Research Needs and Applications to Reduce Erosion and Sedimentation in Tropical Steeplands (Proceedings of the Fiji Symposium, June 1990) IAHS AISH Publ. No. 192, 1990

Traditional adaptation to natural processes of erosion and sedimentation on Yap Island

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ABSTRACT Yap is a high island with a mean annual rainfall of 3040 mm and considerable potential for erosion. The island once supported a dense population with a nature-intensive technology. The traditional food production system incorporated tree gardens which mimic natural forests in intercepting rainfall and holding the soil, and taro patch systems which mimic swamp forests as a silt trap. Trails were stone-paved and drained by stone-lined ditches. In wild forests, the canopy is removed during the dry season and a mixture of crops cover the soil by the time the heavy rains arrive. The system requires an ample fallow period to be sustainable however. Systems of ditches are utilized to manage water runoff. In coastal areas, management of stream flow was used in landfill operations. Means of managing erosion and siltation resulting from new technologies are needed.

INTRODUCTION

Yap is a close cluster of 4 high islands lying within a broad fringing reef at lat.9'33'N. and long. 138'09'E. in the Western Caroline Islands. Politically, the islands are part of the Federated States of Micronesia. The combined area of the 4 main islands is about 100 km2 and the highest point is 174m. Thirty-six percent of Yap's soils are described as having a high to severe hazard of water erosion (Smith, 1983).

The climate is warm and humid. Mean annual temperature is 27'C (81'F). Mean annual rainfall for the years 1949 - 1988 was 3040 mm. The driest months are from February to April with an average of less than 180 mm precipitation each month. Wettest months are from July to October, with an average monthly rainfall of 330 mm. Standard deviation for rainfall is about 457 mm.

Yap is known for its conservatism, and the persistence of some traditional ways gives us a glimpse of how at least one island people adapted to the processes of erosion and siltation before the advent of fossil-fueled technology. Yapese technology used might be termed "nature-intensive" as it made use of natural phenomena. These adaptations are probably clearer on Yap as a result of the island's dense human population in the past. Estimates of the pre-contact population range from 25,000 (Hunter-Anderson, 1983) to 40,000 (Underwood, 1969).

Results of the agricultural system employed to feed such a dense population can be seen in the island's anthropogenic vegetation pattern today. Some 26% of the island has been developed into a system of tree gardens with taro patches categorized as "agroforest". These areas are mainly located along the coast. About 34% of the vegetation consists of a mosaic of native forest, secondary forest, secondary vegetation and garden plots. Another 22% of the interior is savanna grassland. Mangroves make up some 12% of the vegetation. Other types together make up less than 6% of the land area (Falanruw et al., 1987).

TREE GARDENS AND TARO PATCH SYSTEMS

The most stable of Yap's food production systems are tree gardens and taro patch systems which generally occur about villages mostly in coastal areas. Human activities in developing villages, gardens and paths between villages appear to have involved the deepening of low areas to obtain fill for house sites, raised gardens and paths. Useful trees were planted in the raised and drained areas along village paths and around home sites. These became the agroforests of today. Preliminary results of ongoing studies have identified some 55 species of trees producing food or spice products. Commonly associated with these trees are another 62 species of useful shrubs and herbs. Other species are present growing wild or allowed to grow for uses or reasons not yet recorded. Such tree gardens provide food and other products while functioning like natural forests in intercepting rainfall and holding the soil.

Low areas were planted to *Cyrtosperma chamissonis* (Schott) Merr., the giant swamp "taro". Water flow within and through taro patches was carefully regulated to maintain a suitable growing media. *C. chamissonis* requires a about 3 years to reach a good size, but it may be left to grow longer. Sucker corms are generally replanted at the time that the main corm is harvested. Some plants are left to grow especially large for presentation on special occasions. Taro patches are almost always fully stocked with newly planted suckers and harvestable plants of various sizes. Thus, there is minimal exposure of taro patch soils to erosive forces.

