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THE PERSPECTIVE OF AGRICULTURE IN THE LOWER MEKONG BASIN 1/

August 1974

1/ This paper has been prepared by Takashi Kawai, Irrigated Agriculture Planning Specialist of the Mekong Secretariat. The views expressed are presented as a basis for discussion and, as such, do not necessarily reflect a consolidated opinion of the Mekong Committee and its Secretariat.

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9. ABSTRACT

Three types of agriculture exist in the lower Mekong basin: traditional tropical, accelerated tropical, and sustained yielding agriculture. The first two depend mainly on reclamation, resulting in depletion of soil fertility and low ceilings for crop production. Sustained yielding agriculture conserves land productivity with high input. The outcome of the three types of farming may be examined with the help of a simple mathematical model developed to find a way to maintain better production. Data on irrigated double cropping in the Lam Phra Phloeng project in Northeast Thailand provides information for analysis in an attempt to understand the gap between agricultural innovations suggested and farmers' motivation. Tables present information on the succession of agricultural lands, cassava production (1950-1970), maize production (1950-1970), cottonseed production (1950-1970), Kenaf 8: jute production (1950-1970), rubber production (1950-1970), rice production (1950-1970), analysis of rice production in Thailand (1908-1970), rubber production in Thailand (1950-1970), a test of crop production vs newly reclaimed land, a test of crop yield vs soil fertility, the number of farmers participating in second cropping and receiving information in the Lam Phra Phloeng Project, a decision tree of second cropping in Lam Phra Phloeng irrigation project, the relation between given information and second cropping, and second cropping probability as a simple Markov process.

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Introduction

This paper consists of two parts. In part 1, three types of agriculture in the lower Mekong basin have been identified through a historical review of the cultivated lands, i.e. "traditional tropical", "accelerated tropical" and "sustained yielding" agriculture; the first two mainly based on reclamation and resulting in the depletion of soil fertility, have low ceiling for crop production, whereas the last one conserves land productivity with high input. Outcome of the three types of farming is examined with the help of a simple mathematical model and with a view to finding a way to maintain better production.

In part 2, information media, as one of the key factors that would fill the gap between agricultural innovations and farmer's motivation, is analyzed using sampling data of irrigated double cropping in the Lam Phra Phloeng project in Northeast Thailand.

THE PERSPECTIVE OF AGRICULTURE IN THE LOWER MEKONG BASIN

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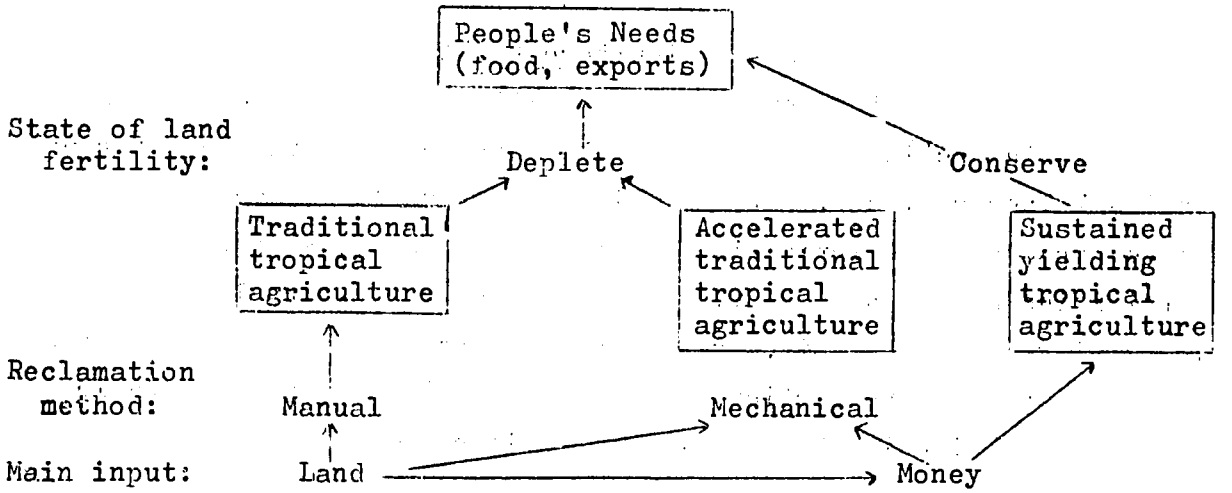
THE PERSPECTIVE OF AGRICULTURE IN THE LOWER MEKONG BASIN

Part 1. A model for perspective of agriculture

1.1. A classification scheme

From a macro view of prevailing tropical agriculture in the lower Mekong basin, the farming activities - past, present, or to come - can be classified into three types, in which their proportion is variable, as shown in the following scheme proposed by W.J. van Liere 1/.



Traditional Tropical Agriculture (TTA): This type is dominant in the tropical region, the cultivable land is chosen with ease of reclamation and availability of natural watering as rainfed or shallow flooding. Various local varieties of crops evolve adapting themselves to the local conditions without use of fertilizers.

1/ Senior Agricultural Advisor, Mekong Secretariat

Accelerated Traditional Tropical Agriculture (ATTA): Since the second half of the nineteenth century, when international rice trade became profitable, reclamation of the Mekong delta and the Chao Phraya delta have been pursued enthusiastically. During recent decades, the pressure of increasing population further accelerated reclamation including that of open forest lands almost everywhere in the Mekong basin with use of heavy machines. Irrigation was introduced to some new areas with governmental investments. However, rational land use maintaining soil fertility has never been seriously considered; thus, the ATTA is basically similar to the TTA.

Sustained Yielding Tropical Agriculture (SYTA): Unlike the other two which are characterized by a soil fertility depleting monoculture resulting in declining yields, the SYTA can conserve the land through rational land use, e.g. with rotation of diversified crops including fodder crops. More irrigation inputs, land consolidation, liming and fertilizing may be necessary. This type of agriculture is still rare in the lower Mekong basin, except in pilot land consolidation areas, some plantations and horticultural units for intensified vegetable farming appearing in the vicinities of big cities.

People's Needs: Needs of food crops for consumption, industrial use and export in the Mekong basin have so far been fulfilled through TTA and ATTA, i.e. by increasing cultivated area. The trend of production of crops, especially of rice, had been almost identical with that of the population, although it was subject to considerable fluctuation from year to year due to climatic conditions. It has been difficult to improve the yield levels, or even to sustain them. Moreover, the limit to the availability of new arable lands is approaching fast; it has already appeared in Northeast Thailand 2/.

2/ W.J. van Liere and T. Kawai, "Topography, population and actual agricultural land use in the Northeast in relation to its present and future land capability", discussion paper for DAGT, Khon Kaen, 31 October - 5 November 1973, Mekong Secretariat.

For a situation of the above type, it is generally recognized that there is no remedy but a shift towards intensive agriculture, i.e. SYTA. We could perhaps say that the necessary conditions for SYTA are physical water supply, management of soil fertility, rotation of crops including new varieties, institutions for credit, taxation, price mechanism, etc., but these were hardly realized in the past. Nor are these conditions enough to attain SYTA. We need insight into motivation of society, especially of the farmers. In this respect, we might learn important lessons from the historical development of the farm lands in the Mekong basin. (See Map 1).

1.2. Historical review of the cultivated lands

A general picture of the successive phases of exploitation of the agricultural lands is obtained from Map 1 3/. In particular it may be mentioned:

(1) Pre-medieval settlements and ancient canals (built about two thousand years ago) were always found within the "savanna floodlands" of the holocen climax vegetation, where the first rice growers came and cropped broadcasting floating rice. The three main locations chosen by the early settlers are (i) the flat grassy plains between the dense riverine forests and deep forests of the higher grounds in the Tonle Sap-Mekong delta, (ii) the vast areas in the Mun-Chi basin of Northeast Thailand, where the lower terraces are flooded to a shallow depth in the wet season and (iii) the belt of shallow floodlands along the border of the Chao Phraya delta. The factors dictating the choice of these sites should have been, everywhere the same: usable water from natural flooding and flat lowlands with sparse vegetation which did not require the strenuous labour of clearing.

3/ Compiled (with additions) from original figures prepared by W.J. van Liere in his article "Archaeology and the Mekong Project", Information Note by the Secretariat, Mekong Committee, March 1973. The description of succession of cultivated lands in this chapter depends upon the article.

(2) Medieval agriculture (since around the tenth century) may still be traced from aerial pictures and topographic maps showing a patchwork pattern of the bunded fields. The farming sites were mostly large areas reclaimed from open diptherocarp forests of the lower terraces around the Great Lake and in the Mun-Chi basin. Most of the flooded savannas, in which the pre-medieval farmers settled, have been abandoned. The reason is still unknown. Someone may attribute it to changes in climate and flood pattern. Some of these abandoned areas grow paddy again, but are known for their infertile soils; in the Mekong delta in Viet-Nam, they are named acid sulphate soil areas and still remain abandoned. Due to lack of rational farm land conservation, together with weathering action, man might exhaust the fertility of soils. Transplanting rice with some water tapping technique and growing fruits and vegetables came into vogue in the Middle Ages.

