臺灣集水區問題之再評價

A Reassessment of Watershed Conditions Problems and Research Needs in Taiwan

狄爾士

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Acknowledgements

This report summarizes my second short visit to Taiwan. The first was during July and August of 1963. Both were under the auspices of or supported by the Chinese-American Joint Commission on Rural Reconstruction (JCRR). I express my deep appreciation to JCRR and especially to Mr. C. C. Koh, Chief of the Forestry Division and Mr. Tien-po Chang of that Division currently working on a doctorate degree at my institution, for their efforts in making this visit possible.

I am deeply indebted to Mr. C. P. Liu and Mr. San-wei Lee of the Forestry Division of JCRR and Mr. Y.L. Lin of the Taiwan Forestry Research Institute (TFRI) for their very efforts in planning my visit and in carrying out these plans. Their great patience in looking out for me and in translation were indispensable.

I express too my sincere thanks to all those friends and agencies who hosted me throughout my visit. While I cannot list them all I would like to give special acknowledgement to the personnel of JCRR, Taiwan Forestry Bureau (TFB), Taiwan Forestry Research Institute, the Mountain Agricultural Resources Development Bureau (MARDB), the National Taiwan University, the National Chunghsin University, the Feng Chia College of Engineering and Business and the several institutes and county governments visited for all their efforts in my behalf.

My field of expertise has always been in watershed management, I feel now almost equally expert in samping and enjoying your extraordinarily good and varied Chinese food! Without question your Chinese hospitality is unexcelled.

Introduction

The thirteen year period since my first visit to Taiwan has brought amazing development in the cities as well as in the country. Everywhere new construction is in evidence. There are marked improvements in housing, there is abundant transportation

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with literally thousands of automobiles and motorcycles and there appears to be an abundance of consumer goods in all categories. Color television has reached the remote areas in the island and the pedicab is rapidly becoming a museum item. Ten major national projects, including the new or enlarged harbors and a new international airport, are currently under construction or some have very recently been completed.

An equally impressive number of improvements and new developments have taken and are taking place outside the cities. Mechanization of farming has progressed substantially. There is an apparently very excellent infrastructure development permitting movement of food and resources to processing and marketing centers. Employment rates appear to continue to be high and in some farm areas there is even a shortage of labor. Continual progress has been made in the area of soil conservation. Integrated farm management-soil conservation is being practiced on some selected larger areas under the sponsorship of MARDB in cooperation with JCRR. In the mountain forest area tens of thousands of hectares of land have been reforested within the past thirteen years.

Taiwan can rightfully take tremendous pride in her developments and accomplishments and indeed is an appropriate model for other developing nations to emulate.

A report of my visit to Taiwan in 1963 was published by JCRR in 1964 entitled "Watershed Conditions Problems and Research Needs in Taiwan". In that report I listed what I felt were major problems facing the country at that time and I suggested a number of research needs and recommendations.

The primary purpose of this visit is to reassess those watershed problems and research needs in light of thirteen years of progress and change.

Despite the developments and progress cited above there remain some major problems in Taiwan with respect to watershed conditions. For convenience I again classify my remarks into three categories: the plains zone, the intermediate zone and the mountain-forest zone. Obviously these three zones cannot be precisely defined and some of the problems of one zone extend into another.

My observations are based upon experience in a wide variety of climatic, geologic and vegetative conditions in many parts of the world. These observations are totally my own based upon wide-spread travel in Taiwan and conversations and discussions with government officials, professionals, university professors and local farmers.

Watershed Problems

Watershed conditions, particularly with respect to the physical conditions, were briefly described in my earlier report. A much better and more current description is available from JCRR in a paper prepared by Thien-po Chang titled "Watershed Management Work in Taiwan".

Plains Zone

The lowland or plains zone occupies approximately 30 percent of the land area of

Taiwan. From a watershed management standpoint there are still relatively few physical problems originating in this zone. Much of the lowland sloping land has been bench terraced or developed into paddies and the flat lands create no special problem. Within physical and economic limits, a good system of check dams and channel control projects has been developed to provide protection from at least the minor floods. However, I believe there are two significant problems concentrated heavily in this zone.

