การจัดระบบแหล่งให้น้ำกับป่าไม้ของประเทศไทย

Watershed Management with Special Reference to Thailand's Forests

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"Mere change without conservation is a passage from nothing to nothing..... Mere conservation without change cannot conserve."
ALFRED NORTH WHITEHEAD

Thailand is presently engaged in perhaps the most progressive national and economic development of her entire history. The conservation of soil and water will play a vital role in this development.

The storage dam, leveling out some of the wasteful highs and inadequate lows of natural stream flow plays an important part in soil and water development. Ultimately however, as history has repeatedly shown, it is what happens to the countries watersheds that determines the nature and quality of stream flow. The objective of watershed management is to meet problems of land and water use, not in terms of anyone resource, but on the basis that all resources are inter-dependent and therefore must be considered together. Practical watershed management will be achieved only to the extent that it rests upon a thorough understanding of the fundamental natural processes which govern the behaviour of soil, plants and water.

"Glamorous Projects"

E.N. Holmgreen, past Chief of Food and Agriculture Division of I.C.A., made the following statement: "People in many countries are in a hurry to see some concrete evidence of progress. This creates pressure for large "glamorous" projects. Such glamorous efforts may take the form of man-handling a land area into a large settlement project, the construction of big dams, extensive irrigation projects, extensive and expensive mechanization projects.....aside from the emotional appeal certain basic issues should be raised."

One such issue pertinent to Thailand concerns the attention, effort and progress being made in terms of the construction of dams compared with the research and capital being invested in watershed management studies. It is not enough to invest in the "glamorous"-dams and irrigation projects-we must proceed to the cause and concern ourselves with the concept of watershed management.

IMPORTANCE OF THE WATER CYCLE

Breaking the water cycle has wiped out civilizations in Mesopotamia, Ancient Rome, North Africa and elsewhere but because of the soaring world population we have reached a new crisis. "Never before" says William Vogt in his book, Road to Survival, "has the hydrologic cycle been so badly dislocated in the presence of so many hundreds of millions of people."

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Waste of water, including unnecessary runoff, or excessive use from anyone place for industrial and domestic purposes, or for irrigation, can lower the underground water table, sometimes far away, and deplete or temporarily exhaust the supply. In Thailand, where the future intensification of agriculture will depend largely on moisture supply, utmost attention must be given to the ground water supply. Thailand's watersheds are the source of this supply.

The primary means of increasing and maintaining water reserves is to protect and improve the plant cover on our watersheds. From these areas of drainage the water is fed by runoff and seepage to surface and underground streams. In tropical Monsoon countries such as Thailand where precipitation occurs only six months of the year the conservation of water is imperative, not only for agriculture but also for industry and municipalities.

The watershed problem is one of the red-letter problems of the day. Almost everything that has to do with renewable natural resources, with forestry, farming, fishing, hunting, and the economics of productions, is tied up with the watershed.

THE MEANING OF WATERSHED MANAGEMENT

A basic premise of watershed management is that the amount and rate of stream flow express the natural and cultural characteristics and conditions of the watershed which produces it. Four factors affect the volume and rate of runoff:

1. Precipitation (kind, amount, distribution and intensity).

2. Drainage basin characteristics (size, shape of basin, length and steepness of slopes and stream density).

3. Soil and its plant cover.

4. Changes in soil and cover through land use and fire.

So far as we know the soil and its cover is the only factor subject to considerable modification by man.

A stream flow gage measures total discharge. This discharge comes from three sources:

1. Base flow.
2. Surface runoff.
3. Sub-surface flow.

Base Flow: Comes from underground reservoirs which are the source of water for streams during rainless periods.

Surface Runoff: This water runs over the surface of the soil; for this reason surface runoff rates are very responsive to the intensity and amount of rainfall.

Sub-Surface Flow: Originates from water stored temporarily in the soil at shallow depths (usually less than 60 cm.) over a more or less impermeable layer. As the water accumulates over this layer it will slowly move down the slope through the soil pores into the stream channel.

The causes of variation in seasonal stream flow resulting from land treatment must be sought in the fundamental properties and interactions of plants, soil and water.