(3) Since near the end of the nineteenth century, most of the deltas of the Mekong and the Chao Phraya, including dense inundated, riverine and tidal forests, have been reclaimed and become the centres of agricultural production. Large forest and savanna areas of the Northeast and the Central Plain of Thailand have been newly exploited. The reclamations were remarkably sped up, e.g. the paddy areas of the Central and Northeast Thailand are now more than 10 times what they were in 1850. Increase in cultivated land in the Central Plain was rather steady with an annual rate of 2 percent. On the other hand, in the Northeast it was the highest during the period after the Second World War. Throughout the modern reclamation period, large savanna areas were recovered from abandoned state after several hundred years. On the other hand, considerable areas of the medieval farm land located at the foot of the Dong Rek range (both Thai and Khmer sides) were given up.

While reviewing the past agriculture, we may observe the following regarding the pattern of the people's farming activities.

1. Apart from migration compelled by wars, changes in climate, floods and so on, a main motive for the migrations leading to new land use patterns, had been land productivity. There have been repetitions of reclamation and abandonment, instances of people having diminished soil fertility seeking better land.

2. Environmental changes, to a large extent, have been "man made". However, the people who have long been unaware of the total outcome of the traditional tropical agriculture, just have been choosing TTA and ATTA. It has been their belief, based on their accumulated experience, that TTA and ATTA were most in harmony with the evolution of tropical cultivation, and perhaps that no alternative assuring better results existed. In recent years, various agricultural innovations have come within our knowledge, although some are still in the experimental stage. We may not be quite sure of the various final outcomes of some of the technological innovations especially as there are instances of unwelcome ecological changes reported in some developed countries. Nevertheless, we have to aim at a system of sustained yielding agriculture, even if it might mean learning again through experience, as that will be the only means to overcoming the inbalance between food supply and demand now looming in the lower Mekong region as a whole.

3. From the human behaviour view point, the motivation behind farmer's activities would be: self-sufficiency for food, monetary gains, least labour input, avoidance of debt and a prosperous life in a liberal community. The farmer already in an extreme situation, at a crossroad, pondering whether to survive or to starve, will be willing to put his best efforts into any hopefully productive system, provided, however, that he is given adequate information about the system in a convincing manner. Now, we face a gap that has to be filled between technological knowledge and farmer's motivation. Today the flourishing mass media reach almost every rural corner, but so far it does not seem to have had any impact in respect of

agricultural improvement. The media needed for diffusing agricultural innovation would seem to require the human touch to a great extent, and should be such that the farmers can see for themselves the actual results of the innovation. The pioneer agricultural projects of the Mekong Committee involving farmer's full participation, should be an effective means to the attainment of the SYTA.

1.3. Application of the model

a. Crop production follows logistic curve

It will be worthwhile to review the trend of crop production under the ATTA and SYTA in the scheme mentioned in 1.1. As seen from Figs. 1-6 which are based on a 20 year record of production, in each Mekong riparian country, of selected crops: cassava, maize, cotton, kenaf, rubber and rice, the production trends by and large seem to follow a logistic curve 4/. The logistic curve pattern appears clearly at the beginning of the period in some cases, on the majority of curves, it is seen towards the latter half of the period and there the production appears to have reached rather close to the ceiling of the curve.

The logistic curve is generally used to represent phenomena such as population growth, and life-cycle of industries, which are characterized by circumstantial growth constraints. The trends

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4/ $dy/dt = b.y(L-y)/L$, then $y = L/1+A \exp(-bt)$, where y is the value in year t, L is the saturation value of y, b(growth rate) and A are constants. Fitting of the curve is made by selecting three pairs of y values, namely y_o, y_1, and y_2 which are situated at equal time intervals.

$L = (2y_o y_1 y_2 - y_1^2(y_o+y_2))/(y_o y_2 - y_1^2)$

$A = (L-y_o)/y_o$

$b = -(1/t) \ln(y_o(L-y_1)/y_1(L-y_o))$

Percentage of y to L is $P = 100y/L = 100/1+A \exp(-bt)$

relating to the ATTA seem to be influenced by the limitation of cultivable land area and declining soil fertility.

In the case of rice and rubber, shown in Fig. 7 and 8, however, the growth trends show a succession of logistic curves. The distinct growth cycles in these cases may correspond to some kind of innovation, price stimulation, demonstration effect or the like, as is usual with certain industries. Under well controlled SYTA the trend would increase gradually and continuously along with technological innovation and its diffusion.

b. Growth curve and its variation

An attempt is made here to trace trends of a pair of variables related to each other such as crop production and reclaimed land, or crop yield and soil fertility. A simple mathematical model is applied for this. This model originated with the "Lotka - Volterra's equation (1927)" to study fluctuations in animal populations as in the case of predator and prey.

The model is described as follows 5/. Two animal populations confined to a closed environment are Y_1 and Y_2 respectively; b_1 and b_2 are their growth rates per unit period when no constraints exist; there are limits to the population, namely L_1 for Y_1 and L_2 for Y_2, due to reasons such as shortage of food. Assuming further that they influence each other as predator and prey, and/or vice versa, there will be predatory loss rates k_1 and k_2 proportional to the populations Y_2 and Y_1; then the population changes ΔY_1 and ΔY_2 for the unit period would be:

$$\Delta Y_1 = b_1 Y_1 (L_1 - Y_1 - k_1 Y_2)/L_1$$

$$\Delta Y_2 = b_2 Y_2 (L_2 - Y_2 - k_2 Y_1)/L_2 \quad \text{.....(1)}$$

5/ Koichiro Takahashi, Ecological study with mathematical model, "Limit to Existence", Mainichi-shinbunsha, 1973.

We can simulate time-serial variables of Y_1 and Y_2 by application of the equations (1) assuming the initial values of $Y_{1,0}$ and $Y_{2,0}$. The final stabilized values of $Y_{1,n}$ and $Y_{2,n}$ (in which "zero growth" of population is expected, i.e. the values in brackets in the numerators in the equations (1) equal zero) would be:

$$Y_{1,n} = (L_1 - k_1 L_2)/(1 - k_1 k_2)$$
$$Y_{2,n} = (L_2 - k_2 L_1)/(1 - k_1 k_2) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The loss coefficients k_1 and k_2, taking either positive or negative values, show the mutual action of the two subjects, and various patterns of the population changes are derivable according to the value of these coefficients. (If $k_1 = 0$, $k_2 = 0$, Y_1 and Y_2 would follow the logistic curves).

The following cases are examined. (see Fig. 9 and 10).

(1). Total crop production (Y_1) vs. newly reclaimed land (Y_2)

We assume in this case that the crop production (Y_1) depends on existing cultivated land and an additional reclaimed land (Y_2). By the former, Y_1 can reach the relative value of 100 and maintain it. By reclamation, however, Y_1 and Y_2 reach maximum (more than 100 for Y_1) in certain period, then decrease and finally arrive at equilibrium levels. If the consumption of soil fertility is saved (reducing the rate of k_2 by input of fertilization and appropriate crop rotation), Y_2 keeps certain level equivalent to the virgin land and Y_1 reaches more than 100.

Case	Initial Value	Final Value	Loss Rate	Interpretation of result
i)	$Y_{1,0} = 0$	$Y_{1,n} = 100$	$k_1 = -1$	Standard for traditional tropical agriculture
	$Y_{2,0} = 0$	$Y_{2,n} = 0$	$k_2 = 1$	
ii)	$Y_{1,0} = 0$	$Y_{1,n} = 50$	$k_1 = -2$	More fertility consuming monoculture
	$Y_{2,0} = 0$	$Y_{2,n} = 0$	$k_2 = 2$	
iii)	$Y_{1,0} = 0$	$Y_{1,n} = 100$	$k_1 = -0.5$	Reduction of k_1 is not effective for both Y_1 and Y_2
	$Y_{2,0} = 0$	$Y_{2,n} = 0$	$k_2 = 1$	
iv)	$Y_{1,0} = 0$	$Y_{1,n} = 133$	$k_1 = -1$	Reclaimed land is conserved by rational land use and fertilization.
	$Y_{2,0} = 0$	$Y_{2,n} = 33$	$k_2 = 0.5$	
v)	$Y_{1,0} = 0$	$Y_{1,n} = 120$	$k_1 = -0.5$	Y_1 reaches more than 100. These iv) and v) are examples of SYTA.
	$Y_{2,0} = 0$	$Y_{2,n} = 40$	$k_2 = 0.5$	

Remark: Curves based on the above are shown in Fig. 9, in which one unit on the time scale corresponds to 10 - 20 years. In equation, (1), $b_1/L_1 = b_2/L_2 = 1/100$ is assumed.