The first of these is the very significant population increase Taiwan has experienced (from about 12 million in 1963 to over 16 million in 1976) and the impact that increase had had on the plains zone. Most of the poople are concentrated in this zone. Most of the new construction for harbors, airports, homes and industries is centered in this zone. As a consequence, a substantial amount of highly valuable farmland has been lost to these other uses, putting even more pressure on the development of the intermediate and mountain forest zones. In many cases these zones are already overdeveloped.

Secondly-and also related to this development and construction in the plains zone-is what appears to me to be a very definite deterioration in water quality. By European or North American standards virtually all the streams flowing through this zone are very badly polluted. It seems a bit incongruous that Taiwan, which imposes a heavy fine for throwing a cigarette stub out the window of a car and has literally thousands of containers for the deposition of surface litter throughout the country, still condones the casting of all kinds of sewage and waste into her streams as well as the dumping of raw sewage into Sunmoon Lake. A major project of admittedly gigantic proportions that Taiwan should consider initiating in the next decade is a thorough cleaning up of her so important rivers and sources of water. Continued pollution will create an ever-increasing health hazard and deterioration of the environment where most of her people reside.

There is actually a third problem of a slightly more localized nature in the plains zone. Landslides and serious erosion and sedimentation in the lower mountains within the plains zone occurs south of Taichung through which flow the Muddy and Black Rivers. The same problems occur in the foothills between the plains zone and the intermediate zone as evidenced in the slide areas in the mudstone formations to the east of Chiayi. At least portions of these problem areas have been placed in protection forest halting further land development at this time. There has been some limited light recreation development in a few areas of this type. I urge that these areas continue in the protection forest status. With increasing population concentrations in the plains, additional and judicious recreation development seems a highly appropriate form of land use.

In view of the ever-increasing loss of prime agricultural land due to new construction and the spread of cities I suggest that the responsible government agencies give very serious consideration to further construction and development on some of the more stable and more gently sloping land in this zone. Implied with this suggestion

is also the application of soil conservation and protective practices that would be essential to any such construction and development. With its very great population increase of the past few decades and considering that these increases will continue Taiwan will need every hectare it has of this prime agricultural land for food production. Even with the best management and application of conservation practices I do not feel that the mountains land are capable of greatly increased production both from an agronomic stand point and from the standpoint of erosion and flood control.

Intermediate Zone

As used in this report the intermediate zone is considered to be roughly that elevational area lying between 500 and 1500 meters. In my judgement the watershed management problems in this zone center on landslides, which are discussed under the mountain forest zone; on the cultivation of sloping lands and on illegal cultivation, which transcends both this zone and the mountain forest zone.

While there has been a substantial increase in agricultural slopeland placed under soil conservation practices there is still much to be done. Some of these lands either by virtue of soil properties or excessive slope or both probably should not be cultivated at all. With the application of rigorous conservation practices they might be utilized for crops that would permit infrequent full cultivation, there appears to be a real reduction in up and down row cropping on some of the steep sloping lands. I would hope that the Mountain Agricultural Resources Development Bureau might continue and expand its effort in soil conservation and that it would apply, in cooperation with local governments, legal restrictions on these lands even more strictly.

A major problem which I feel could well invite disaster unless arrested and reversed is that of illegal cultivation. As indicated above this problem also extends well into the montain forest zone. It appears in my travels around Taiwan that there is in fact a substantially greater area today under illegal cultivation than there was in 1963. Undoubtly increasing population and loss of agricultural land on the plains to expanding cities and their services has contributed to this. Unless stern political-legal measures are taken the situation will surely worsen.