A. Soil As A Storage Reservior

Soils are not static but rather dynamic, continuously changing in color, depth, texture and structure in response to the activities of living organisms. The normal processes

of geological weathering and soil formation tend to deepen the soil due to breakdown of the underlying rock. This is a long process. Whenever the soil supports vegetation it is enriched to some degree by organic matter. But the soil is a porous framework made up of mineral particles and pore space which is occupied by air and water. Hydrologically, soil is an agent which holds water or passes it on to stream flow. How effectively it does this depends on the inherent nature of the soil and how man has managed this soil. Rate of infiltration of water into the soil, percolation of water through the soil and storage of water in the entire soil are most important factors in watershed studies. In Thailand's forest these factors vary not merely because of the inherent nature of the soil but also because of past management. Thus in one case we have deeply weathered soils derived from limestone rocks and in other instances shallow soils over shales and sandstones. But fire and shifting cultivation have modified many of natures soils in such a way that the infiltration and percolation of water in a given soil has been reduced. Consequently, ground storage water has been reduced while runoff water has increased.

B. Vegetation and Retention Storage

Vegetation affects the amount of water that can be stored in the soil through the influence of organic matter on the storage capacity of the soil and on soil depth. Water is removed from retention storage in the soil by evaporation and transpiration. Rates of evaporation on the relations of temperature, wind movement and vapor-pressure gradient –all three of these are influenced by type and density of vegetation. Hydrologically, those relations are highly significant. Vegetation whose roots are 4 ft. deep will provide twice as much water retention storage in the soil as vegetation whose roots are only 2 ft. deep. The ability of plants to occupy soils shallower than their inherent root depth capacity is very important in watershed management. Inherently deep-rooted plants growing on shallow soils will take advantage of any increases in soil depth resulting from the incorporation of organic matter.

The effects of treatment of vegetation in retention storage are reflected in the amount and rate of stream flow. By managing forest vegetation so that both the depth to which water is stored and the water–holding capacity of the soil particles is increased, more rainfall can be stored. Consequently, less will drain off to streams and water yield will be reduced.

In Thailand, many of the soils are shallow but frequenly they are developed over partially decomposed shales, sandstones and igneous rocks which, if they contain tree roots and organic matter, permit groundwater storage in their weathered cleavages. Repeated fires and shifting cultivation annually removes most of the ground cover vegetation, including young trees. Moreover, much of the natural forest lands are underrocked esspecially in the commercial forest like teak. Under these conditions not only is the canopy cover lost and little or no litter remains to protect the bare soil but also root growth into the subsoils is restricted. Water retention storage is reduced. The weathered rock cracks and cleavages which could store water under virgin forested conditions never become filled. Instead, water runs off the bare soil surfaces on the steep slopes into the streams,

it is wasted and contributes to the flooding and silting up of rivers beds and dams.

In summary, loss of vegetation by fires, shifting cultivation and improper forestation will reduce soil depth, water infiltration, water-holding content and storage capacity by preventing the accumulation and incorporation of organic matter.

BASIC INFORMATION NEEDED

Certainly the basic principles of movement and storage of soil water apply in all countries. Stream flow in turn, wherever it may occur, reflects the interaction of soil and vegetation.

Application of the principles of watershed management requires specific information as to the conditions affecting plant-soil-water relations for the watersheds to be managed. First of all, broad regional differences, such as climate must be considered. Secondly, consideration must be given to the local variation in climate, vegetation and soil (including geology) of the specific watersheds to be managed.

Basic data may be conveniently placed in three major categories: (1) Water, (2) Soils, and (3) Vegetation. Data required under item (1) include the precipitation over the watershed, and the proportion represented by stream flow. Knowledge of precipitation characteristics should include types and intensities of rainfall, and the amounts that fall as rain. Data should be collected on the distribution of stream flow throughout the year, the uses to which the water is put within and below the watershed, and the problems, if any, associated with streamflow variation and quality.