(2). Crop yield (Y_1) vs. soil fertility (Y_2)

We assume the case that the crop yield Y_1 depends solely on the soil fertility Y_2. During the initial period Y_1 increases rapidly consuming Y_2 which accordingly diminishes, and after certain periods they reach an equilibrium and co-exist. During the above periods, Y_1 and Y_2 values sometimes oscillate due to occurence of over-consumption of Y_2, reduction of Y_1, recovery of Y_2 and again increase of Y_1. The way to maintain the higher yield and conserve the soil fertility is, here again, to reduce the rate of k_2 by the input of fertilizers and the rational rotation.

Case	Initial Value	Final Value	Loss Rate	Interpretation of result
i)	$Y_{1,0} = 0$ $Y_{2,0} = 100$	$Y_{1,n} = 50$ $Y_{2,n} = 50$	$k_1 = -1$ $k_2 = 1$	Standard for TTA
ii)	$Y_{1,0} = 0$ $Y_{2,0} = 100$	$Y_{1,n} = 33$ $Y_{2,n} = 33$	$k_1 = -1$ $k_2 = 2$	Soils more hazardous than i), more exhausting, and resulting in lower yield
iii)	$Y_{1,0} = 0$ $Y_{2,0} = 100$	$Y_{1,n} = 67$ $Y_{2,n} = 33$	$k_1 = -2$ $k_2 = 1$	More fertility consuming monoculture. Yield better but big fluctuations.
iv)	$Y_{1,0} = 0$ $Y_{2,0} = 100$	$Y_{1,n} = 33$ $Y_{2,n} = 67$	$k_1 = -0.5$ $k_2 = 1$	Reduction of k_1 makes no better yield; poor input agriculture.
v)	$Y_{1,0} = 0$ $Y_{2,0} = 100$	$Y_{1,n} = 67$ $Y_{2,n} = 67$	$k_1 = -1$ $k_2 = 0.5$	Reduction of k_2 (with fertilizers and crop rotation) resulting both better conservation and yield, i.e. SYTA.

The qualitative outcome of the three types of agriculture has been compared through the simple mathematical model by changing the factors. While the actual state of agriculture in the Mekong basin is of course of a complicated nature, the basic characters disclosed by the model seem to be revealing.

The important principle for obtaining sustained yielding tropical agriculture is <u>rational land use and soil conservation</u>. For this, several relevant regional problems will have to be solved, agronomically and institutionally, and in doing so, suitable irrigation and/or drainage systems will be inevitable.

As for the key factor for the materialization of the SYTA, namely the "media" for connecting technological innovation and farmers' motivation, we identify that mainly as feeding information to the farmer, and deal with it in the next part.

Part 2. Information as a leading factor

2.1. Dry season irrigated agriculture in the Lam Phra Phloeng project

At the moment, we at least have a good example of irrigated farming in the dry season practiced in the Northeast, Thailand. That is the Lam Phra Phloeng project by Royal Irrigation Department, located along the Lam Phra Phloeng river in Ampur Pak Thong Chai, Nakhon Ratchasima province. Salient features of the project are the following:

Reservoir

catchment area: 807 km^2

gross storage capacity: 149 million m^3

Irrigation system

main canal and 5 laterals for total 7 zones

tertiary and distribution system for the first 1-3 zones

Completion of the project

main system as originally designed was completed in 1970 starting in 1963, though further improvements of water distribution system still remain.

water supply in wet season: since 1967

in dry season: since 1970

Irrigation area 6/

original irrigable area: 10,500 ha in wet season

6,700 ha in dry season

cultivated area 1965: 9,100 ha (paddy 7,400 ha)

1971: 11,200 ha (paddy 10,400 ha) 7/

6/ Source: Ronald C.Y. Ng., A survey report on the dry season irrigated agriculture in the Lam Phra Plerng project area, 1972/73, IBRD, June 1973.

7/ Forest area and sugarcane fields of 3,000 ha have been converted into paddy.

irrigated area in ha:

	1969	1970	1971	1972	1973
wet season	9,890	10,060	10,470	8,130*	10,690
dry season	-	220**	220**	220**	1,220***

* this reduction is due to shortage of water in the zones 6 and 7.

** all upland crops

*** upland crops: 190 ha; paddy: 1,030 ha

The most significant development in the project area is the increase in cropping during the dry season of 1972/73 when over 1,000 ha were planted with the newly introduced high yielding non-glutinous rice variety, RD1. Ronald C.V. Ng and his team made a survey 6/ of the project area and concluded that the reasons for bringing about this encouraging situation of the expansion of second cropping area are:

(i) an assured irrigation water supply;
(ii) an availability of the necessary farm inputs on credit;
(iii) an effective extension agent; and
(iv) a favourable price for the crop (paddy) introduced.

Now we will try to weigh the above four elements quantitatively based on the data of farmer's motivation inquired by the team. The analysis is limited to the zones 1, 2, and 3 because no second crop is so far seen for the other zones due to incomplete water distribution system.

First of all, among those key elements mentioned above, (i) assured irrigation water supply is of course essential. However, in 1970/71 dry season, the irrigation water was physically made available for at least upper tracts in the project area, though almost nobody used the water. At that time, in 1971, 110 farmers were interviewed by officials of Land Development Department asking why a second crop in the dry season had never been attempted. The reasons

were i) no water supply for 52 percent of the respondents (this might mean that the farm ditches were not yet completed) ii) uncertainties of proper second crops, market prices, land suitability, cultivation technique and yields for the remainder.

Flourishing second crops in the project area had to wait until 1972/73 dry season, when-early 1972-the programme for accelerated development of dry season cropping in the upper zones was launched by the Departments of Land Development, Land Cooperative and Irrigation.

The following Table 1 shows statistics of land use and 1972/73 cropped areas in the three zones.

Table 1. Statistics on 1972/73 cropping

	Zone 1	Zone 2	Zone 3	Total
Total project area				
a. no. of households	844	821	826	2,491
b. planted area in wet season	1,922ha	1,494ha	1,520ha	4,936ha
c. average holding of irrigated area in wet season (b/a)	2.28ha	1.82ha	1.84ha	1.98ha
d. planted area in dry season	436ha	690ha	99ha	1,225ha
e. no. of households for the above	389	644	123	1,156
f. average holding of second cropped area (d/e)	1.12ha	1.07ha	0.80ha	1.06ha
g. percentage of second cropped area to total irrigated area (d/b)	22.7%	46.2%	6.5%	24.8%
h. percentage of second croppers to total households (e/a)	46.1%	78.4%	14.9%	46.4%
i. percentage of second cropped area to average holding area in second croppers (f/c)	49.1%	58.8%	43.5%	53.5%

(Cont'd)

Table 1 (continued)

	Zone 1	Zone 2	Zone 3	Total
Sample enumerated				
j. no. of households	113	147	37	297
k. average total holding including outside project area	4.29ha	3.50ha	3.92ha	3.86ha
l. average holding of irrigated area in wet season (project area)	2.43ha	1.45ha	1.60ha	1.84ha
m. k-l: rainfed paddy, upland, uncleared forest, house plot, etc.	1.86ha	2.05ha	2.32ha	2.02ha
n. no. of households cropping in dry season	77	113	26	216
o. percentage of irrigated area to total holding area (l/k)	56.6%	41.4%	40.8%	47.7%

Source: 6/

A few remarks derived from Table 1 are:

(1) Percentage of second cropped area with irrigation in the dry season 1972/73 to the planted area in the wet season (total irrigated area) was around 50-60 percent in the group of second croppers (i). This percentage and a planned irrigable rate in the dry season, that is 6,700 ha to 10,500 ha or 63 percent in the original project plan restricted by the reservoir capacity, almost coincided.

(2) Would the same percentage potentially be expected also in the group of single croppers who didn't plant their irrigable lands in the dry season of 1972/73? In other words, actual percentage of the dry season cropped area with irrigation to the total project area was 24.8 percent (g = h•i), then question is whether or not this percentage can be raised up to around 60 percent, if 100 percent of farmers participate the second cropping.

(3) The sample survey 8/ discloses that the average holding of irrigable area is only 1.84 ha or 48 percent of the total holding area, i.e. the average farmer also has 2.02 ha or 52 percent for rainfed paddy, upland, homestead and uncleared forest which are located outside the project area. Given this state, the second cropped area of the participants is an average 22.1 percent (o•h) of their total holdings including outside project area. The other farmers who made no dry season crops in the irrigable area might be busy working at the outside project area, i.e. clearing the forest, or cash earning job.