Some 68,000 hectares of released national forest land were I believe taken out of the national forest reserves. While this relieves the Taiwan Forestry Bureau of one problem which they were ill-equipped to handle, the real difficulty remains. Of this 68,000 hectares only about 5,000 have been subjected to some conservation measures or influence. Even here I judge that many of these 5,000 hectares are marginal from the standpoint of soil erosion. Some of the remaining area can probably be cultivated with relative safety but only with the application of intensive conservation practices. Much of the remaining area however should be replanted to forest as an erosion and flood prevention measure. In places such as the Lishan area, excessively steep slopes are still being cleared and converted to orchards. Either the provincial or local governments lack the authority or the will to stop these potentially disastrous developments. As in the case of the water pollution problem cited under the plains zone, this is basically a socio-economic political problem rather than one subject to

physical or biological solution.

The forest portions of this intermediate zone, particularly after excepting the 68,000 hectares of illegal cultivation, show marked improvement. There has been a substantial amount of reforestation and seemingly a very noticeable improvement in management.

Mountain Forest Zone

Landslides on a vast scale have plagued Taiwan's steep and sloping land for many millennia and will continue to do so. While the problem is greatest in the mountain forest zone they occur almost everywhere except on the flat plains. The majority of these landslides are obviously geologic in nature. However I firmly believe that both road construction and agricultural development on steep mountain lands have greatly increased the occurrence and size of slide areas particularly as they tend to concentrate runoff water which serves as a major landslide triggering mechanism. Taiwan's defense against the slides has been to designate large areas protection forest and where slides have occurred to build check dams to attempt to keep large volumes of debris out of the streams and reservoirs. Other than extreme caution in road location, construction and maintenance (especially drainage) as well as in the development of this steep country for agriculture, which might reduce the problem to a degree, I know of no practical solutions. I do believe that emphasis on these latter categories will continue to reduce the severity of the problem.

A second problem area in the mountain-forest zone is that of the location, construction and maintenance of road systems. This includes the major highways as well as logging, industrial and farm access roads. This is an area too where I believe remedial or improvement measures can be effective.

Detailed knowledge concerning the geology and soils in the mountain forest zone particularly appears to be quite scarce. (Refer also to Dr. Stanley Gessel's report of his 1974 visit to Taiwan). In some cases the roads appeared to have been located more for convenience than with consideration of the potential stability of geologic parent material or soil cover. It is quite evident that accelerated erosion and landslides have been induced as a result of road construction. In forest areas that have been logged on developed steep land and along the east-west cross-island highways, visual evidence as well as aerial photographs show a much higher concentration of landslides immediately above and below roads. Where roads have been in place longer and are generally a bit more stabilized, slides and deep gullies are frequently associated with poor or virtually non-existent road drainage. From what I have observed in many areas, I believe better stabilization both structurally and vegetatively and especially better provisions for drainage of storm water off the roads will reduce erosion losses, lessen the potential for landslides, reduce road maintenance costs and provide a safer transportation system. Initial road costs will be somewhat greater but I feel the overall benefits in all terms: erosion, sedimentation, maintenance of reservoir storage capacity, dollars and safety will be much greater. In the construction of future logging roads the Taiwan Forestry Bureau should provide technical leadership to the construction

agency in the location and stabilization of these roads. Whoever is responsible for their maintenance should be required to apply strict standards. Similarly, the Mountain Agricultural Resources Development Bureau in cooperation with local governments should provide every assistance in assuring similar standards on new farm access roads. In both cases corrective measures should be taken on already existing roads. Examples of very sound roads systems that might be used as models are those in the immediate vicinity of Sunmoon Lake and the new road leading into Chitou. Even stricter standards should be applied to the more heavily used east-west cross-island highways.

Another problem in this zone is that dealing with the utilization and management of the national forests. The new Taiwan forest policy of 1975 has decreed a substantial reduction in forest harvest (approximately 35—40 percent) which will require greater imports. I believe no logging is currently permitted in those areas designated as protection forest and that in the commercial forest areas the practice of clearcutting has been rigidly curtailed-especially those cuttings in larger blocks. I believe this to be a sound decision on at least a temporary basis. Investigations should be initiated to determine the economic feasibility of clearcutting in small areas (not to exceed 10—20 hectares) except under unusual conditions, and of some form of partial cutting in the commercial forest area. Concurrently the additional road systems that would be required in logging under such restrictions should be investigated. Again, under any form of careful logging, I feel the road system and its maintenance are potentially far more damaging to the watershed than the logging itself.