In category (2), information should be acquired on the storage characteristics of the several important soil types, especially water-holding capacity, and depth in relation to root depth. The collection of data on the seasonal movement of soil moisture will provide an essential guide to the volume of available storage under different types of vegetation and of land treatment. Runoff, infiltration, and percolation values will be needed to determine the proportions of precipitation that go to surface, sub-surface and base flow, respectively, as well as the utilization of storage space by soil-water movement. Rates of accumulation and incorporation of organic matter into the soil will require systematic observation. The preparation of maps indicating the pertinent hydrologic characteristics of the soils will provide necessary "working tools" for the conduct and evaluation of management practices on the watersheds concerned.

In category (3), information will be needed on root depths of plants of various species and ages. A working knowledge of ecology, particularly in reference to the water-using characteristics of various stages of plant succession, is also required as a basic for determining the possibilities of influencing water yield by manipulating the plant cover. In addition, phenological observations will help in providing useful indications of seasonal water use by plants.

The information just outlined is basic to effective watershed planning because it will permit an evaluation of the effects of current forest practices on stream flow. It can also be used to help determine which practices will best meet the requirements for stable conditions of soil and stream flow,

and how intensively forest areas can be used without endangering these conditions.

STUDIES INITIATED BY KASETSART UNIVERSITY

Preliminary studies aimed at gathering some of this needed basic information related to problems in watershed management have been initiated by Kasetsart foresters.

A recent soil–site index investigation in the teak forests of Lampang province has already revealed some interesting data about the water retention storage of contrasting soils. Moreover, specific soil characteristics such as depth, texture, permeability and effective rooting have been indentified. Much more of this kind of information is urgently needed.

Observations made in Northern Thailand confirmed previous reports written about the problems of the watersheds (soils, water loss, understocking, etc.) associated with excessive fire, shifting cultivation and poor forest management practices. On this occasion other forested areas in Chiengmai and Lampang provinces provided convincing evidence that pilot experiments must be urgently initiated to help determine solutions to some of these watershed problems.

Two rather different, though related problems exist in the areas visited. Both, however, concern the misuse of forested lands and thus mismanagement of important watersheds.

A. Lampang Area

The brief report which follows might be conveniently presented under the following sub–heading:

1. Watershed studies initiated at Huay Tak.
2. Suggestions for further studies at Huay Toa.

1. Watershed Studies at Huay Tak

Four pairs of runoff erosion plots which were set up by the Kasetsart Forestry staff last May are already yielding very interesting and informative data. The plots are located in teak plantations, natural teak forest and on dry Dipterocarp forest. One of each pair of the plots is being burnt while no fire will be permitted on the other.

Rain gages are located at each site. Volume of runoff water and weight of sediments from each plots is beginning to give some idea of the loss associated with different forest management practices and type of vegatative cover. A summary of the results obtained from the runoff plots during the first three months is presented in Table 1.

2. Suggestions for Further Studies at Huay Toa

The collection of data from runoff erosion plots is just one phase of a watershed management programs.

The Huay Tak Station offers unique possibilities for continuing pilot studies in watershed management for 4 important reasons:

(a) Huay Tak is the only Forestry Training Camp in Northern Thailand for Kasetsart University and Phrae forestry technical students to carry out their practical forestry training.

(b) Huay Tak is situated in a very important forestry region where watershed problems are quite severe.

(c) Preliminary studies in forest soils, silviculture and watershed management have already been initiated jointly by Kasetsart

University Forestry Faculty and the Royal Forestry Department.

(d) Pilot studies in watershed management are urgently needed in Thailand. Information obtained at Huay Toa could be useful in other areas.

Table 1. Runoff Sediments at Huay Tak Forest, Lampang Province, for Period May 22–August 26, 1960, from Two Pairs of Plots

Plot		Treatments	Rainfall mm.	Wt. of Sediments per plot (Kg)	Wt. of Sediment per hectare (Kg)	Vol. of Runoff per plot (Litre)	Vol. of Runoff per hectare (Litre)
			Total	Total	Total	Total	Total
	A	Burned		123.253	61,969.59	2,954.37	1,600,426
1			644.90				604,784
	B	Unburned		9.078	5,921.085	741.68	
	A	Burned		70.12	39,128.83	1,944.32	
2			581.97				1,175,804
	B	Unburned		82.02	43,674.46	1,593.27	1,195,617

It is quite obvious that the date presented above involves both insufficient time and too few plots to permit much comment. Nevertheless, some interesting trends are already beginning to appear.