So important is *C. chamissonis* that the land tenure system provides for ownership of taro patches in areas which may be removed from the main estate. As a result, taro patch habitat is often divided into many small segments managed by different owners. The division of taro patches and garden plots into many small plots belonging to different estates probably occurred at the time that Yap was densely populated. With post contact depopulation the number of taro patches per estate increased. A census of land in one of Yap's ten municipalities revealed some 2,689 taro pits (Mahoney, 1958), or a ratio of 15-16 taro patch plots per person. At the time of the survey, 1957, only 20% of these taro patches were reported to be in use. Prior to depopulation, Mahoney (1958) estimates a much larger population and less than 2 taro plots per person. During the period of high population density there was pressure to convert other vegetation types into taro patches. Taro patches are common adjacent to swampy areas and the inner reaches of mangroves. Hunter-Anderson (1986) reports archaeological evidence of mangrove soils below a taro patch in an area where no mangrove currently exists. Today, only remnants of swamp forest can be found. Though taro patch systems replaced many coastal wetlands, they maintain the ecological function of a coastal silt trap.

STONE-PAVED PATHS AND LANDFILLS

Winding through village agroforests are stone-paved paths which are often drained by stone-lined ditches in order to minimize erosion. Where agroforests and taro patch systems with their stone paths and lined drainage ditches are intact, rainfall runoff runs clear.

Along coasts, there was considerable land extension. These involved the construction of seawalls which were then backfilled with debris. In some cases streams or portions of streams were diverted so that debris carried by running water was deposited within L-shaped stone retaining walls. Hunter-Anderson (1986) reports a case of women diverting a stream to create more land.

INTERMITTENT MIXED GARDENS IN FORESTED AREAS

Inland of villages, gardens are alternated with wild forest and bamboo cover. The species composition and production of these gardens is being evaluated in an ongoing study. The development of these gardens involves the burning of slash around tree trunks during the dry season to open a "skylight" in the forest. In addition to admitting light this results in a fall of leaf mulch and removal of root interference with crops. Ashes contribute to soil fertility. Larger branches and stems that are not burnt are piled around the perimeter of the garden or across it to help reduce erosion. The most important crop in these gardens are yams of the genus *Dioscorea*. Twigs are piled over mounds of softened soil where yam cuttings are planted to cool the soil, maintain moisture, and protect the plantings from jungle fowl and ground doves. The burn-girdled trees are left standing to serve as trellises for yam vines.

Over 15 crops are commonly grown in today's mixed gardens. Curcubits planted in ash soon after the burn grow especially fast. By the time the heavy rains come, a ground cover has generally become established. The fast growing herbaceous crops help to suppress weeds. Weeds of gardens made in forested areas are generally tree seedlings. *Macaranga carolinensis* Volk. is especially common. Unless they interfere with crops, seedlings are initially left growing as they help to suppress more noxious weeds and can be used as mulch at a later time. The crop species composition changes through the gardening cycle as harvesting is accompanied by a sequence of replanting.

There are no inputs other than the biological inputs of the site, human labor, and planting material. Technology consists of a knife, matches, digging bar, and the gardener's experience. For approximately 19 person days of labor plus harvesting time, one gardener harvested 2,122 pounds of carbohydrate produce in one year. In addition, from about the second month on, greens of limited weight but considerable nutritional significance for her family of 7 were gathered daily to weekly.

A considerable number of species and varieties of *Dioscorea* yams planted at the end of one dry season are harvested about the beginning of the next dry season. Some may be left to grow one or more additional years. If there is need, the gardener generally begins to prepare the next year's yam garden about this time. In this way, planting material from one garden will be recycled into the next, and the harvest from a first year garden is complimented by the harvest of longer term crops such as bananas from second and third year gardens.

Gardens are visited less frequently as less is harvested and they become more weedy. Nowadays at least, the most common reason given for abandoning a garden is the work involved in weeding. The introduction of noxious weeds such as *Mimosa invisa* Mart. and *Eupatorium odoratum* L. is causing considerable problems. Species which grow up in abandoned gardens, include trees which were cut and left to coppice, seedlings which were left growing and others sprouting from seed imported by birds and bats from the nearby forest. Sometimes cuttings of *Hibiscus tiliaceus L.* may be planted around the perimeter of raised garden beds to hold these banks and contribute to the fallowing process.

Once gardens are no longer maintained, a canopy of fast-growing species is established within two to three years. In 9 gardens observed over the last 2 years, the species composition of the secondary vegetation varied somewhat by site but included a predictable set of species in common. A much longer period appears to be required for the development of a mature-species diverse forest, and the system does result in a loss of primary forest species.

