臺灣坡地機械化之推展

Promotion of Slopeland Mechanization in Taiwan

中華水土保持學會顧問

涂　本　玉

Pen-yu Tu

摘　　要

臺灣近十數年來大力推展坡地機械化，目的在加强山坡地之保育與利用，維護坡地資源，促進坡地農業之發展。

推展坡地機械化所採行之方法有三：一爲推行坡地機械施工作業，改進施工技術，以利水土保持處理，基本公共設施興建，及坡地環境改善之有效完成；二爲改良及發展適於坡地作業之農業機械與機械設施，以節省勞力，增加農業生產，提高農民收益；三爲建立坡地機械化作業體系，藉整合水土保持處理，土地利用方式，作物栽培方法，及機械作業配置，以求坡地農業之現代化與永續發展。

經由有關單位與人員之協力參與熱誠貢獻，臺灣坡地機械化之推展已獲致多方面成效，其最顯著者爲：(1)使政府各年度山坡地保育利用計畫下之水土保持處理與公共設施工作量得以順利完成，並保持良好之工作品質。(2)已完成改良及研製一系列坡地農業機械與機械設施，使坡地重要作物栽培管理作業均得以機械化。(3)配合土地利用方式與作物栽培方法，已建立多種坡地機械化作業體系，可供農民參考採行，以獲致坡地保育利用之最大效益。

ABSTRACT

The purpose of promotion of slopeland mechanization is to intensify the slopeland conservation and use through application of well developed mechanical methods. Three main tasks undertaken are: (1) application of mechanical operation with construction machines for performing soil conservation treatments and improving slopeland conditions, (2) development of slopeland farm machinery for promoting slopeland farm production, and (3) establishment of mechanized slopeland conservation farming systems for securing the progressive and sustainable slopeland agriculture through integration of soil conservation, farm installations, crop production and machinery operation.

The significant results made include full completion of the yearly projected soil conservations works, improvement of mechanical operation management and techniques, mechanization of important slopeland farming practices with the various machinery developed, and providing appropriate mechanized slopeland conservation farming systems for farmers to conserve and use the slopeland to the best advantage.

1. Introduction

In the mountainous island of Taiwan, the slopeland is an important natural resource, not only constituting the vital part of the ecosystem, but also providing the space for land-use expansion.

Nearly thirty years ago, the fast population growth and the accelerated economic development exerted great pressure on land demand, and many local people were induced to go onto slopelands for agricultural exploitation. They were mostly not prepared to reclaim and use the land in a sense of soil conservation and proper use. Consequently, many slopelands were destructively reclaimed and seriously abused, bringing about soil erosion, landslides, increased sedimentation in watersheds and reservoirs, and frequent flood damage in the downstreams.

With a view to conserving the slopeland resources and ensuring their proper use, the former Joint Commission on Rural Reconstruction (JCRR) commenced in early 1960 the Integrated Soil Conservation and Land Use Program and carried it out over the island through the concerned agencies. In an effort to step up the effectiveness of this program, a slopeland mechanization program has been implemented since 1970.

The slopeland mechanization program was directed toward the attainment of effective soil conservation and sustained land use through application of well developed mechanical methods. It covers three major tasks, namely, (1) performing mechanical operations for construction of soil conservation works and improvement of slopeland conditions, (2) modifying and developing suitable farm machines and mechanical installations for promotion of slopeland farm poduction, and (3) establishing mechanized slopeland conservation farming systems for securing the progressive and permanent slopeland agriculture through integration of soil conservation, crop cultivation, farm installations and machinery operation.

With efforts of the government and all participants, this program proceeded progressively and many significant results were made in the past eighteen years. It is hoped that this report will serve as a reference to the people interested in slopeland conservation and use, and, meanwhile, comments are cordially solicited for further improvement on this subject.

II. General Slopeland Physical Conditions And Use Problems

1. General slopeland physical conditions

The slopelands which are delimited under the scope of conservation and use amount to 973,730 ha, standing for 27.03% of the total land of Taiwan. They are extensively distributed over the island. Their general features are steep slopes, irregular terrain, and weak geological formation. According to a slopeland distribution survey made by the Mountain Agricultural Resources Development Bureau (MARDB), the lands with slopes between 30-55% occupied 49.4% of the slopeland suited to farming use. This dominant feature of steep slope has a great impact on slopeland use.