Plot 1 is situated in a 12 year teak plantation on a 27 percent slope. The soil is a silt loam and about 50 cm. deep over weathered shale. The plantation had not been burned for about 5 years which permitted a good vegetative "Litter" to build up on the soil surface. Plot 1A was deliberately burned while Plot 1B was not. As can be seen from the data in Table 1 both loss of soil by erosion and runoff is considerably higher on the burnt plot. Indeed, the loss of soil is more than 10 times higher on the burnt plot and the amount of runoff water is in the order of three times as much. It must be reemphasized that these records are from one pair of plots and during the period which only represents the early Monsoon rains.

If one were to extrapolate these results using total rainfall to date one could show that even on an initially dry soil, already about 25 percent of the rainfall has runoff and not infiltrated into the soil on the burnt plot as compared with only about 8 percent runoff on the unburnt plot. Similarly, one could show that erosion had already accounted for about 3.5 mm. of surface soil on the burnt plot.

Plot 2 is located in natural teak forest on a 14 percent slope (as compared with 27 percent in plot 1) on a shallow soil

over shale. The teak forest has been burned annually for probably the past 10 years. The amount of runoff on these plots is comparable with that in Plot 1A. However, in subsequent years the effect on non-burning in plot 2B should be reflected in the soil loss and runoff data.

Many more plots are needed together with other investigation which are suggested later in this report to collect basic data essential for a watershed management program.

The recent reconnaisance made by Nai Sa-ard Boonkird, Mr. Feather, USOM Conservationist and the author, though incomplete, certainly revealed the desirability of intensifying a preliminary study in the Huay Toa watershed.

Situation

The Huay Toa watershed consists of about 50,000 rai immediately behind the Huay Tak Forestry Training Camp. The river which serves this watershed passes through this camp and supplies the only water available during many months of the year.

The watershed consists of three main vegetative associations. In the lower portion there are about 1,000 hectares of teak plantations, the second forest association and by far the largest is the dry Dipterocarp. Near the summit of the watershed the semi evergreen forests dominate. The soils and land form of the region is quite variable and includes considerable area of residual sedimentary and alluvial fans derived from a variety of rocks.

Water in the Huay Toa stream during the past three years in the 6 summer months has been nil. Prior to this some stream flow had continued even during the dry summer months. Fluctuations in the rainfall cycle appear to be insufficient to account for the lack of water in the past three years. Sedimentation of the old dam is serious. In fact, the dam is silted up entirely. Two other factors appear to be involved, both of which undoubtedly have detrimentally affected the effectiveness of this watershed, particularly with respect to its capacity to store ground water during the heavy monsoon rains.

1. The young teak plantations, though perhaps of lesser importance, provide less canopy, less debris and more semicultivated soil which together contribute to increased water runoff and sedimentation.

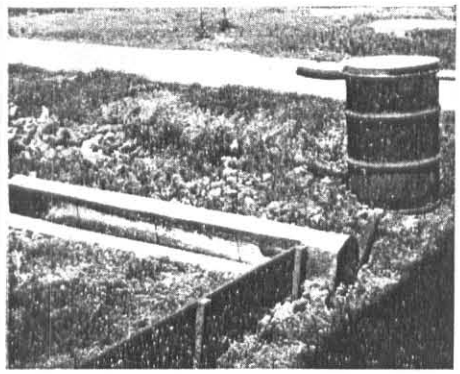
2. Undoubtedly of major importance because of the area involved, is the annual burning and cutting of the national forest land. Repeated burning of this area has resulted in denuding almost all the undergrowth of some of this area and certainly reducing it in others. Much of the watershed appears to be situated on long, steep (50 to 70 percent) slope. Considerable evidence of both sheet and rill erosion has already occurred.

A striking absence of forest litter prevails. Auger borings taken well into the middle of the Monsoon season indicate that water had infiltrated only about 70 cm. on these reasonably permeable soils indicating perhaps more than half of the water has run off.