Despite the fact that there is a substantial volume of excellent quality timber now tied up in the protection forests I feel the policy of no harvesting should be continued at least until such time as the Taiwan Forestry Bureau and the Taiwan Forestry Research Institute can conclusively show that they have harvesting methods or techniques developed that would cause minimal watershed damage. In light of current technology this may be some distance in the future unless the timber becomes so valuable that helicopter or balloon logging might be justified.

In this connection I urge that consideration be given to the possibilities of railroad logging in the future. The construction of railroads could be substantially less destructive to watersheds than are truck haul roads. The road bed is narrower and the operable grade is less thus requiring smaller cuts and fills. Short and not unduly expensive bridges can be used in lieu of some cuts and fills and thus total land disturbance is less. Moreover, surface road disturbance is minimal after construction and maintenance costs are far less. In Taiwan's unusual mountain terrain I think there would be many benefits to this form of logging and log transport.

General Comments

My area of expertise does not lie in economics or sociology. However I read with interest several documents contained in briefing materials provided by JCRR as well as published and unpublished articles or manuscripts by Dr. T. H. Shen; Senner, Thelin

and Bridgman; and by Tien-po Chang dealing with socio-economics aspects of Taiwan's agriculture and population.

Several new programs are underway or suggested to deal with some of the stated agricultural problems such as its declining contribution to Taiwan's net domestic production, the loss of farm labor to the industrial cities and the net loss of comparative income to farmers. The high production costs and management difficulties with so many small properties are also being carefully studied.

One recommendation called for continued and further agricultural development on the sloping lands. I would urge that from the standpoint of watershed protection (flooding and erosion) the expansion in slopeland development be accomplished only after a very critical analysis of each parcel of land in question. Too much of Taiwan's sloping land has been developed either illegally or haphazardly with, usually, little regard to slope, soil depth or potential productivity, erodibility or for soil conservation practices which were necessary (even mandatory) during or following development.

In this regard I raise a question for which I have no answer. Would Taiwan be better off economically and socially if more farm families on sloping and steep mountain lands did move to the cities? Such an action would permit the retirement of some of the steep farm land to a more permanent protective cover. Certainly it would be beneficial from the watershed management standpoint. Any positive answer or answers to this question would have to assume that Taiwan's growing industrial strength would permit it to import food to make up for the loss of production from such retired lands. Secondly, those better lands remaining in farm production might be consolidated and better integrated to provide higher productivity than they currently do. Thirdly, Taiwan's growing industry would have to continue to be able to support increasing numbers of the labor force. Housing and the necessary amenities for this additional influx to the cities would have to be available over time. This would likely require planning for the dispersal of industry and the planning of new cities to serve that development.

I take full responsibility for any major omissions in the listing of these watershed problems and in any possible misinterpretation in what I have read, understood from my many discussions and observed myself. There are doubtless many other areas worthy of note and discussions. My brief visit could not permit as detailed an analysis as might be desirable. With this discussion of Taiwan's watershed problems I now turn to some suggestions and recommendations for research.

Research Recommendations

Gaged Watershed Research

In the report of my 1963 visit I recommended the initiation of some gaged watershed research in Taiwan since there was virtually no data available at that time on the basic hydrology of Taiwan's unique mountain country. Since 1963 such a program has been initiated by the Taiwan Forestry Research Institute in cooperation with JCRR. One of my assignments during this visit was to assess the current status

of this program and provide some recommendations on future action. During the course of my tour I have visited most of the 15 experimental watersheds that have been established throughout Taiwan. Again the brevity of my visit as well as my language limitation did not permit detailed examination of the data which have been collected. I do however submit the following suggestions and observations.

