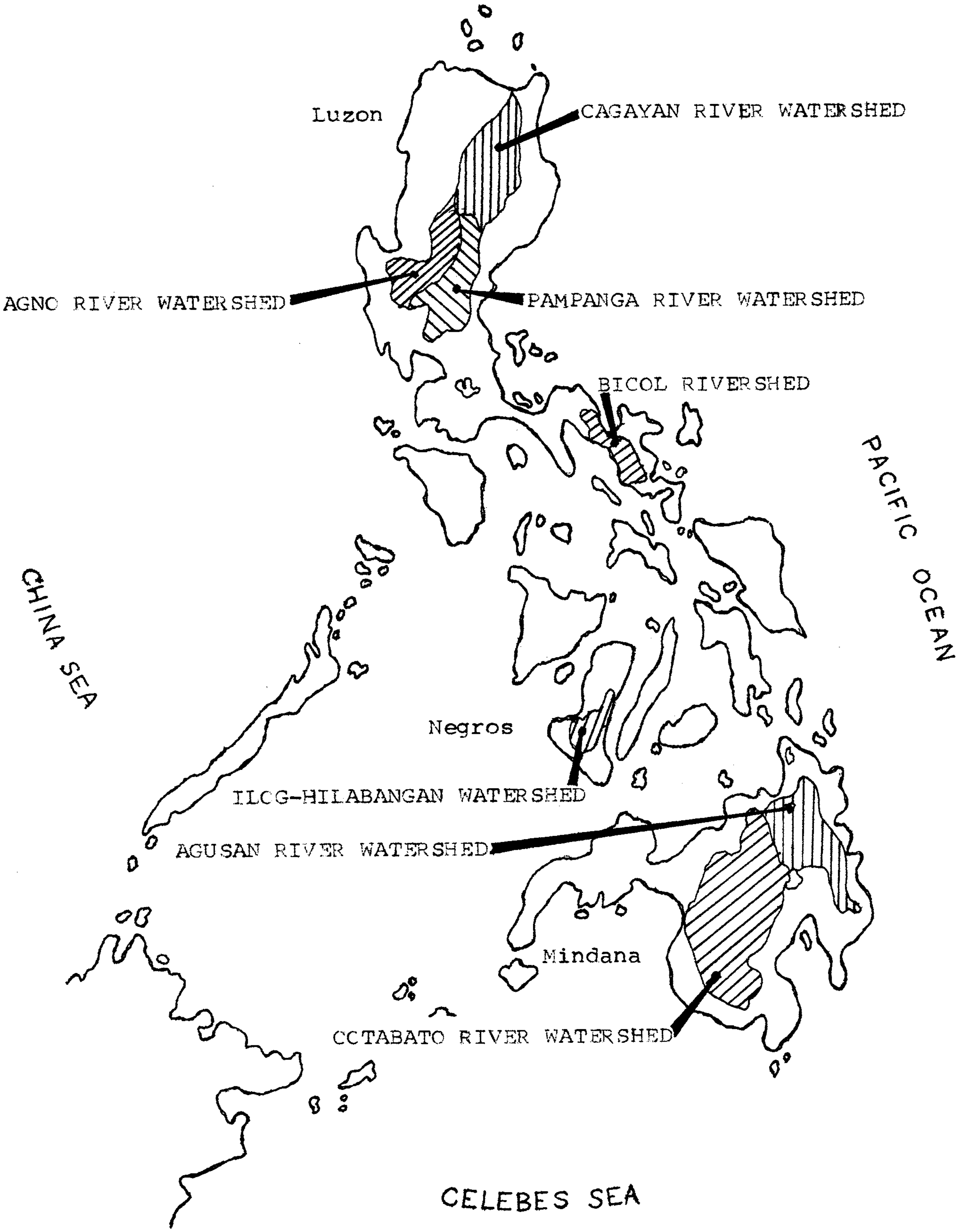

Figure 1. Water resource areas for river basin studies.

about 25 km^2 from the mouth. The basin is characterized by a dry season, January, through May and a wet season, May through December. Flooding is a serious problem and would be a major justification for the project. Aquatic weed problems would be related flood control.

Aguan River. This river basin is in the eastern part of the Island of Mindanao, the second largest Island in the Philippines. It includes most of Agusan Province and a large part of Davao Province. The basin covers about 11,500 km^2. The Agusan River is the principal drainageway. It originates in Davao Province and flows in a northerly direction and discharges into Butan Bay. Numerous potential damsites exist but basin engineering data are not available to formulate a comprehensive plan. Aquatic weed problems would be related to flood control.

Cotabato. This basin covers an area of approximately 20,000 km^2 in eastern Mindanao. It is bounded by the Central Cordillera Mountains on the east, the Tiruray Highland in the south, and the Lanao-Bukidon in the north. The principal drainageway is formed by the Pulangi and Alah Rivers. The Liguasan and Libugan Marshes cover extensive portions of the lower basin. Lake Bulan and Lake Sebu are two large bodies of inland water. Much of the arable land is periodically flooded during the rainy season and flood control would be a major justification for construction of the project. Aquatic weed control would be related to flood control.