3. Study Needed at Huay Tak

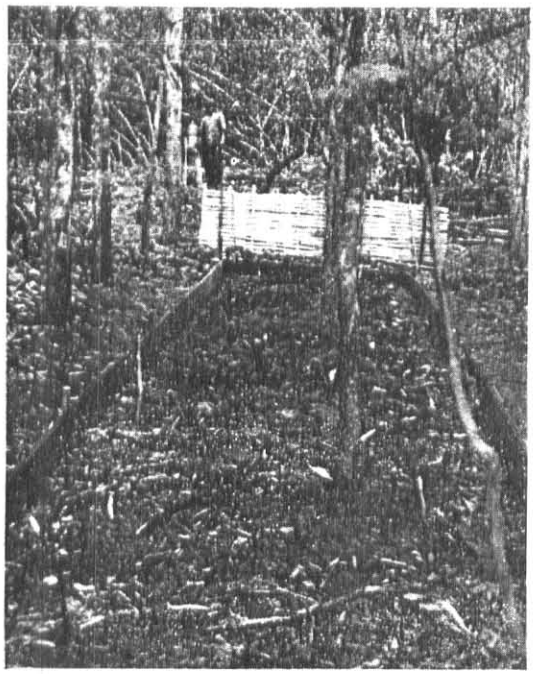
Valuable information and training could certainly be obtained by initiating a watershed study in this area. It seems to this

Runoff–Erosion Plots Installed by Kasetsart University



← **Fig 1.1** *Construction of a frame and trough for the Runoff–Erosion plot studies. Note also the drum and pipe connections used for conveying and storing the runoff water.*

Fig 1.2 *One of the Runoff–Erosion plots→ at Huay Tak Forestry Training Camp. Note this plot has not been burnt. Much "litter" covers the ground.*



←**Fig 1.3** *After installation* **one** *of each pair of plots was burned. This photo shows the plot after having been burnt. (Plot 1A)*

Permanent Damage to Thailand's Watersheds Because of Cultivation and Fire with Subsequent Erosion

Fig 2.1 *Corn grown on steep, long slopes is commonly practiced by Hill Tribes (and some Thais). Such practices cause serious permanent damage to the watersheds.*

Fig 2.2 *Rill erosion is often severe when row crops like corn are planted on steep slopes. Soil is lost and water–runoff instead of infiltrating into the soil and replenishing the ground–water supply.*

Fig 2.3 *Rill erosion leads to gulley erosion. Watersheds are permanently damaged. Villagers then move to new sites to destroy more of Thailand's watersheds.*

writer that the experiment would involve primarily three things:

(1) Installation of a gaging station located at or near the dam in front of the Huay Tak Forestry Station. This automatic measuring device would be designed to record seasonal water flow off the watershed.

(2) Installation of several pairs of runoff plots (similar to those already installed at Huay Tak) on carefully selected sites. One of each of the plots could be annually burnt. Additional information related to infiltration, percolation and retention storage of water could also be obtained.

(3) Careful delineation of the watershed by aerial map and reconnaisance after which a fire break might be made around the area in question. It would be necessary to patrol this fire break. Perhaps local villagers (who, incidentally, are the main instigators of the forest fires) could be paid to do this job.

The Forestry Faculty and students of Kasetsart would be thoroughly technically competent to carry out the study. Perhaps it would be desirable for them to cooperate with the Irrigation Department in the installation of the gaging station. Moreover, significant technical and financial assistance from USOM would undoubtedly contribute to the success of this important undertaking.

Indeed, such a watershed study would certainly be classified as conservation and with real justification to be considered as part of and contribute to the USOM Conservation Project.

B. Chiengmai Area

1. General Statement

Above the Forestry Station at Doi Sutep on the moutains behind Chiengmai there is located the watershed for the city of Chiengmai. In recent years shortage of summer water supply in and around Chiengmai has been frequently reported.

An aeroplane flight on a clear day reveals the mosaic pattern that shifting cultivation and fire have left scarred on the mountain side. Not infrequently both these hazards of forest land can be traced to the activities of the various Hill Tribes. Yet the dilemma that many of the Hill Tribes find themselves in is a serious one. Opium has been officially banned–an important source of their income is curtailed. Alternative cash crops are being established in the mountains by the Hill Tribes in their fight for existence. Such conditions lead to unrestlessness when viewed throughout Thailand as a whole. Unofficial counts estimate the Hill Tribe population total near 150,000. A shifting form of agriculture in the watersheds associated by fire after fire and involving so many people readily explains these mountain scars–and reduced ground water supplies.