1. A cursory examination of the hydrologic data indicated a number of areas where there is missing data which in its present form very much restricts its utility. There are however some fairly well established analytical techniques which might be used to give relatively reliable estimates to fill in these blanks. I do not know if these would apply to the data collected here. I suggest your consideration of submitting copies of selected runoff data to Mr. Tien-po Chang, a member of the Forestry Division of JCRR currently working on a doctoral degree at Colorado State University for checking with experts in hydrology at that university to determine if reasonably reliable data gaps might be estimated utilizing these techniques. If that is judged to be feasible, then the calibration period in several watersheds may be shortened by several years.

2. Two of the gaged watersheds, numbers 11 and 12, are located at Piluchi. From discussions with TFRI staff the data appears to be good (except for some missing records). Tentative plans are for treatments in 1978. Watershed No. 11 is essentially undisturbed and in good forest cover and would be used as a check against watershed No. 12 which would be logged. A new logging road goes across watershed No. 12. Prior to the forest harvest planned, I suggest that as much information as possible be derived regarding the impact of the road in No. 12. I believe this information is currently being collected. In view of the new 1975 forest policy with logging and logging area (size of area) restrictions imposed I suggest the actual detailed logging plan be jointly developed by TFRI, TFB and JCRR specialists. The basic treatment plan appears sound.

3. At Lien Hua Chi there are five experimental watersheds now being gaged. An examination of the data indicates that watershed No. 1 consistently shows substantially more runoff than precipitation. This would indicate that there is watershed leakage in the form of ground water or subsurface flow from other areas into this watershed. Becouse of the high level of unreliability and difficulty of comparison I suggest consideration be given to discontinuing work on this watershed at this time. Watershed No. 3 is scheduled to be used as a control watershed. One branch at least of watershed No. 2 would probably be treated with some type of logging. The suggestions for watershed No. 12 above, particularly with respect to road construction and coordination of the logging method to use, apply equally here. Watersheds numbers 4 and 5 are somewhat separated from numbers 1,2 and 3 and are on somewhat more gentle slopes. Tentatively, plans call for a total clearcut on watershed No. 4 and a clearcut in blocks of 10 ha. or less on watershed No. 5. I suggest that treatment proceed on only one of these at any one time. This would provide an additional temporary control (against watershed No. 3). Because of their more gentle slopes these watersheds could well be

utilized to test a major land use change such as clearcutting followed by changing to tea with the application of the best known soil conservation practices. If such a suggestion were followed, close cooperation with MARDB should be sought. Other land use changes subsequently for watershed No. 5 might be determined jointly with MARDB, TFRI, TFB and JCRR.

4. The one experimental watershed on the Taiwan National University Experimental Forest is essentially unoperable. The station on the main stream has washed out and I suspect any subsequent replacements would also be destroyed in that particular stream. A Parshall flume still exists on branch of this stream. This flume was designed to measure irrigation flows on flat land and I question its utility in steep mountain streams with heavy sediment and bed load movement. I could not justify its continuance. I believe however that a gaging station on a more favorable site near the Chitou headquarters could have high utility as a demonstration and training station for students attending the NTU training center. They could get basic instruction in stream gaging techniques, instrument maintenance and data analysis from such a station. Moreover, with the very heavy recreation visitor load at Chitou, such a station would have excellent demonstration value-particularl if explanatory signs were used. Further the information derived would provide some additional basic hydrologic data from Taiwan's mountain forest watersheds.

5. There are five gaged watersheds located on the TFRI Experimental Forest near Liukuei. These are all undergoing their calibration periods and except for watershed No. 1 which the runoff data was not available since it is undergoing computer analysis. There are no definite plans at this time as to the type of treatments which may be applied to these watersheds. I have no specific recommendations regarding treatments except to urge that joint discussions be held between the TFRI, the TFB, JCRR and possibly MARDB regarding the type of land management practices for which more information is needed and which might be fitted to these watersheds. In this regard it appears logical that TFB will have to develop new standards for logging by 1981. One or more of the Luikuei watersheds might be used to test such standards or practices. I also suggest that as early as practical some discussion be held and decisions made as to high priority watershed treatment needs in order for the TFRI to have as much lead time as possible for thorough advanced planning.