Aside from physical availability of irrigation water, the above (3) implies a labour constraint to do second cropping. Thus the answer to the previous question (2) whether 100 percent participation could be expected, is doubtful. However, due to lack of land holding data which bring out the differences between single croppers and second croppers, further analysis has not been possible.

2.2 Effect of information upon second cropping

Returning the second cropping factors raised by Ronald C.Y. Ng, the elemental factors (ii), (iii) and (iv) could be considered to depend mainly on the availability of information that is really valuable for

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8/ Sample survey, May 1973 in reference 6/

farmer's decision making. Constraints on land use, holding, labour power etc. would also be reflected in the farmer's response to the given "information" (if the constraints exist, some farmers may not attempt to crop in the dry season even though they have the information).

Now, we do have such data 9/ resulting from enquiries to farmers whether or not they received such information and tried to do second cropping. In the following analysis, we assume that the key factor towards second cropping can be measured by quantifying farmer's response to the given information including assurance of water supply, farm inputs on credit, extension services and market prices, given that irrigation water is at least 60 percent available and certain other constraints exist. The total number of second croppers and respondents to the information are shown in Fig. 11, for each of three zones.

It is noted that the source of information (advice for irrigated second cropping) received by farmers was mostly from Government officials such as District Officer (more than 50% of farmers heard from him in every zone), Agricultural Officer and RID Officer. A comparison of the different sources of information is discussed in the Annex.

Fig. 11 shows the total number of farmers, both second croppers and the non-croppers in the dry season of 1972/73, for each of the three zones, and as a whole. One source of the data is the Royal Irrigation Department of Thailand. Another set of data shown in Fig. 11 as the enumerated sample is from the sample survey of May 1973 (reference 6/; part of the data also are based on interview with second croppers and those who had information about the merit of second cropping from some source or other).

9/ Sample survey, May 1973 in reference 6/. Number of respondents is calculated from percentage values in the report.

The effect of information upon second cropping is clearly seen from a comparison of the two proportions relating to second cropping by those informed and those not informed. That the differences are significant for each of the zones will also be borne out by statistics tests such as that of contingency chisquare or that for the difference between two proportions.

In order to estimate the total number of farmers who obtained information, we assume that the proportion of those who received the information (or those who did not) within the second croppers in the sample could be equal to that in the entire zone as well. A similar assumption could be made for non-croppers. These estimated proportions in each complete zone are shown by dotted lines in Fig. 11.

The real effect of information motivating farmers to participate in second cropping could be measured by the proportion of second croppers among the total number of information receivers. Also, we have the proportion of those who made the second crop but had not received information, for each complete zone. The results are shown in Table 2 and Fig. 13.

Table 2. Percentage of farmers receiving information and participating in second cropping

		Zone 1	Zone 2	Zone 3	Total
a.	Information given	79.3	89.1	67.3	76.9
b.	Information not given	20.7	10.9	32.7	23.1
c.	Second croppers among those receiving information	56.6	87.2	19.6	58.6
d.	Second croppers among those not receiving information	5.8	6.4	5.2	5.6
e.	Second cropper* in 1972/73 [=(a)x(c)+(b)x(d)]	46.1	78.4	14.9	46.4

As shown in Table 2, the proportion of second croppers to total farmers through zones 1-3 is 46.4 percent; this is under the condition that 76.9 percent of the total farmers had received information on irrigated dry season farming. The "efficiency" of information as given by (c) in Table 2 is 58.6 percent on the average. Second croppers not receiving information but having a second crop form 5.6 percent. The percentages under (c) in Table 2 would apply when information reaches 100 percent of the farmers. This rate of about 60 percent for second cropping participation, is to be considered as more or less a maximum at the moment, in view of the various physical constraints such as insufficient water supply, poor land condition, off-farm work, etc.

* this percentage is of course the same as the proportion of the total number of second croppers to the total farmers given in Fig. 11. Note that these percentages can be improved by increasing (a).

The above calculation procedure falls in line with Bayesian decision theory. Thus, for more general use, a mathematical expression is given in the Annex. The results of Table 2 are also shown in a "decision tree" in Fig. 12.

2.3. Second cropping probability as simple Markov process

The farmer will continue their second cropping when they have succeeded once. If they failed, they may not try again. For this reason, supervision on irrigation farming is needed for the initial several years. This tendency that the past result affects the present outcome suggests a Markov process.

Suppose the state of second cropping in this year, i.e. attribute form of participating (s_j) or not participating ($\bar{s}_j$), was determined by only the state in the previous year (s_i or $\bar{s}_i$), a conditional probability (P_t) transferring the state in t=i to that in t=j is as given in the following transition probabilities matrix.

$$P_t = \begin{array}{c|cc} \text{state in } t=i=j-1 \backslash \text{state in } t=j & s_j & \bar{s}_j \\ \hline s_i & P(s_j/s_i) & P(\bar{s}_j/s_i) \\ \bar{s}_i & P(s_j/\bar{s}_i) & P(\bar{s}_j/\bar{s}_i) \end{array}$$

A shorthand notation is adopted, e.g. $P(s_j/\bar{s}_i)$ is the probability that the outcome in year t=j would be s_j if $\bar{s}_i$ represented the state in t=i. Then the probability $P_j=(P(s_j), P(\bar{s}_j))$ of the second cropping participation or non-participation at t=j is given by the following matrix product equation.

$P_{j-1} \cdot P_t = P_j$, that is

$$(P(s_i) \quad P(\bar{s}_i)) \cdot \begin{pmatrix} P(s_j/s_i) & P(\bar{s}_j/s_i) \\ P(s_j/\bar{s}_i) & P(\bar{s}_j/\bar{s}_i) \end{pmatrix} = (P(s_j) \quad P(\bar{s}_j)). \qquad \ldots\ldots\ldots (3)$$

Over the years, the probability will tend to be stabilized. In the final stage, the probability must be:

$$P_{j-1} = P_j \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

For instance, if the second cropping level is to be maintained at 70 percent, the transition probability matrix must be such that obtained as follows:

$$(0.7 \quad 0.3) \cdot \begin{pmatrix} P(s_j/s_i) & P(\bar{s}_j/s_i) \\ P(s_j/\bar{s}_i) & P(\bar{s}_j/\bar{s}_i) \end{pmatrix} = (0.7 \quad 0.3)$$

$$0.7\, P(s_j/s_i) + 0.3\, P(s_j/\bar{s}_i) = 0.7$$

$P(s_j/s_i) = 1 - 3/7\, P(s_j/\bar{s}_i)$, for which

$\begin{pmatrix} 0.85 & 0.15 \\ 0.35 & 0.65 \end{pmatrix}$ is one of the answers.

The above simple Markov process applied for the second cropping probability is shown in Fig. 14. Indications as to the strategy for raising the second cropping level emerging from Fig. 14 are:

i) when P(s) is less than 0.5, a more effective effort should be to raise $P(s_j/\bar{s}_i)$ rather than $P(s_j/s_i)$, i.e. encouraging non-second croppers than keeping existing second-croppers,

ii) when P(s) is greater than 0.5, the effective effort should be to maintain and encourage the existing second-croppers, i.e. raising the $P(s_j/s_i)$ value.

In support of the conclusions derived from sections 2.2 and 2.3, below we quote from a statement[10/] by Dr. L.M. Sing, leader of the Chinese Mission for the 6,585 ha Sappaya Multi-purpose Cooperative Pilot Project, Chainat, Thailand.

"What are the necessary steps to be taken to execute the project?

(i) As there had been so many promises made to farmers by various missions, none of which materialized, it was imperative that the targets set were those that could really be achieved in order to regain the farmers' confidence.

(ii) Because it is an important element for success, the proper selection of the project area must take the following points into account:

a. Constant and adequate water supply;

b. Good drainage;

c. Selection of the proper type of crops with good market prospect and demand;

d. Efficient organization;

e. Choice of small area initially, gradually increasing to larger area.

(iii) The project team must work side by side with the farmers and must seek their active involvement in the project.

(iv) The first attempt must be successful".

10/ Report of the ADB Regional Workshop on Irrigation Water Management, July 1973.

Annex Analysis of effect of information on second cropping using Bayesian decision theory.

We know the percentage of second croppers in 1972/73 for each of three complete zones. This percentage however, is subject to change as evidenced by the subsequent sample survey which has shown that the second cropping participation clearly depended on whether or not the farmers received information on second cropping.