2. Slopeland use problems

The problems in slopeland use can be stated in the following three aspects:

(1) The unfavorable physical conditions of steep slope and weak formation tend to cause soil erosion, especially when the slopeland is not used properly.

(2) The difficult slopeland surroundings such as remote location, scattered land distribution, irregular topography, as well as shortage of access bring about low land-use rate and efficiency, hard farming work, high production cost and low farm income.

(3) The careless and short-sighted manner of exploiting slopeland by local farmers give rise to illegal reclamation, abuse of the land, serious erosion damage, and a hindrance to slopeland agricultural development.

III. Purpose And Ways Of Promotion Of Slopeland Mechanization

For dealing with the above-metnioned slopeland use problems and securing the development of slopeland agriculture, the essential work is to intensify the slopeland conservation and use. It is for this purpose that a slopeland mechanization program has been conducted in the follow-

ing three ways:

1. Application of mechanical operations with construction machines for performing soil conservation practices and improving the slopeland management conditions under an overall plan.

2. Modification and development of slopeland farm machinery and mechanical installations for reducing labor demand, enhancing work efficiency, and increasing farm income.

3. Establishment of mechanized slopeland conservation farming systems for integration of soil conservation, crop cultivation, farm installations and machinery operation towards a progressive and sustainable slopeland agriculture.

IV. Application Of Mechanical Operations For Better Slopeland Conservation And Use

The Mountain agricultural Resources Development Bureau has been responsible for the mechanical operation work with technical and financial assistances from former JCRR and Council for Agricultural Planning and Development (CAPD) and now Council of Agriculture (COA).

1. Selection and purchase of construction machines

To meet the need of the construction work on slopeland, 31 sets of small- and medium-size bulldozers were purchased from 1978 to 1987. John Deere's JD-450 and JD-350 types were the first choice for their desirable features and adequate capability. Among other types purchased later on, Komatsu D31A and E have become the majority machines now.

As the construction work diversified in recent years, 5 sets of small- and medium-size excavators were purchased from 1984 to 1988 for the purpose of improving the farming conditions in confined and irregular areas.

2. Setting up of the machinery maintenance shop and training of operators and mechanics

MARDB set up one machinery maintenance shop in 1972 for repair of the possessed construction machines and keeping them on workable status. The shop was adequately equipped with skilled mechanics and necessary repair facilities.

MARDB has a force of 27 operators and 10 mechanics to run the machinery operation and maintenance. To promote their proficiency, they were given a seminar every year except the technical training for the newcomers. The activities of the seminar included class instruction and field observation. More important, they could make use of this occasion to exchange their work experience.

3. Management of the mechanical operations

In the very beginning, a regulation for directing the mechanical operations was prepared by MARDB with the JCRR's assistances. The regulation prescribed the scope of the mechanical operation, preparation of the annual work plan, assignment of construction machines, management of operators, management of field operation work, and collection of operation charges.

4. Work accomplishment

(1) Major construction works done

In carrying out the integrated slopeland conservation and use program, the major works performed by construction machines were hillside ditching, orchard hillside ditching, bench terracing, link road construction, farm pond excavation, slope shaping, etc. The work amount increased year after year with the increase in purchase of construction machines. The important works accomplished are construction of hillside ditches (including orchard hillside ditches) for an average of about 2,000 ha per year and construction of link roads in an average of about 140 Km per year. The work of bench terracing decreased year by year while farming path construction increased greatly in recent years. The total yearly working hours were around 32,000 hours.

(2) Investigation on the construction machine use rate

In performing mechanical operations on slopeland, the construction machine use rate is determined by the use conditions such as the weather, in repair and wait for repair, wait for work, transportation, holidays and others. An

investigation on the construction machine use rate was made by MARDB for the period from 1979 to 1985. According to the investigation, the average working days are 189.5 days per unit per year, representing an average use rate of 51.91% for a machine throughout the year, and the average working hours are 1,188 hours per unit per year, or 6.27 hours per unit per day. The non-use rate of 48.09% was made up by 13.94% for repair or waiting repair, 2.3% for waiting land preparation, 13.64% for raining days, 10.00% for holidays, 2.34% for transportation, and 5.86% for other reasons.