The problem at Doi Pui situated within a part of this Chiengmai watershed involves a Maew Village of about 300 people.

2. Situation

(a) By agreement, the local forest officer has negotiated with the Maew villagers and permitted them to remain in their settlements on certain terms. These terms include moving the Maews to less steep slopes where they can continue to cultivate their crops. The Maews however, by tradition are shifting cultivators. To enforce a forest law which forbids Maew moving to other forested areas would likely be, at the best, only partially effective. More over, such an enforcement would undoubtedly be very costly.

(b) The Government at the same time has thrust upon the Royal Forestry Department the problem of establishing these Maew villagers in form of agriculture which will provide them with an economical existence yet still minimize the damaging of the watersheds.

There is little question that, by Western standards, the area involved should be in forest. Much of the land is situated on long 50–55 percent slopes. Serious rill and gully erosion already exist in the corn and hill rice fields. More will develop.

3. The Problem

Simply stated might read: what system of farming can these Maew engage in which will provide them an economic return yet maintain the productivity of the resources over a long period of time?

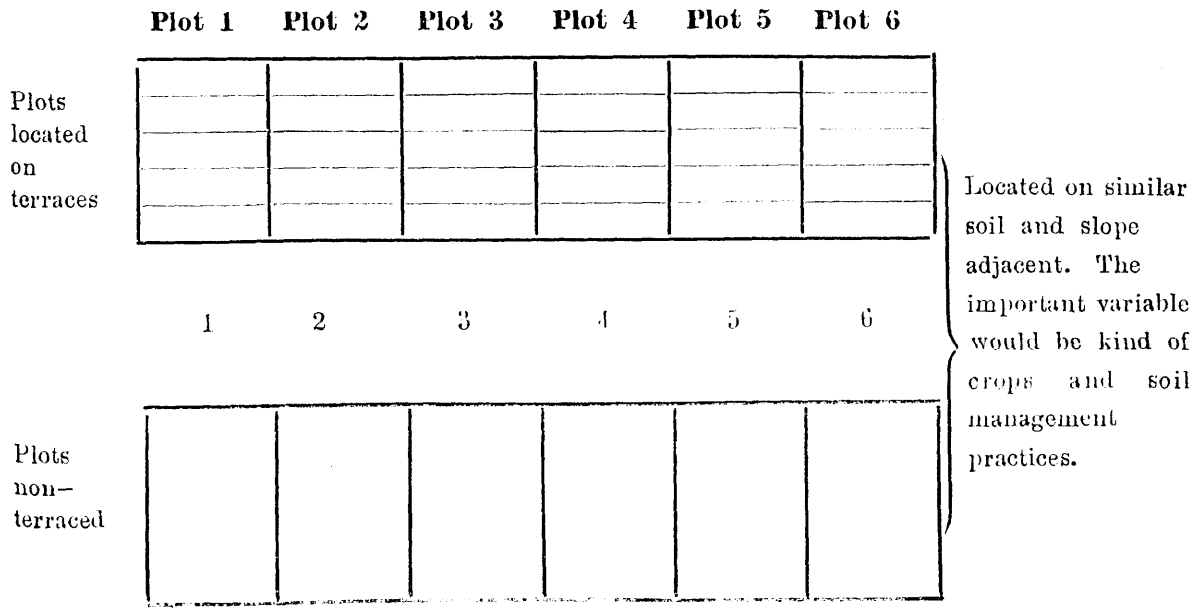
The important thing to note is that this problem could well apply to much of the watershed area of Northern Thailand. It is related but different from that described at Huay Tak.

4. Proposals For Consideration

Maew stabilization and forest watershed management are both involved in finding solutions to this problem. Since we have little, if any, data to draw on in finding solutions, several pilot studies would seem necessary. These pilot studies would involve studying a combination of soil and crop management practices on a variety of plants. Much of this land in order to support any crops other than forest would require the most intense conservation practices such as terracing and cover cropping.