We denote the initial or prior probabilities of second-cropping state as $P'(s)$, e.g. in Fig 11 in Zone 1, $P'(s)=389/844=0.461$, $P'(s) = 0.539$ ($\bar{s}$ is for non-second-cropping state). The revised or posterior probabilities of the state is denoted by $P''(s)$, which we want to know. As the result of the action (i.e. providing information to farmers), we have an outcome (a/s); this is a shorthand for outcome a given the state s, e.g. in Zone 1, $(a/s) = 75$, $(\bar{a}/s) = 2$, $(a/\bar{s} = 23)$ and $(\bar{a}/\bar{s}) = 13$, in which the bar above symbol means "no information given" or "no second crop planted". The problem now is to combine this new information, i.e. sample likelihoods $P(a/s)$, with the prior probabilities of the state $P'(s)$ to obtain posterior probabilities of the state $P''(s)$. We do this with the help of Bayes'rule. This rule is derived as follows starting with the two alternative products, each of which is equal to the joint-probability $P(a,s)$:

$$P(s/a)\ P(a) = P(a/s)\ P'(s) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

in which a shorthand notation has been adopted, e.g., $P(a/s)$ is the probability that the outcome of the action would be a if s were the given state of second cropping.

Solving for $P(s/a)$ which is the same as $P''(s)$,

$$P''(s) = P(s/a) = P(a/s)\ P'(s)\ /\ P(a) \ \ldots\ldots\ldots\ldots\ldots(2)$$

where

$$P(a) = \sum P(a/s)\ .\ P'(s) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

The procedure of calculation is as follows:

$$P(a) = \begin{pmatrix}\text{sample likeli-}\\ \text{hood, given s}\end{pmatrix} \cdot \begin{pmatrix}\text{prior proba-}\\ \text{bility of s}\end{pmatrix}$$

$$= \begin{pmatrix} P(a/s) & P(a/\bar{s}) \\ P(\bar{a}/s) & P(\bar{a}/\bar{s}) \end{pmatrix} \cdot \begin{pmatrix} P'(s) \\ P'(\bar{s}) \end{pmatrix} = \begin{pmatrix} P(a) \\ P(\bar{a}) \end{pmatrix} \text{.....formula (3)}$$

Zone 1 $\begin{pmatrix} .974 & .639 \\ .026 & .361 \end{pmatrix} \cdot \begin{pmatrix} .461 \\ .539 \end{pmatrix} = \begin{pmatrix} .499 + .344 \\ .012 + .195 \end{pmatrix} = \begin{pmatrix} .793 \\ .207 \end{pmatrix}$

Zone 2 $\begin{pmatrix} .991 & .529 \\ .009 & .471 \end{pmatrix} \cdot \begin{pmatrix} .784 \\ .216 \end{pmatrix} = \begin{pmatrix} .777 + .114 \\ .007 + .102 \end{pmatrix} = \begin{pmatrix} .891 \\ .109 \end{pmatrix}$

Zone 3 $\begin{pmatrix} .885 & .636 \\ .115 & .364 \end{pmatrix} \cdot \begin{pmatrix} .149 \\ .851 \end{pmatrix} = \begin{pmatrix} .132 + .541 \\ .017 + .310 \end{pmatrix} = \begin{pmatrix} .673 \\ .327 \end{pmatrix}$

All Zones $\begin{pmatrix} .972 & .593 \\ .028 & .407 \end{pmatrix} \cdot \begin{pmatrix} .464 \\ .536 \end{pmatrix} = \begin{pmatrix} .451 + .318 \\ .013 + .218 \end{pmatrix} = \begin{pmatrix} .769 \\ .231 \end{pmatrix}$

Posterior probability of s, given the sample outcome

$$P''(s) = \begin{pmatrix} P(s/a) = \dfrac{P(a/s)\ P'(s)}{P(a)} & P(\bar{s}/a) = \dfrac{P(a/\bar{s})\ P'(\bar{s})}{P(a)} \\ P(s/\bar{a}) = \dfrac{P(\bar{a}/s)\ P'(s)}{P(\bar{a})} & P(\bar{s}/\bar{a}) = \dfrac{P(\bar{a}/\bar{s})\ P'(\bar{s})}{P(\bar{a})} \end{pmatrix}$$

.....formula (2)

Zone 1 $\begin{pmatrix} 0.566 & 0.434 \\ 0.058 & 0.942 \end{pmatrix}$

Zone 2 $\begin{pmatrix} 0.872 & 0.128 \\ 0.064 & 0.936 \end{pmatrix}$

Zone 3 $\begin{pmatrix} 0.196 & 0.804 \\ 0.052 & 0.948 \end{pmatrix}$

All Zones $\begin{pmatrix} 0.586 & 0.414 \\ 0.056 & 0.944 \end{pmatrix}$

The above results can be illustrated in a "decision tree" as shown in Fig. 12.

It is clear from the decision tree which action we have to choose in order to get the maximum number of participants for second cropping. That is P(a) which is a variable, is to be maximized. The basis is as follows:

$$
\begin{aligned}
P(s) &= \sum P(a,s) = \sum P(a)\ P(s/a) \\
&= P(a)\ P(s/a) + (1-P(a))\ P(s/\bar{a}) \\
&= P(a)\,((P(s/a) - P(s/\bar{a})) + P(s/\bar{a}) \qquad \ldots\ldots.(4)
\end{aligned}
$$

$$
\begin{aligned}
P(s) &= 0.508\ P(a) + 0.058 \quad : \text{Zone 1} \\
P(s) &= 0.808\ P(a) + 0.064 \quad : \text{Zone 2} \\
P(s) &= 0.144\ P(a) + 0.052 \quad : \text{Zone 3} \\
P(s) &= 0.530\ P(a) + 0.056 \quad : \text{All Zones} \qquad \text{(see Fig.13)}
\end{aligned}
$$

Taking the total of zones of 1 to 3 into account, the present state of second cropping is 46 per cent participation, given that information regarding irrigated dry season farming was received by 77 per cent of the total farmers. The potential percentage would be around 59 per cent provided that the information reaches 100 per cent of the farmers. Recall that until 1971 the farmers were totally uninformed about irrigated second crops, with the result that only 220 ha were planted in the dry season. This can be seen from the graph in Fig.13, a very low availability of information, that a presumable P(a) was identical with 5 per cent a/ during the period.

The potential percentage towards second cropping depends upon P(s/a) which is shown as the second branches of the decision tree (Fig 12) and it is rather fixed at the moment by physical constraints. For example, the result of inquiry b/ relating to farmers who were not

---

a/ P(s) = 0.530 X 0.05 + 0.056 = 0.083
rate of irrigable area in dry season to the total irrigable area in wet season = 0.535 (see Table 1,i)
4,936 ha (zones 1-3) X 0.535 X 0.083 = 220 ha.

b/ Source: Table 14. Per cent distribution of reasons for not planting a second crop, Sample Survey, May 1973 in reference 6/.

planting a second crop in zones 1 - 3 shows that over 60 per cent of the reasons for no participation relate to insufficient water supply and poor physical land condition, and the rest to occupation in off-farm or other agricultural activities, uncertainty of crop result, insufficient family labour and other reasons.

It will be worth reviewing the contributions by various officials and villagers towards giving information for second cropping to the farmers in zones 1 - 3. Table A [c/] is based on the sample survey of 1973, previously mentioned.

Table A Reported source of advice for irrigated second cropping

(percentages, cropper/non-cropper)

Source	Zone 1	Zone 2	Zone 3	Total
1. District Officer	72.7/52.8	69.9/44.2	88.5/63.6	73.2/50.6
2. Agricultural Officer	22.1/8.3	26.6/5.9	15.4/9.1	23.6/7.4
3. RID Officer	22.1/19.4	19.5/14.7	8.0/0	19.0/14.8
4. Friends in village and others	6.5/13.9	10.6/2.9	5.1/0	8.3/7.4
5. Not heard	2.6/36.1	0.9/47.1	11.5/36.4	2.8/40.7

An individual farmer often repeated more than one source of information, thus, percentages do not add up to 100 per cent.

c/ Source: Table 12 in reference 6/.

Following the same procedure as previously taken, the marginal probability of action $P(a)$ and the posterior probability $P(s/a)$ are calculated for zones as a whole assuming that the prior probability of second cropping state is common to every action ($P'(s) = 0.464$, $P'(\bar{s}) = 0.536$).

Table B Comparison of information sources

Source of information	$P(a/s)\ P'(s) + P(a/\bar{s})\ P'(\bar{s}) = P(a)$	$P(s/a) = P(a/s)\ P'(s)/P(a)$
1	0.340 + 0.271 = 0.611	0.556
2	0.109 + 0.040 = 0.149	0.732
3	0.088 + 0.079 = 0.167	0.527
4	0.038 + 0.040 = 0.078	0.487

From the above results it may be inferred that the farmers get information mostly from the government officers and among those officers, the district officer's share of effort is outstanding. The $P(s/a)$ may reflect the farmers reliability as to the source. The villager's information does not seem to have much appeal to the farmer. The farmers seem to attach importance to the agricultural officer and to follow his advice. Also, the agricultural officer might have selected farmers considered capable and acceptable for his guidance. Further efforts needed are to augment the $P(a)$ for the agricultural and RID officers. The reason for emphasizing it is clear when we judge it from the comprehensive effects of their efforts on the state regarding second cropping. That is shown as $P(a,s) = P(s/a)\ P(a)$, and such joint probabilities appear as the first term in the second column [d/] in Table A, in which the district officers' contribution is remarkable, i.e. 34 per cent followed by 10 per cent or less for the other officers.