6. Near Taimali a watershed has been selected that is fairly representative of southeastern Taiwan and its somewhat different precipitation pattern. The gaging station for this watershed has just been completed thus there is no runoff data yet available. Precipitation data is also quite limited-as there is just one short term station at an elevation approximately 800 meters lower than the watershed in question.

Unfortunately from a research standpoint this watershed has already been logged and replanted so that there is only limited opportunity to assess changes in either runoff or erosion and sedimentation as a result of the treatment. Further access is difficult especially during the rainy season which increases the cost of research at this site.

Serious discussion and thought should be given as to how to best utilize the investment already made. No doubt some valuable hydrologic data can be collected, perhaps for a few years now and then again after the planted trees attain crown closure. Results that might be applicable to forest management however will require a longer time period than utilizing the watersheds at Luikuei or Piluchi where the calibration periods are now nearly complete and the impacts of roads and logging can be measured within a few years after the treatments.

If the streamgage data that might be collected at this watershed is to be meaningful some additional precipitation measurements would be required.

Although I am not an expert in gaging staion design or construction the new gaging station is located in a difficult site and if there is very heavy erosion and bedload movement the station appears to be susceptible to damming up and overflow around the sides. This of course would negate the most important data-what happens during very high flows.

As discussed with TFRI, JCRR and MARDB staff (on the ground) there are additional opportunities to utilize this area for a variety of demonstration and research purposes. Should more research funds become available it might be desirable to conduct gaged watershed studies on the East Coast. However, in that event it would well to look for paired watersheds (for control and comparison) in an area more readily accessible.

The TFRI has appropriately taken a lead role in gaged watershed research in the mountainous areas of Taiwan. I understand that there is consideration being given within TFRI to the elevation of the watershed management program to departmental status. Assuming that Taiwan expects to continue and expand its efforts in this very important area I would certainly encourage this administrative change. Departmental status for the program should give it much greater visibility and enhance its budgetary status.

Since watershed management research ivolves so many aspects of land management it is especially important to continue and to expand cooperative efforts and coordinated planning with other concerned and responsible agencies, JCRR, TFB, MARDB particularly. Further, the watershed staff should examine opportunities for watershed research other than solely the use of gaged watersheds which obviously is an expensive and time consuming approach.

Research on Mountain Roads

Throughout this report I have emphasized the importance of roads as a maior source of watershed damage, both present and potential. My concern applies to all the roads in the mountain areas, the cross island highways, the logging roads, industrial roads and farm access roads. In this regard several studies are suggested.

A study designed to measure the number, the size and the frequency of landslides immediately above or below roads compared with roadless areas of similar topography, soils and geology could show the severity of the problem.

Secondly, a study to compare the costs and the effectiveness of a carefully planned

road maintenance and drainage program as compared to most current programs or lack of programs would be worthwhile. Again comparable conditions of slope grade, soils and geology should be used and the standards for a controlled maintenance and drainage program should be carefully defined i. e. culverts, drainageways, surface grading, ditching, etc.

Thirdly, a start has been made I believe attempting to use conservative measures in logging road location construction and maintenance on watershed No. 12 at Piluchi. I suggest a review of the location and construction standards applied as compared with other areas, a review of maintenance standards that should be applied during and immediately following the proposed 1978 logging in this watershed and that these be documented. Such standards may serve as a basis for future road construction if they show that they do provide more protection from erosion and sedimentation, landslides and lower overall maintenance costs. I believe too that more basic research on soil properties, soil mechanics and stability would be very helpful in future road location, construction and maintenance.

With relation to logging roads (as well as to access roads to the mountain country for other purposes) I suggest investigations comparing costs, efficiencies, and effectiveness of railroads versus truck haul roads be conducted. For reasons indicated earlier the railroad could well have many advantages in the steep and erosive mountain terrain.