AGRICULTURAL DEVELOPMENT

Agricultural production in the Philippine Islands is largely limited to a pastoral system of the small family farm. Unit production is low and unit costs are high, because much of the field work is done by hand, crop varieties are low yielding, market facilities are generally inadequate and input costs are high for most elements of the production system. The Filipino farmer sells his crop at a low competitive price and he must buy fertilizers, pesticides, and machinery at high import prices. As a result, agricultural production does not meet the needs of the people for food and fiber (1,3).

Programs to stimulate production of agricultural commodities to meet current needs for food and fiber are in progress. The International Rice Research Institute has a program of development of high yielding varieties. Similar programs are underway at other universities and colleges. The Department of Agriculture has programs for better utilization of fertilizers and pesticides. The program includes extended use of irrigation water, and an effort is being made to improve marketing of agricultural products (3,8).

Studies of river basin development suggest that practically all phases of agriculture and local industry could be expanded under a program of development of water resources. In as much as water supply itself is not limiting, there is reason to believe that such a development would be in the interest of the public. Philippine agriculture is neither as labor-intensive as that of other countries in Asia nor as capital-intensive as that of western countries. The overall picture of low productivity per man-hour of labor, as well as the meager yields per ha, are nevertheless, real. While abundant rainfall and high temperatures sufficient for a long growing season are important assets to be taken into account for future development by the addition of improved technology, these same features rob the soil of nutrients and require improved management to attain these ends (1,3,8).

SURVEY OF AQUATIC PLANTS

Aquatic plants are commonly found in all bodies of water in the Philippines to a greater or lesser extent. The diverse nature of these habitats provides for a great many different ecological adaptations, but from the standpoint of control, these plants are simply classified as floating, submersed, and marginal. Floating plants may be free floating or rooted and emergent. Submersed plants may be free floating or rooted. Marginal aquatic plants are equally diverse, ranging from those rooted to the bank and growing horizontally out over the water to those which grow upright on the shoreline (3,4,6,7). A summary according to plant type, common name and scientific name is given in Table 1.

Floating Aquatic Plants. Waterhyacinth, waterlettuce, and waterfern were the most widely observed floating aquatic plants in the Philippines. Waterhyacinth is by far the most troublesome pest. Under the influence of current, wind or tide, masses of waterhyacinth move about in rivers, lakes, reservoirs, and navigation channels and increase the hazards of operation. They interfere with the movement of all types of craft. These plants may accumulate in huge masses at the bow of a barge or boat and may even stop forward motion. Floating masses may also interfere with the operation of locks and gates involved in water control in the distribution system. They are known to build up in

TABLE 1. SUMMARY OF AQUATIC PLANTS OBSERVED IN THE PHILIPPINE ISLAND ACCORDING TO TYPE, COMMON NAME, AND SCIENTIFIC NAME.

Common Name	Scientific Name
A. Floating and Floating Leaf	
Waterhyacinth	*Eichhornia crassipes* (Mart.) Solms.
Waterlettuce	*Pistia stratiotes* L.
Waterlily	*Nymphaea* spp.
Watersprite	*Ceratopteris siliquosa* (L) Copel.
Cloverfern	*Marsilea crenata* Presl
Waterfern	*Salvinia* spp.
B. Submersed	
Ottelia	*Ottelia alismoides* (L.) Pers.
Hydrilla	*Hydrillia verticillata* Royle
Elodea	*Elodea* spp
Myriophyllum	*Myriophyllum* spp.
Curlyleaf-pondweed	*Potamogeton crispus* L.
C. Marginal	
Waterwillow	*Ludwigia octovaluis* var. Sessiliflova (Mich) Raven
Waterprimrose	*Ludwigia perennis* L.
Watermorningglory	*Ipomoea aquatic* Forsk.
Kalagoa	*Monochoria vaginalis* (Burm.) Presl
Veronica	*Veronica cinerea* (L.) Less
Maismais	*Sphenochlea zeylanica* Gaertn.
Junglegrass	*Echinochloa colonum* (L.) Link
Barnyardgrass	*Echinochloa crusgalli* (L.) Beauv.
Bagang	*Phragmites australis* (Cav.) Trin.
Sedge	*Cyperus difformis* L.
Sedge	*Cyperus compactus* Retz.
Sedge	*Cyperus imbricatus* Retz.
Sedge	*Cyperus iria* L.

sufficient quantity to destroy a bridge and/or related structure of the waterway.

Submersed Aquatic Plants. Vallisinaria, hydrilla, ottelia were observed to be the most serious submersed aquatic plants. Frequently the latter is found growing with floating types and presents a difficult problem for control. Submersed plants interfere with small boats in a closed channel, by jamming the propeller, clogging the cooling system, blocking the rudder and possibly stopping all forward motion of the boat. These plants may retard the flow of water as much as 80%, reducing the irrigation system to a point of uselessness. Extensive growth may also interfere with the development of fisheries and limited industrial and municipal uses of water.