(3) Investigation on the performance of the construction machines

As JD-350 and JD-450 bulldozers were the main machines and the hillside ditching and the bench terracing were the main works in early years, most of investigations were made on the performance of these two machines in performing these two works. The useful results are given below.

a. General work capacity

Machine type	Work item	Average length (m/ha)	Work capacity (m/hr)	Time requirement (hr/ha)
JD-350	Hillside ditching	450	46 – 37	7 – 12 (10)
	Bench terracing	2,000	50 – 33	40 – 60 (50)
JD-450	Hillside ditching	450	90 – 50	5 – 9 (7)
	Bench terracing	2,000	71 – 51	28 – 40 (35)

The above results were estimated from several years of field work observation on the average slopes of 15°–25°. The major specifications of JD-350 and JD-450 were 46 net hp with a 2.36 m blade and 64 net hp with a 2.69 m blade respectively. The average width of the hillside ditch was 2.0 m and that of the bench terrace 2.5 m.

b. Job efficiency

Machine type	Work item	Job efficiency
JD-350	Hillside ditching	0.461
	Bench terracing	0.841
JD-450	Hillside ditching	0.572
	Bench terracing	0.839

The above job efficiencies were figured out from the actual operation in construction of 50 ha of bench terraces and 1,634 ha of hillside ditches.

c. Formula developed through field tests for estimating the time requirement in construction of hillside ditch and bench terrace by JD-350 and JD-450 bulldozers on different slopes:

$$T(W1M1) = 1.766e^{0.027R} \times R^{0.176} \times A^{0.838}$$

$$T(W1M2) = 1.545e^{0.027R} \times R^{0.176} \times A^{0.838}$$

$$T(W2M1) = 25.880e^{0.027R} \times R^{-0.129} \times A^{0.838}$$

$$T(W2M2) = 22.636e^{0.027R} \times R^{-0.129} \times A^{0.838}$$

where: T = operation time (hr), W1 = hillside ditching
W2 = bench terracing, M1 = JD-350, M2 = JD-450
R = average slope (°), A = work area (ha)

(4) Investigation on the mechanical operation costs

a. Machine life expectancy:

The machine life expectancy varies with the use conditions. Statistics for 15 years showed the general life expectancy of JD-450 was at

10,000 years, 8,000 years, and 6,000 years per unit respectively under excellent, average, and severe slopeland work conditions.

b. Breakdown of the operation cost of JD-450 (NT$/hr)

Depreciation	Maintenance	Fuel	Allowance	Transportation	Overhead	Total
170	153	87	41	14	50	515
33.01%	29.7%	16.89%	7.96%	2.72%	9.71%	100%

c. Breakdown of the maintenance cost of JD-450

The maintenance cost was about 90% of the depreciation cost. It was composed of the repair costs of 45% for under carriage, 20% for transmission, 12% for engine, 7% for hydraulic system, 3% for electric system, and 13% for others.

5. Farmers' payment and government's subsidies for mechanical operation

For encouragement of the slopeland mechanical operation, the government gave farmers subsidies in two ways. One was to reduce depreciation cost by 50% in payment of the operation charge. The other ways was to give farmers subsidies for mechanical operations. The major subsidies included NT$3,000/ha for hillside ditching, NT$4,500/ha for orchard hillside ditching, NT$6,500/ha for bench terracing, NT$25/m for building link road, and NT$20/m for building farming path. With the reduced depreciation charge and the subsidies, farmers only paid little amount of the cost and, in some cases, even needed not to pay because the subsidy was enough to cover the operation charge.

6. Improvement of mechanical operational techniques

For efficient and safe operation on slopeland, a set of general operational procedures and a series of improved operating techniques have been developed.