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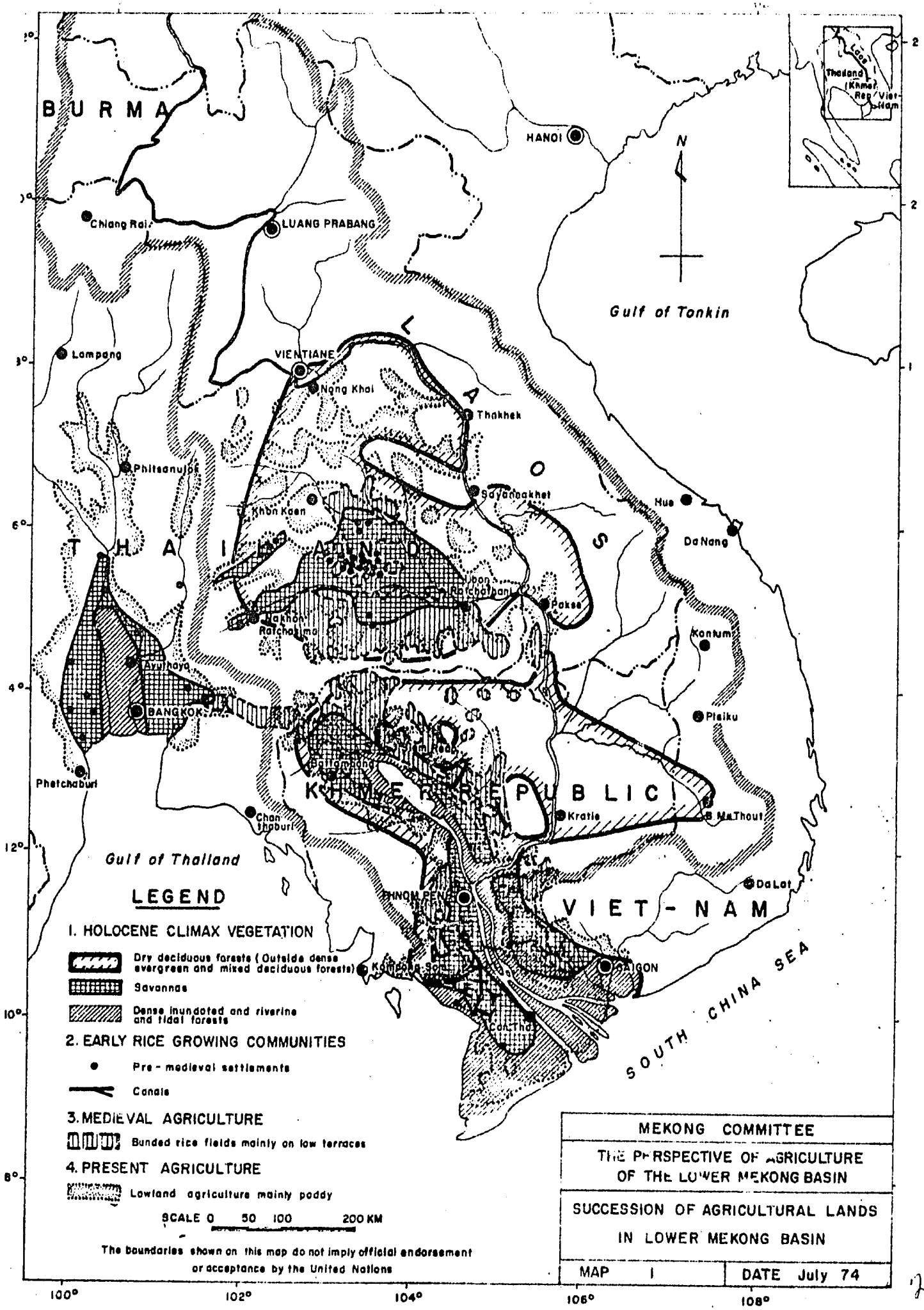
d/ Recall the formula (1) : $P(s/a)\ P(a) = P(a/s)\ P'(s)$