Marginal Aquatic Plants. By definition, these plants grow along the shoreline and are a natural part of the vegetation. They include an extremely diverse group of plants from dicots to sedges, aquatic grasses to woody plants, such as the waterwillow. In the Philippines, marginal aquatic plants such as waterprimrose and the watermorning-glory present the greatest problem. They tend to overgrow a particular site and render it useless for domestic purposes. If the banks are properly engineered, however, the weeds frequently can be controlled by mechanical means, and the foliage can be used agriculturally.

MEASURES OF CONTROL

Control measures to date in the Philippines have been largely limited to mechanical devices such as floating booms, draglines and manual removal of plants by hand and hand tools. In the United States the same methods have been used, and specialized equipment has been developed by commercial companies and the Corps of Engineers. For waterhyacinth control the most effective mechanical method is the "Destroyer" or "sawboat". Across the bow of this boat is mounted a horizontal axle with cotton-gin saws spaced about 10 cm apart, raised and lowered on an out-rigger. For this method to be effective, it is usually necessary to cut the floating aquatic material four to five times. The chopped material decays and falls to the bottom in 3 to 5 weeks.

Chemical Methods. Most aquatic plant control done since the end of World War II has been accomplished by means of herbicides. By far the larger part of this effort has been with the herbicide (2,4-dichlorophenoxy)acetic acid (2,4-D) and of the treatment in aquatic sites has been for control of waterhyacinth. Herbicide may be applied from the bank or shoreline, from a boat or from an airplane. Most of the work done by the Corps of Engineers has been with a standard boat using pumps of 38 to 132 liters capacity at 11 to 54 kg per cm^2 (60 to 30 psi). There are a number of innovations that can be introduced to reduce drift of the herbicide. These should be used as needed.

Biological Control. Techniques for control of aquatic plants with biological agents in tropical climates are relatively well developed at the laboratory level but few are or have been applied in the operational sense. Application of these agents for aquatic plant control in the Philippines would require a research and development program on the lakes and reservoirs as they exist or may be constructed in the future.

Biological control by the use of the alligator weed flea beetle (*Agasicles hygrophila* Selman and Vogt) to control alligatorweed in the United States is one example of the successful use of an organism to control aquatic plant growth. However, alligatorweed was not observed in the Philippines. Currently, a number of insect enemies of water-hyacinth are being developed but are not yet operationally developed for application in the Philippines (1,14).

The use of herbivorous fish to control aquatic vegetation has received considerable attention. Fish which feed partly or entirely on aquatic vegetation include Congo tilapia (*Tilapia melanopleura* Dumeril), Java tilapia (*Tilapia mossambica* Peters), Nile tilapia (*Tilapia nilotica* L.), *Tilapia zillii* Gervais, silver dollar (*Metynnis roosevelt* Eig.), *Mylossoma argenteum* E. Ahl, Common Carp (*Cyprinus carpio* L.), the Israeli strain of the common carp, and the white amur (*Ctenopharyngodon idella* Val.). Of these fish the white amur appears to be the most promising for the control of aquatic macrophytes, particularly submersed ones (11,12).

The white amur is native to those rivers of China, Manchuria, and Siberia which run into the Pacific Ocean from latitudes 50 N to 23 N .This fish has been successfully introduced into a number of countries in Southeast Asia, Eastern and Western Europe, and the United States for research and field trials. Arkansas is the only state in the United States to have released the white amur in natural bodies of water (10).

The white amur is also called the grass carp and Chinese grass carp. It is classified in the Cyprinidae family, to which the carp and minnows belong, and can be readily distinguished from other carp by their double-rowed, compressed, and comb-like pharyngeal teeth. The pharyngeal teeth are falciform and toothed. The body of this fish is slightly elongated and is moderately compressed, laterally. The upper part of the body is dark gray to oblive brown and golden brown with the lower part silver-white in color. The white amur has a high tollerance to temperature changes and can withstand salinities as high as 10,000 ppm and oxygen concentrations as low as 0.5 ppm. Only two instances of natural spawning outside their native range have been reported, however, artificial spawning of the white amur can be conducted with relative ease. Artificial spawning could be used to control the number of fish in an area where natural reproduction does not occur (2,10,13).

Growth of the white amur depends on the amount and type of vegetation present, length of the growing season, temperature, and the interrelationships of these factors. The white amur prefer soft vegetation and will eat more than their weight daily of such plants as pondweeds (*Potamogeton* spp.), coontail (*Ceratophyllum* spp.), elodea (*Elodea* sp.), and cattails (*Typha* spp.). Hydrilla is readily consumed by this herbivorus fish with the amount eaten depending on water temperature and fish size (13).

The results of these studies indicate the white amur has great potential for control of submersed aquatic weeds in the Philippines.

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