(1) General operational procedures

a. Stake out the central line of the work to be performed across the slope.

b. Open an access road to reach the top of the work site on slopeland.

c. In earth moving or land clearing, work down the slope to get greater power.

d. The distance of moving materials should be kept as short as possible, no more than 20 m up and down the slope or 30 m across the slope.

e. In building hillsides ditches or bench terraces, the link road should be made first and then start hillside ditching and bench terracing from the link raod.

f. In shaping a slopeland with irregular topography, shaping work should be made section by section, using the slope-dividing lines as the partition for different shaping treatments.

g. When moving up a steep slope, back the machine and lower the blade about 30-50 cm above the ground.

h. When moving down a steep slope, lower the blade so as to readily stop the machine and avoid the machine to turn over in case of an accident.

i. Drive the machine slowly on rugged terrain or steep slope and never too close to the edge of the cliff or a deep hole.

(2) Improved operating techniques

a. Using the blade angled for side-casting to the lower side of the bench terrace, hillside ditch, or link road and for back filling ditches or depression spots.

b. Using the blade tilted for upside slope cutting, digging out rocks and stumps, and, more importantly, making the reverse-slope bottom of the hillside ditches.

c. Under ordinary slopeland conditions, three passes of operation are adequate to complete the cross-section of a bench terrace, hillside ditch or link road. The first pass is to open the ground for the machine to work forward and cut as much as possible the upside slope for forming the bottom of the work. The second path is to make out the full width bottom and the third path is to make a reverse slope of the bottom and smooth it, especially in building the hillside ditch.

d. In building the hillside ditches, the width of cut and the width of fill are about 2/3 and 1/3 respectively of the bottom.

e. In building the bench terraces, it is desirable to work from the bottom to the top so that the top soil cut from the upper terrace could be turned down to cover the lower terrace.

f. In shaping a large and uniform slopeland, the machine could work across the slope as steep as 18°. In doing so, the soil removed is lined on the contour, giving a good soil conservation effect.

g. In shaping a steep and irregular slopeland, if the cut amount is insufficient to cover the fill amount, the better solution is to cut and lower the top for getting sufficient fill.

V. Development Of Slopeland Farm Machinery For Mechanized Slopeland Farming

The slope is an unique feature of the slopeland. This feature limits the workability of farm machinery on slopeland. The steeper the slope, the more limitation the machinery suffers. When an ordinary farm machinery is put to work on the slopeland, it works well as usual on slopes below 4°, it needs some adjustments and skilled techniques on slope between 4°–8°, it requires certain modifications on slopes between 8°–15°, and it wouldn't work properly or even totally on slopes over 15°. In Taiwan, as the average slope of slopeland is over 15°, it is necessary to modify and develop slopeland machinery to suit the steep slopes.

To serve this purpose, a slopeland farm machinery development program has been implemented since 1977 under the direction of former JCRR and CAPD and now COA. This is a research program with participants from concerned universities, colleges, agricultural and livestock research institutes, and district agricultural improvement stations.

1. Guidelines for the research work on development of slopeland farm machinery

(1) Priority should be given to the machinery needed for the highly labor-demanded farming work such as transportation, pest and weed control, tree-fruits harvest and grading, forage grass-cutting, etc.

(2) To fit the slopeland conditions, cropping patterns, soil conservation and farm management scope, the slopeland machinery to be developed can be classified into two types. One is the self-propelled type of which the machines are to be driven to run on the slopeland field. The other is the stationary type which is a set of fixed mechanical installation working for a certain area.

2. Key points for development of slopeland farm machinery

(1) In modification and development of the slopeland self-propelled machines:

a. Conducting experiments on the performance and behaviors of the conventional machinery working on slopelands to find out their discrepancies and problems such as lack of power, low traction, slanting to the downhill side, sliding down the slope, tipping over, etc.

b. Based on the performance and behaviors of the conventional machinery showed in slopeland working, modification and development should be made in respects of the size of the machine, structure of the body, the arrangement of wheel and axle, method of steering, the system of power drive, as well as the safety device.

c. Useful methods which can be adopted include lowering the center of gravity, distributing the body weight evenly over the wheels, applying four-wheel drive, using four wide wheels with the same size and low pressure, adopting the hydraulic steering of front wheels, adopting the articulated arrangement between the front and rear frames, and installing a safety frame in the middle or rear part of the machine for preventing roll over.