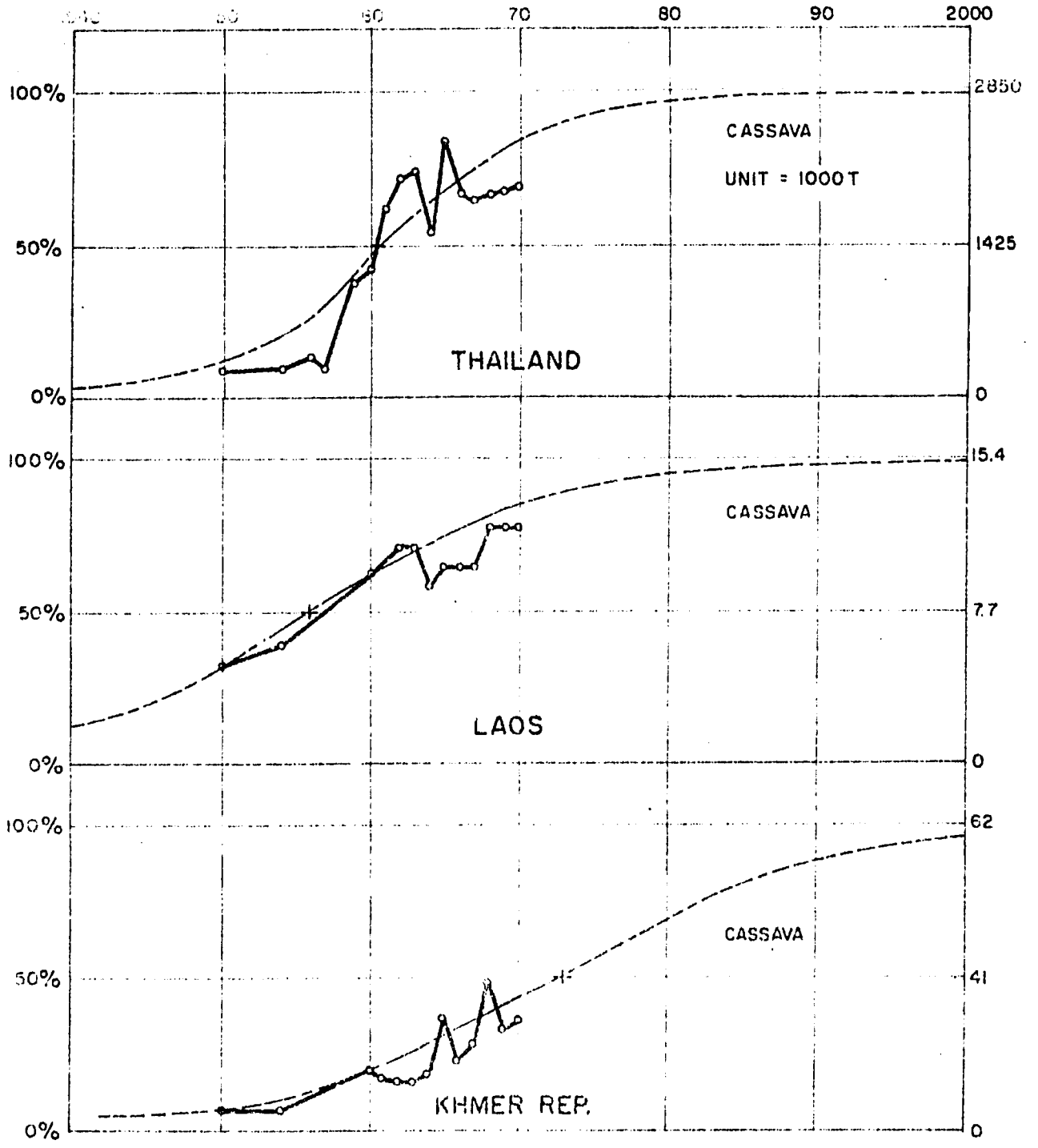


MEKONG COMMITTEE

THE PERSPECTIVE OF AGRICULTURE OF THE LOWER MEKONG BASIN

SUCCESSION OF AGRICULTURAL LANDS IN LOWER MEKONG BASIN

MAP 1 | DATE July 74



SOURCE: PRODUCTION YEARBOOK, FAO

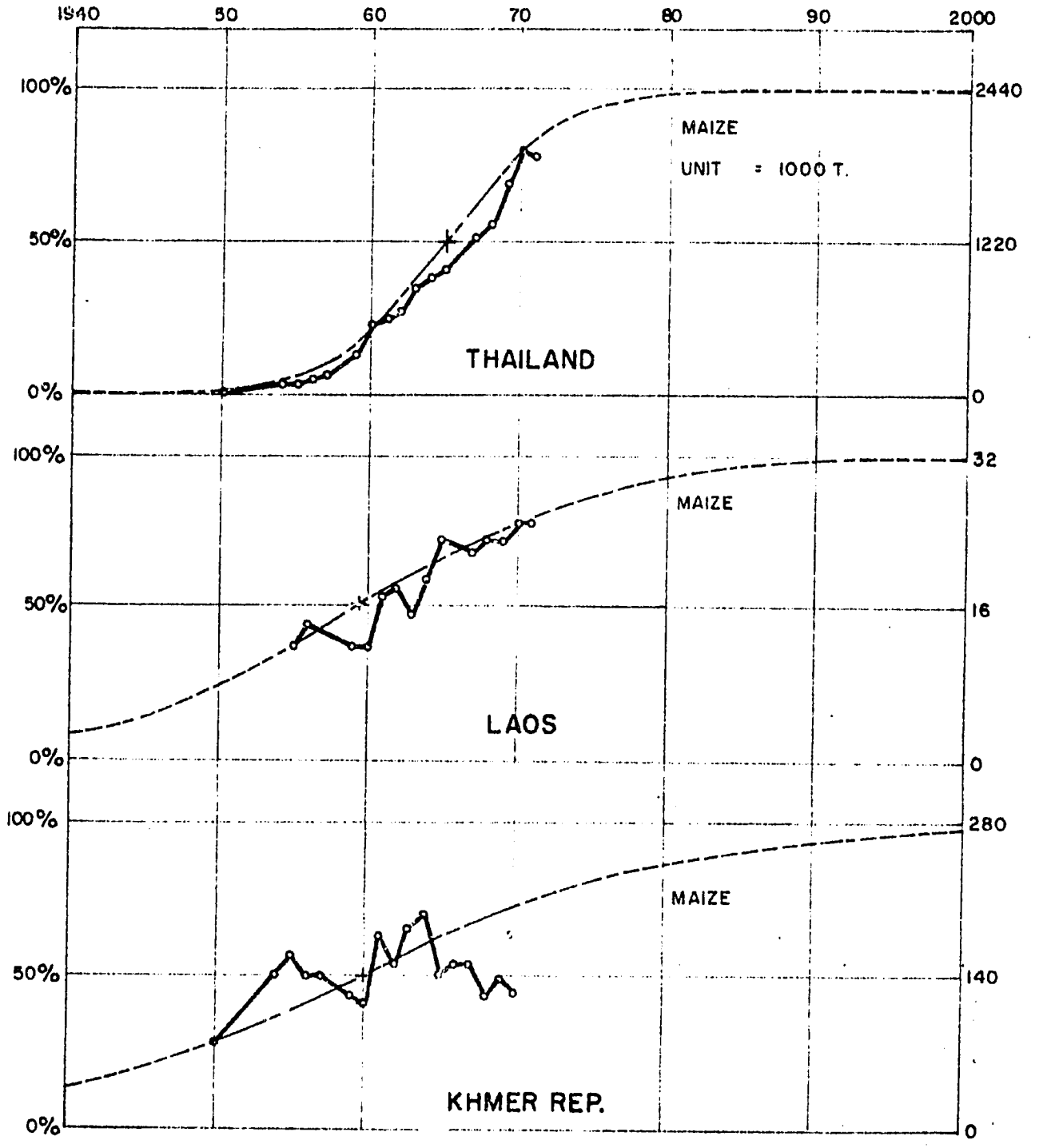
MEKONG COMMITTEE

THE PERSPECTIVE OF AGRICULTURE OF THE LOWER MEKONG BASIN

CASSAVA PRODUCTION 1950 – 1970

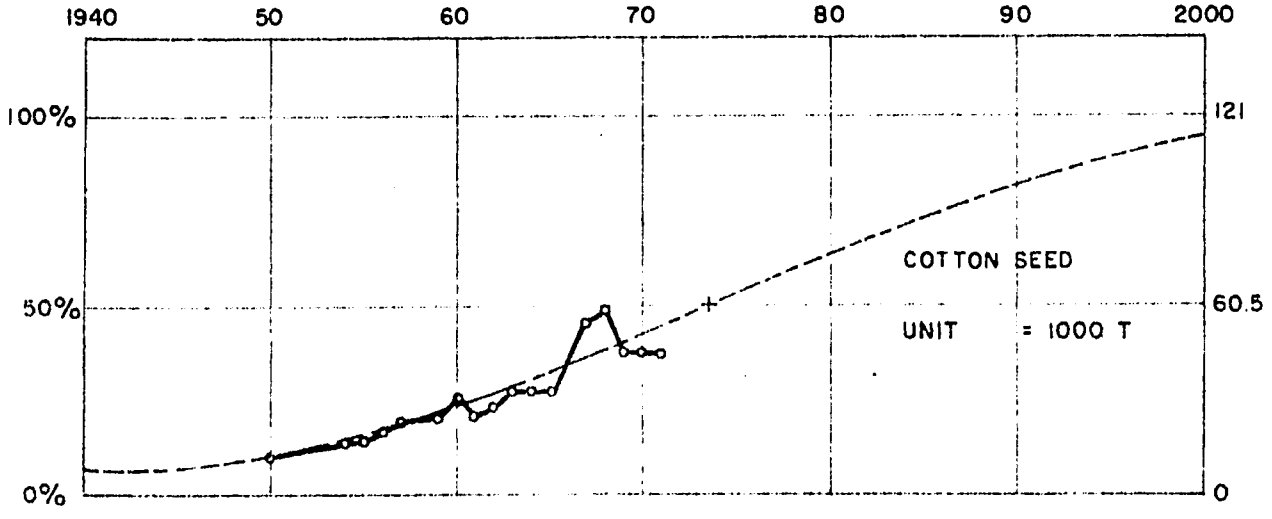
FIG. 1 | DATE July 74

28



SOURCE : PRODUCTION YEARBOOK, FAO

MEKONG COMMITTEE	
THE PERSPECTIVE OF AGRICULTURE OF THE LOWER MEKONG BASIN	
MAIZE PRODUCTION 1950 – 1970	
FIG. 2	DATE July 74