Intermittent gardens are generally not large, all seen thus far being under an acre in size. They are generally surrounded by forest, thus reducing the potential for scaling up of erosive effects. Six inch spikes were placed in gardens made on slopes from 24-36%. By the end of one year, the most noticeable difference observed was a decrease in leaf litter, and exposure of bare soil about some of the nails. Little soil erosion could be measured.

It is generally felt that too frequent burning of the forest canopy resulting in soil degradation led to the development of the savanna grassland vegetation type. When questioned about the origin of the savanna, contemporary elders merely reply that it has always been thus, so if the area was once forested it was long ago. It seems likely that during times of high population density land was cleared too frequently to allow for the re-establishment of forest canopy. It might be noted that Yapese gardens were not as diverse prior to the introduction of a majority of the species now grown in mixed gardens. This may have resulted in less ground cover in addition to the decreased fallow time.

The 1957 land census (Mahoney, 1958) reports some 2,127 garden plots in one municipality. This gives a ratio of 45 plots per household with 6%, or 2-3 plots per household in use at the time of the census. This is consistent with a pattern of initiating one new garden each year with continued but decreasing use being made of gardens from the 2 previous years. At that rate of use, and with a ratio of 45 plots per household, a fallow period of about 15 years would be possible.

Yap's population in 1957 was but 51% of the 1987 population and far below pre-contact levels. Based on a count of 485 stone dwelling platforms, Mahoney (1958) estimates a maximum population 10 times the population at the time of the 1957 municipal census. Divided among 485 households, 2107 garden plots would give a ratio of 4.3 garden plots per household. If garden plots were developed each year and maintained for 2-3 years, the fallowing period could only be about 1 year. This would not allow enough time for the development of a secondary canopy, much less the emergence of primary forest species.

The inhibition of the formation of a forest canopy would result in decreased transpiration and percolation of rainfall into the soil. This increases the need for water management. Evidence of water management is abundant. Ditch-drained garden beds can be found in many areas of Yap - areas currently covered with forests, secondary vegetation and savanna grassland. The presence of these beds is obscured by taller vegetation but they can be identified on aerial photographs in some 23% of savanna grasslands.

Today, drained beds in savanna grasslands, mostly established prior to the memory of contemporary elders, are used mainly to grow sweet potatoes. Within each rectangular bed there is generally a series of ditches running perpendicular to the long axis of the garden. These ditches are closed at either end. They are said to drain water from the planted beds and, being closed at either end, also provide a reservoir of water to "cool the soil" and maintain moisture. When beds are prepared, tall grasses and other growth is first cut and left on site. Additional slash from surrounding areas may be added. Soil is then thrown on top of this vegetation to cover it and prevent it from growing. The soil used to cover the mulch is evacuated from the ditches surrounding and within the bed. Thus soil runoff from previous years is replaced on top of the gardens. Clumps of clay soil from the bottom of the ditches is sometimes piled around the perimeter of the garden bed to reduce erosion. When the "water reservoir ditches" within the beds become too deep or reach a zone of clay soil not suitable for use on the garden bed, they are filled with grass and soil and another ditch is prepared parallel to the old one. Sweet potato vines are planted in the beds and grow rapidly to further shade out grass.

There are a number of problems with the sweet potato gardens. Compared to forest gardening the work involved is more arduous, the harvest is less diverse, they are increasingly subject to pest and disease problems, and sweet potatoes are not as favored as yams. Thus we may expect a continued decline in such gardening in favor of forest gardening. Unfortunately, forest resources are limited and the population of Yap island is now rapidly increasing. After a long period of financial support from the United States, the end of the trusteeship period has brought increased need for exports to earn foreign exchange for this new island nation. This is placing increased and new demands on land and this will eventually impact the traditional agricultural system which requires a long fallow period for sustainability. Modern development efforts generally begin with the bulldozing of land and result in considerable erosion and siltation of taro patches, mangroves, seagrass beds and marine life within the lagoon. Increased understanding and means of dealing with erosion and sedimentation in tropical steeplands is greatly needed to offset the impact of new technology on natural resources and traditional support systems.

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