(2) In improvement of the stationary mechanical installations

Stationary mechanical installations under improvement included the farm cable-way, monorail, ordinary spraying system and automatic spraying system. These mechanical installations have the advantage to give fast mechanization in slopeland transportation, spraying and irrigation

because they could serve the operation in long lines or large areas and their installation could be set up in a short time with little interference with the existing land-use and cropping patterns. They are especially suited to the steep and irregular slopelands where general farm mechanization is difficult to be performed.

a. On installation of farm cableway:

The location and site of the cableway should be properly decided for control of an adequate area and having a sufficient elevation difference between the upper and lower stands for efficient operation. The power drive and automatic control should also be studied.

b. On development of automatic spraying system:

Emphasis should be put on the improvement and development of the three main parts of the system, namely, the chemical mixing and pumping station, the timely controlled pipelines, and the self-rotating sprinkle-type spraying head.

3. Major slopeland machinery and mechanical installations improved and developed

With joint efforts by the government and participants, various kinds of slopeland farm machinery and mechanical installations have been improved and developed in the past eleven years. The remarkable accomplishments are briefly introduced below.

(1) Wu's articulated-frame and floating wheel power-carts

Among Wu's Company manufactured various types of power-carts, the newly developed articulated-frame type and floating-wheel type have their special features to fit the slopeland transportation conditions. The former type has an articulated hinge in the center to allow the rear frame with the two rear wheels to swing from side to side so that both wheels can rest on the sloping ground for getting better stability and bigger traction. For the latter type, there is a floating frame of 4 rear wheels on the rear axle to allow the rear wheels to swing upward and downward with the change of ground slope for the same purpose as above.

(2) The wheel-adjustment power cart

This type of cart, developed by Mr. Y. S. Lin of Taitung District Agricultural Improvement Station (Taitung DAIS) has a hydraulic mechanism to change the vertical position of both rear wheels with the change of the ground slope of both sides to maintain the cart body in the level position for more traction and stability.

(3) The cable-drawn mono-rail

The cable-drawn mono-rail, developed by Prof. K. N. Wang of National Taiwan University, is a combination product of the farm cableway and the mono-rail. It is a kind of mechanical installation that has a carrier on the mono-rail with a cable-driven mechanism to draw the carrier on the rail for up and down transportation. Its advantages are bigger power with a diesel engine on the ground, more carrying capacity, less vibration on the rail, and improved brake system.

(4) The multi-use slopeland machine

This machine, developed by Mr. Y. S. Lin of Taitung DAIS, has good slopeland work suitability and can perform different jobs with a variety of attachments. The important features of the machine include wide and low-pressure tires, low center of gravity, hydrostatic drive, even-arranged attachments, and roll-over protection frame.

The attached implements and equipment included a flail-type mower, a auger-type digger, a rotary tiller, and a blower-type sprayer. The blower-type sprayer has made the multi-use slopeland machine a very popular machine because of its splendid spraying performance.

4. The self-propelled rope-drawn shaker

This type of shaker was developed by Prof. K. Y. Liu of National Taiwan University through a series of studies on shakers for harvesting tree-fruits. This shaker is mounted on a slopeland power-cart for convenient operation in slopeland orchards. The main components are the power of a diesel engine, the reciprocating piston in a square groove, a rotary plate, and the adjustable parallelogram frame. It can work in all directions on complicated slopeland. Field tests showed

that the shaker is good for harvesting plums, peaches, olive, citrus, etc. with vibration frequencies of 200 – 500 rpm and amplitude of 5 – 30 cm.

5. The automatic pipeline spraying system

The system was first improved by Mr. L. C. Chou of MARDB Second Word Station to adapt th local slopeland farming conditions and then modified by Mr. F.T. Kiang of Ta-hu Senior Professional Agricultural and Industrial School in development of the electronic-controlled operation system and by Prof. Y.J. Huang of Chunghsin University, Mr. K.K. Lee and Mr. M. C. Hung of Taitung DAIS in development of the self-rotating spraying head. Its main components include a deep-well pump to give bigger spraying capacity and higher spraying pressure, a set of electronic-controlled operation appliances for automatic operation section by section, and a number of self-rotating spraying heads to make a steady and uniform mist spraying. The significant advantages are no risk of poisoning, timely pest control, and large area coverage in few minutes.