There may be a long range plan available indicating developmental needs and projections for agriculture, for forestry, for industrial development, for transportation and for national defense. There may be plans particularly for the total roads systems that would be required to meet these developments. I am not aware of the existance of such plans. It would seem highly desirable to initiate this type of planning if it does not already exist.

Landslides

To my knowledge there are few areas in the world experience landslide problems of the magnitude of those common to Taiwan and also where there is a research program underway to classify, assess causes, predict and procure a defense against them. If there are answers they will likely have to come from Taiwan's natural landslide laboratory and in large measure from Taiwan's scientists. Some investigative work has been undertaken by government agencies and universities and wherever possible this work should be at least continued and preferably expanded. If the causes can be identifed (slope, soil and geologic conditions, climatic conditions, etc.) then it might be possible to identify slide-prone areas and avoid them in any type of road or land development. It conceivably might be possible too with that knowledge to forestall some slides by constructing artifical drainage ways around danger areas. This I must admit is only speculation.

A significant effort has been made in snow avalanche research in Europe, North America and I believe Japan. There may be some close physical ties in the mechanics of and triggering of snow avalanches that could be applied to landslides in some

fashion. In this regard it might be useful for Taiwan to invite a visit by one of the experts working in this area of research such as Mr. Hans Frutiger, a forest engineer working with the Swiss Snow and Avalanche Research Institute at Davos, Switzerland.

Steep and Sloping Agricultural Lands

Again my concen over the continual development of agriculture on steep mountain lands appears throughout this report as in my 1963 report. As shown in several publications dealing with Taiwan's agriculture, considerable attention has been directed to research in agricultural production (The Nine-Point program for Accelerating Agricultural and Rural Development in Taiwan-December, 1972). Apparently still only very limited attention has beeen given to the question of the suitability of steep mountain land to support additional agricultural production without potentially very high costs in terms of erosion and sediment production and increased flood hazard. As mentioned under the section on gaged watershed research, watersheds No. 4 and No. 5 seem to be suited to a treatment involving major land use changes such as clearcutting the forest and converting to steep land agriculture. A joint effort by JCRR, MARDB and TFRI is highly recommended to provide some quantitative information on such developments. It would be highly desirable in such a study or could be replicated in several areas of Taiwan under varying soil, topographic and land use conditions.

Personnel-Training Needs

While there is now a limited number of professionally trained people working in watershed management in Taiwan the numbers and the variety of specializations are still inadequate. The gaged watershed research program of the TFRI is substantially understaffed, both in professionals and in technicians. The watershed sites are widely separated and difficult of access and consequently a substantial amount of research time is consumed in travel particularly for the supervisory scientists. If at all practical from a budgetary standpoint this program should be substantially increased in dollars and in personnel. If my suggestion for reducing or eliminating some of the work for technical reasons is followed this might ease the burden a bit.

It would be extremely useful to add scientists to the TFRI program with expertise in forest soils and soil mechanics, one with a strong interest and ability in forest engineering, particularly roads and harvesting methods, one with ability and interest in geology (and soils preferably) to work on landslides and one with a strong background in mountain agriculture and slopeland development. Probably most important of all however would be the addition of a trained hydrologist in TFRI with ability and aptitude in research design and methodology, data analysis and interpretation and statistical methods. It seems highly appropriate that such an addition be made as early as possible since many of the gaged watersheds are nearly at the end of the calibration period and treatment planning should be initiated well ahead of the actual application. If such specialists are not available within TFRI or by interagency transfer or through loan from TFB or MARDB, arrangements should be made to provide specialized training for capable persons interested in pursuing this line of

work.

Similarly in the TFB, specialists who can apply the latest technology-especially conservation practices-should be assigned to the problems of road planning, construction and maintenance. This apparently is being done in the area of landslide defense measures. In view of the 1975 forest policy actions and the decision to very substantially reduce the forest harvest this seems particularly significant.

From my (limited) discussions I understand that watershed management principles are now being taught in the forestry and the soil and water conservation curricula in several of Taiwan's universities and that the agencies are cooperating with these universities in planning and conducting specialized training courses. I would hope that JCRR, TFB and MARDB would continue to give encourage to the universities in such efforts.