A preliminary pilot study which could provide some useful data could involve plots containing different plants under contrasting management such as terracing versus row planting, with and without cover crops. Runoff erosion data, together with yield data could be collected. Undoubtedly, other data could be collected in accordance with recommendations in needed basic watershed information, reviewed earlier in this paper.

A diagram of such a study carried out on hill side in the Maew village at Doi Pui is presented below:



Possible Crops for Study

Coffee, Corn, Lichi, Tangarine, Rice, Tea and others.

5. Possible Soil Management Practices

(1) Use of different cover crops including variety of plant residues.

(2) Constructing different kinds and types of terraces.

(3) Use of composts and/or manures.

(4) Weeding and mulching, etc.

6. Justification

Data which would be helpful in determining cultural practices which might help stabilize the Hill Tribes against shifting agriculture, yet at the same time conserve Thailand's national watersheds, is urgently needed.

Possibilities of the location in regard to the nature, scope of problem, and probable cooperating agencies in the area are good. The Forestry Department, Department of Agriculture, Ministry of Education, Department of Public Welfare Service, Border Police, Kasetsart University, and USOM working cooperatively together could obtain meaningful data useful in finding solutions to the Hill Tribes or uphill cultivator and watershed problem in Thailand.

The two proposals for pilot projects in watershed management to be initiated at Doi Pui and at Huay Tak are by necessity presented as general outlines. Obviously, before the initiation of either of these projects it would be desirable for more complete project plans to be drawn up and reviewed. However, the ideas proposed herein should prove helpful, especially when considered in the light of earlier sections in this report which are concerned with the collection of basic watershed data.

EXAMPLE OF A REGIONAL WATERSHED PROJECT

Watershed management studies lend themselves to team investigations. The opportunities and needs for study are many and are not confined to separate fields.

In Oregon, U.S.A., a project has been set up. The title of the project is "The Alsea Watershed Study of Integrated Land-Water Management." and the study objective is to learn how to obtain maximum productivity of a river basin for the greatest public good. Interestingly enough the major products, actual and potential of the Alsea basin are very similar to many watershed areas in Thailand—trees, fish and recreation, crops, and livestock and the products of industry.

Active projects in Alsea which have been already initiated are designed to supply basic information related to watershed management. These active projects, are in effect, the kind of projects which have been either proposed above, or alternatively should be considered initiating in Thailand. It is of interest therefore to review briefly these Alsea projects and consider them in the light of urgently needed similar projects in Thailand.

1. Water Survey

The objecive of this study is to determine yield of water, quality of water, and rainfall patterns in the basin. Five recording stream gages have been installed: one on each major tributary of the Alsea River. Flow and temperature recording has been continuous since August, 1958. An additional three to four years will be required before a satisfactory stream calibration is obtained. Observer stations have been established at

several points in the watershed for the recording of rainfall data. Records are available from summer 1958.

2. Soil–Vegetation Survey

The objective of this project is to secure a basic survey of soils and vegetation in order to provide a basis for management decisions, for soil conservation practices, and for research on forest and farm lands. The survey is a cooperative venture financed jointly by the U.S. Forest Service, Oregon State College, Bureau of Land Management, Soil Conservation Service, and Oregon State Board of Forestry.

The steps involved in securing the soil vegetation survey are these

a. Procurement of aerial photographs for stereoscopic coverage at a scale of 1 : 12,000.
b. Pre–typing of land forms and vegetation in the laboratory, coupled with short field trips to verify and extend pre–typing.
c. Field survey to verify, complete, and extend pre–typing.
d. Interpretation.
e. Publication.

3. Logging–Aquatic Resources Study:

The objective of this study is to determine the effects of two logging methods upon the physical and biotic characteristics of small coastal streams. Three small streams, 350 to 800 acres in size, will be kept unlogged for a period of six to seven years (from July, 1958). During this period, data will be accumulated on physical and biotic factors in the streams. Stream flow and temperature gages, enumeration facilities for migration of fish, rain gages, and other physical facilities have been installed in each stream. One of the streams will be held as a control before and after logging takes place. A second drainage will be completely clear–cut and a third will be logged with a staggered–setting pattern. Such physical factors as stream flow, suspended sediment load, and chemical water quality are being investigated. Biotic factors being evaluated include fish production, survival of fish embryos, and production of algae and insects.