VI. Establishment of the Mechanized Slopeland Conservation Farming Systems

1. The concept of the mechanized slopeland conservation farming systems

In terms of slopeland conservation farming, the slopeland should be treated for conservation according to its need, and, in the meantime, the cropping and cultural practices be fitted to the slopeland capability and suitability, so that a sustained slopeland agriculture can be achieved. For intensifying the slopeland conservation farming, we have applied construction machines to perform soil conservation treatments and improve the slopeland conditions, adjusted the cropping pattern to fit the improved land use type and developed slopeland machinery to mechanize slopeland farming. By integration of thse three works, the so called mechanized slopeland conservation farming system was established.

2. Major mechanized slopeland conservation farming systems developed

Four major mechanized slopeland conservation farming systems have been developed based on the slopeland use types.

(1) The mechanized conservation farming system for existing moderate slopelands

a. Hillside ditches built across the slope on the existing slopeland serve both as a measure for soil and water conservation and as a farming path for small machinery operation. There are link roads built between hillside ditches to form the road net work on the slopeland.

b. The most useful machine is the slopeland power-cart that can be used on hillside ditches for transportation and spraying. The pipeline system can be set up for spraying and irrigation where there is a water source.

c. This system which needs not to change much the existing slopeland and farming conditions is suited to the ordinary slopeland plantations or orchards under extensive management.

(2) The mechanized conservation farming system for the improved moderate slopelands

a. Mechanical operation has been applied to shape the slopeland area by area according to the slope distribution. Soil conservation and public farm works such as hillside ditches, irrigation and drainage systems, farm and link roads, etc. have been constructed in accordance with an integrated plan on land use and cropping methods.

b. Hillside ditch or orchard hillside ditch which is the skeleton of the system, serve the purposes for soil and water conservation, transportation, as well as machinery operation on the projected slopelands.

c. Crops and tree-fruits are planted horizontally between hillside ditches. Cover grasses, especially the bahia grasses, are planted on slopes, ditches, and roads. For facilitating mechanized operations, improved cultural practices such as using dwarfstocks, reducing the tree size by training and pruning, close planting on rows, etc. should be applied when demanded.

d. This system which is technique and capital intensive is suited to rather large scope of slopeland farm management and for cooperative,

joint, or contract operation.

(3) The mechanized conservation farming system for the existing steep slopelands

a. The bench terrace and link road make up the framework of the system. On existing terraced steep slopelands, one farming path should be built between every two terraces to provide a space for transportation or small machinery operation. The tree crops along the both sides of the farming path should be heavily pruned to leave an adequate space over the farming path.

b. When new bench terraces are to be built on the steep slopeland, the bench should be outward-sloped so as to lower the terrace wall between two neighboring terraces for easy field work and getting more useful land area. The tree crops should be planted on the outer side of the bench to leave a space on the inner side for transportation and small machinery operation.

c. Cover grasses should be planted on the bench and the terrace wall when possible. Pipeline systems are most useful for spraying and irrigation.

d. This system is only suitable to individual management in small scope because of the lower land use efficiency and higher terrace construction cost.

(4) The mechanized slopeland conservation farming system for the totally shaped slopelands

a. This system gives the special significance in the transformation of the steep, irregular, and complicated slopelands into a large whole piece or several connecting large pieces of gently sloping, all even and inform slopelands on which the innovated farming techniques can be applied as in the flat area.

b. Soil and geological formation survey should be made first to decide if the land is capable of standing the deep cut and high fill. Then, mechanical operation for shaping the irreguar terrain should be well planned for the effective operation, soil conservation, and land use.

c. Hillside ditching and grass cover are still the fundamental soil conservation treatments. Farm facilities and cropping pattern are to be provided and adopted as required.

d. On the land with a gentle slope, all farming practices can be mechanized with large ordinary farm machinery and mechanical installations. If the land has a steeper slope, slopeland machinery should be used for intensive farming.