Where training for specialized assignment such as indicated above is not available in Taiwan, arrangements should be made to provide foreign travel and training to selected personnel.

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中 文 摘 要

臺灣最近幾年來在工商、交通、農業等經濟和社會建設方面，都有顯著的成就，生活水準也大爲提高，但是對人類的生活環境—集水區—之經營上，仍有許多問題急待解決。

在平原地區，由於工商發展農田大量變更用途，導致山坡地之過度開發，若干丘陵地帶之崩坍、冲蝕情形極爲嚴重，必須加强坡地開發之規劃工作。另外，平原地區之溪流水質受到極度污染，今後亦應加强水質之改善與維護措施。

在低山地區，也因爲山坡地之大量開發引起嚴重的崩坍與冲蝕，有關單位應加强推廣水土保持工作，以求合理利用山坡地。此外對濫墾問題，須阻止其繼續擴大，並根據有關法令嚴格執行取締工作。

在高山森林區，除崩坍、濫墾問題外，因林道修築所引起的災害，如崩坍、淤沙等日益嚴重，今後對林道選線、構築標準和維護方法，均須研究妥善的標準作業方法。關於保安林之經營問題，冀待林務局和林試所研究出妥當之作業方法後，才能進行保安林砍伐作業。此外在運材作業上，似可考慮鐵道運材在臺灣之可行性。

一般而言，臺灣不合理、不合法的山坡地開發尚多，除加强水土保持工作外，不妨考慮山坡地居民移居平地之可行性。

關於集水區經營研究方面，提出下列數點建議：

1.應設法進行缺失資料之補充，以縮短集水區之檢測時期。

2.畢祿溪集水區，宜以11號集水區爲對照，處理12號集水區，砍伐12號之前，先築林道觀測一段時間，再行伐木，以觀測林道對冲蝕之影響。另外在伐木作業設計上，林試所應與林務局、農復會之專家們保持聯繫交換意見。

3.蓮華池集水區，1號考慮停止觀測，2號進行砍伐方式之比較試驗，3號爲對照區，4號、5號分年砍伐，並實施由鳳山等試驗機構試驗獲知之最佳水土保持方法，藉以探究土地利用變遷對溪流水量及水質之影響。

4.溪頭實驗林之量水堰位置設計不甚理想，如果把觀測站設在營林區管理處旁，將俾利於觀測、教學及大衆教育等多種用途。

5.六龜集水區尚在檢測之中，希望各有關單位能加强聯繫，研究適當之處理方法，以得到目前所迫切需要的資料，提供林務局在民國七十年修訂林業政策時之重要參考。

6.太麻里集水區，須做長期觀測，各項設備有待加强。

7.集水區經營研究工作爲長期性之工作，所須經費頗鉅，林試所成立一個專責部門確有必要，各有關單位應予技術與經費上之支持。

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*本摘要由臺灣省林業試驗所范明光、盧惠生二先生共同編撰。

**並請參考狄爾士博士1964年著「臺灣之集水區問題」（農復會特刊第四十一號）。

關於山地道路研究方面，以現有林道之災害爲基礎，進行調查比較研究，新闢林道時，可參照其他地區之標準修築，並觀測其冲蝕崩坍等災害情形，以尋求更佳之林道設計與修築標準。

在崩坍問題方面，應加强有關基本資料之調查與蒐集，並探討適當之處理方面。此外崩坍與雪崩有若干相似之處，可邀請國外有關雪崩方面的專家來臺考察研究，或許有助於崩坍問題之解決。

在坡地農業開發之研究方面，除在林試所之蓮華池集水區砍伐後，進行研究外，希望在其他集水區具有不同地形、土壤及土地利用情況下，分別進行觀測研究。

有關人員訓練方面，希望從業人員能加强森林工程、土壤、地質及水文分析等方面的專業知識，或選派人才往國外進修，並期各業務機構與研究機構能加强聯繫，交換意見，互相支援。