Cooperators in the logging aquatic resources study include U.S. Geological Survey, Oregon State College, Game Commission, U.S. Forest Service, Fish Commission, U.S. Public Health Service, and Georgia–Pacific Corporation.

Integration of Projects

Water flow data, after the necessary five year calibration period, should be used to conduct an economic evaluation of water use and for formulation of a water management plan. The flow data, in conjunction with soils–vegetation information should be used to select areas for research on such factors as vegetation manipulation for water yield, and vegetation successional patterns on various soil types.

Of course, the soil–vegetation survey will have other valuable used entirely apart from its role as a research base. The survey has served as a pilot study in which private and governmental agencies has a part, and will be useful to land managers as soon as the public action becomes available.

The logging–aquatic resources study is an entity, but soil–vegetation survey data obtained in the three test drainages should be considered a part of the study.

CONCLUSION

Thailand's watershed problem must be tackled now. Establishment of multipurpose dams must first be preceeded by control of the watersheds above the dams. If this is not done, the dams will silt up due to excessive runoff and erosion from the hills and mountains which are the catchment areas that feed the water to these dams.

In Thailand the watershed problem is complicated by the traditional fire and shifting cultivation practices exercised by the Hill Tribes. Establishing forest laws and enforcing police action on violators can at the best, only temporarily suppress the problem of mismanagement in the forested areas. The only effective alternative is a vigorous program of reafforestation and improved land use. But before a grandiose national program should be engaged upon many pilot studies should be immediately initiated (similar to the ones discussed in this report) which would supply needed data on which to plan the National Watershed Program.

Leadership is needed. Watershed studies must involve several professional groups, therefore, inevitably several ministries must accept a share of the responsibility towards solving the watershed problem. The Ministry of Agriculture, Ministry of Education, Department of Public Welfare, Border Police, Kasetsart University, and the Royal Forestry Department among others.

สรุป

ปัญหาเกี่ยวกับแหล่งให้น้ำของเมืองไทยเป็นปัญหาที่ต้องดำเนินการอย่างรีบด่วน การสร้างเขื่อนกันน้ำเพื่อประโยชน์หลายด้านนั้น ควรจะได้จัดควบคุมแหล่งให้น้ำเหนือเขื่อนที่จะสร้างเสียก่อน ถ้าละเลย เขื่อนนั้น ๆ จะหมดประโยชน์ในระยะสั้น เพราะตะกอนที่จะมากับน้ำซึ่งไหลเซาะพังทลายจากแหล่งให้น้ำ มาโดยปราศจากสิ่งช่วยชะลอนั้นจะสะสมจนเต็มอ่างได้

ในประเทศไทย ปัญหานี้ยังยุ่งยากสับสนเนื่องมาจากความนิยมของชาวเขาหลาย ๆ เผ่าที่ชอบเผาป่าทำที่เพาะปลูกและย้ายที่เสมอ ๆ การออกกฎหมายและใช้กำลังตำรวจควบคุมนั้น ก็เพียงแต่จะได้ผลชั่วขณะ ทางออกทางเดียวที่พอจะได้ผลก็คือการลงมือปลูกป่ากันจริง ๆ และปรับปรุงการใช้ที่ดินให้เกิดผลดียิ่งขึ้น แต่ก่อนที่จะวางนโยบายระดับชาติได้นั้น ต้องการศึกษาหลาย ๆ ด้าน เพื่อหาข้อเท็จจริงซึ่งจะใช้ได้แน่นอนเสียก่อน

ความพยายามอันนี้ต้องมีผู้นำ การศึกษาต้องใช้เจ้าหน้าที่วิชาการหลายด้านร่วมมือกัน แบ่งงานกันจึงจะหวังผลสำเร็จได้ ต้องการคนจากหลายแห่งเช่น กระทรวงเกษตร กระทรวงศึกษา กระทรวงพัฒนาการ ฯ และมหาวิทยาลัยเกษตรศาสตร์มาร่วมกัน

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