VII. Conclusion

As everybody knows, the slopeland needs adequate conservation, and, meanwhile, the use of slopeland for agricultural purpose is inevitable under the circumstance nowadays. Accordingly, a slopeland mechanization program has been implemented to intensify the soil conservation and promote the slopeland use. The program covers three major activities, namely, application of mechanical operation for enhancing soil conservation and improving slopeland conditions, development of slopeland farm machinery for performing mechanized farming practices, and establishment of mechanized slopeland conservation farming systems for securing a sustained slopeland agriculture.

The program has made various accomplishments in the past eighteen years. Among the remarkable ones are:

(1) Full completion of the projected soil conservation and farm installation work for about two thousand hectares a year by mechanical operation.

(2) A series of practical slopeland machinery and mechanical installations have been developed so that almost all important slopeland farming practices such as weeding, pest control, pruning, fruits harvesting and grading, irrigation, tilling and transportation can be mechanized.

(3) With the establishment of mechanized slopeland conservation farming systems, farmers have the guide to conserve and use the slopeland to the best advantage.

VIII. Acknowledgement

The author wishes to make grateful acknowledgment to all the program participants including concerned agencies and expert workers for their dedicated work and contributions in implementation of this program. Especially, the author is debated to Mr. C. C. Koh and Dr. M. C. Liao for their foresight and expertise to initiate

and guide the program for which the author had the opportunity to carry it out with every effort.

References

1. CAST Report No. 96 (1983) Agricultural Mechanization: Physical and Social Effects and Implication for Policy Development.
2. Caterpillar Tractor Co., (1977) Caterpillar Performance Handbook, Peoria.
3. Dept. of Agricultural Machinery Engineering, National Taiwan Univ. (1985) Research Reports on Slopeland Mechanization.
4. Japanese Institute of Agricultural Machinery (1980) Studies on Slopeland Machinery and Installations.
5. Liao, M. C. (1980) Soil Conservation Research and Development in Taiwan. J. Agi. Assoc. China. No. 112 pp. 159-172.
6. Liao, M. C. (1981) Soil Conservation Measures for Steep Orchards in Taiwan. Proc. South-East Asian Regional Symposium on Problems of Soil Erosion and Sedimentation, Bankok, Thailand.
7. Neumeier, K. (1970) Cross-Country Vehicle with Automatic Inclination Compensation, J. of Terramechnies, Vol. 7, No. 1, pp. 9-17, Pergamon Press.
8. MARDB. (1984) Taiwan Slopeland Resources Investigation Report
9. Ruhling, W. (1980) Schlepper fur Weindausteillagen, Der Deutache Weintsche Weinbau, No. 112. pp. 522-528.
10. Sano, F. (1985) Study on Mechanized Construction Works for Farmland Development, J. Mechanization of Agro-Civil Engineering Practices, Vol. 16. No. 1 pp. 2-28.
11. Tanabe, H. (1988) Farming Mechanization in Slopeland, Shimane University.
12. Tu, P. Y. (1981) Development of Slopeland Mechanization in West Europe. J. Chinese Soc. Agri. Eng. Vol. 27, No. 2, pp. 54-58.
13. Tu, P. Y. (1983) Development of Slopeland Machinery in Japan. J. Chinese Soc. Agri. Eng. Vol. 29, No. 4. pp. 59-67.
14. Tu, P. Y. (1985) Mechanical Operation Techniques for Slopeland Shaping. J. Chinese Soc. Agri. Eng. Vol. 30, No. 4, pp. 35-39.
15. Tu, P. Y. (1986) Improvement and Development of Slopeland Machinery in Taiwan. Korea-China Bilateral Symposium on Reclamation and Soil Conservation of Sloping Farmland. pp. 167-186.
16. Wu, S. L., B. S. Yu, and F. M. Wu (1982) Observation on the Performance of Construction Machines in Slopeland Development and Economic Analysis, MARDB and Taiwan Uniersity Agri. Eng. Dept. Report.