THAILAND

SOURCE: PRODUCTION YEARBOOK, FAO

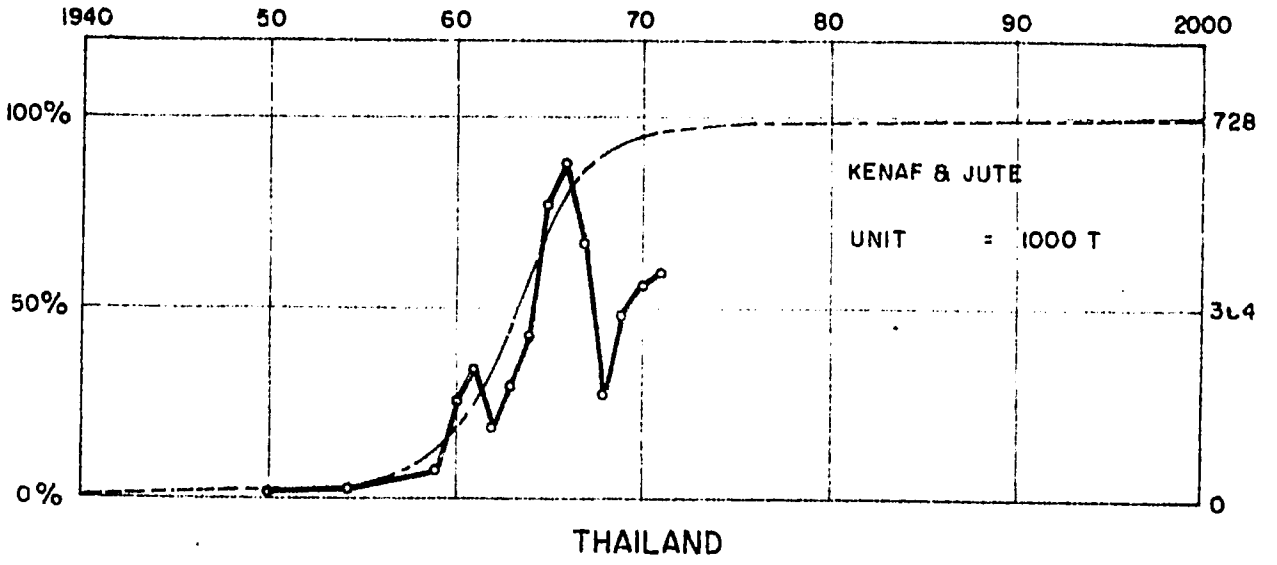
MEKONG COMMITTEE

THE PERSPECTIVE OF AGRICULTURE OF THE LOWER MEKONG BASIN

COTTON SEED PRODUCTION 1950 – 1970

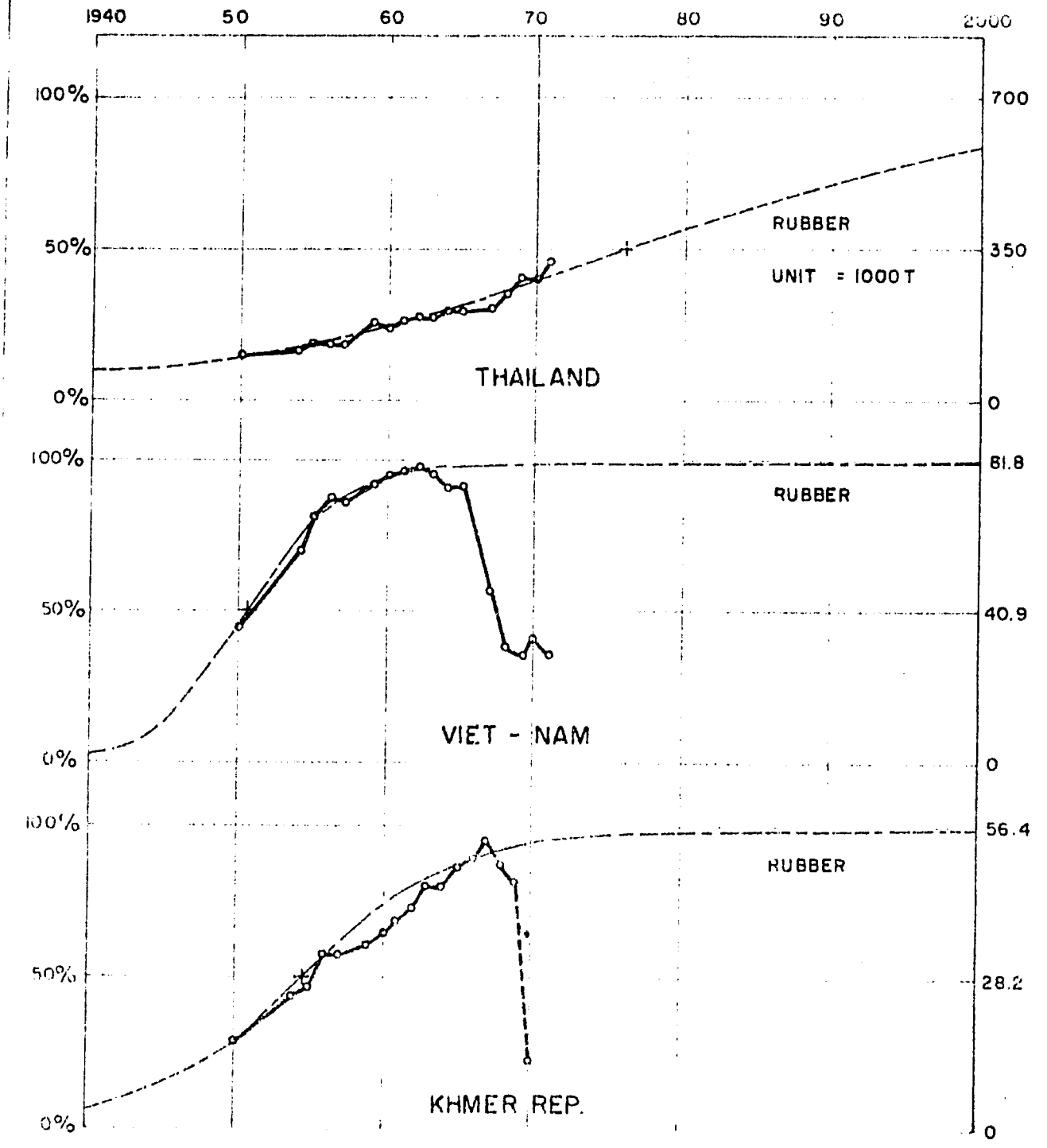
FIG. 3 DATE July 74

30



SOURCE: PRODUCTION YEARBOOK, FAO

MEKONG COMMITTEE	
THE PERSPECTIVE OF AGRICULTURE OF THE LOWER MEKONG BASIN	
KENAF & JUTE PRODUCTION 1950 – 1970	
FIG. 4	DATE July 74



SOURCE: PRODUCTION YEARBOOK, FAO

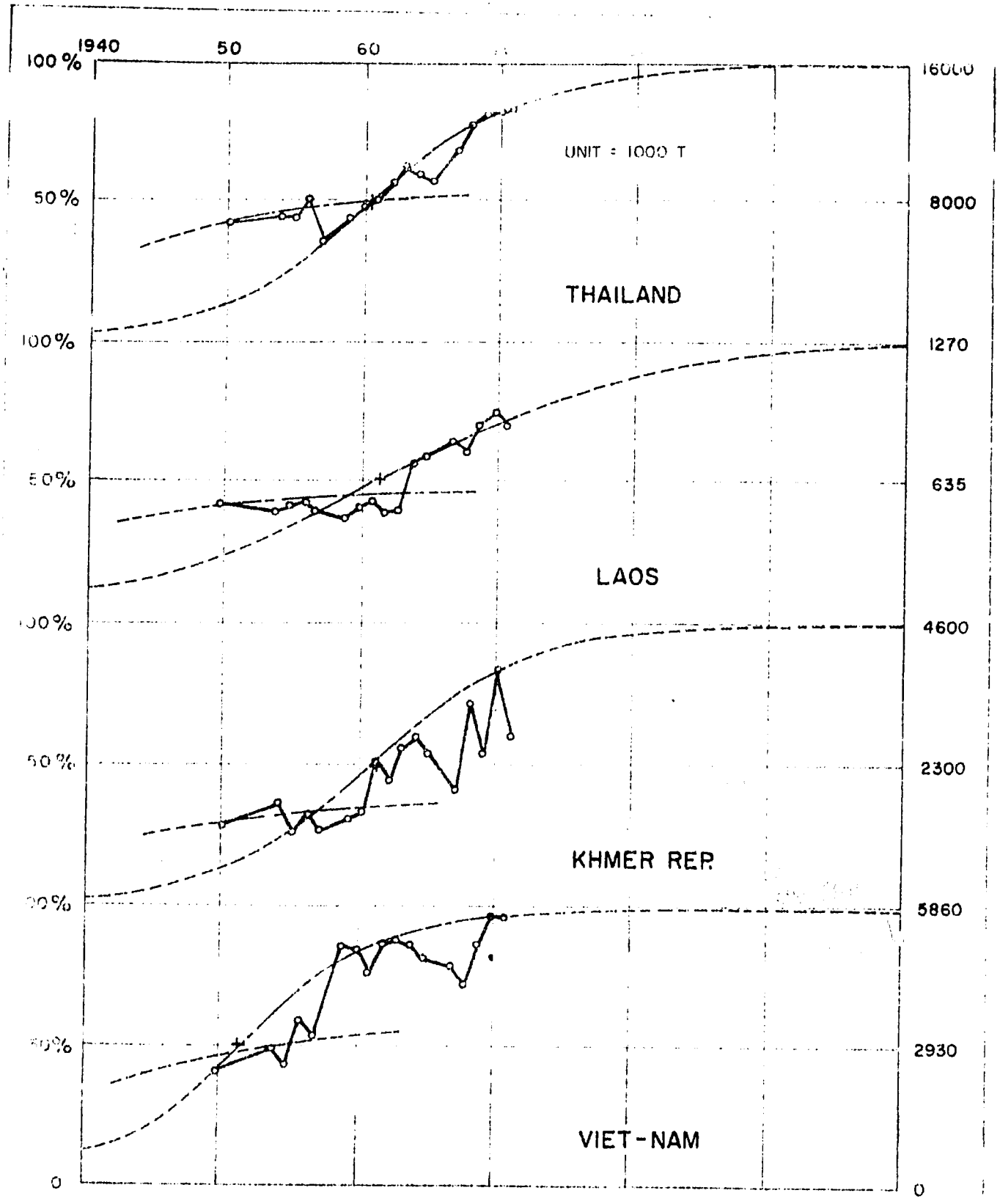
MEKONG COMMITTEE

THE PERSPECTIVE OF AGRICULTURE OF THE LOWER MEKONG BASIN

RUBBER PRODUCTION

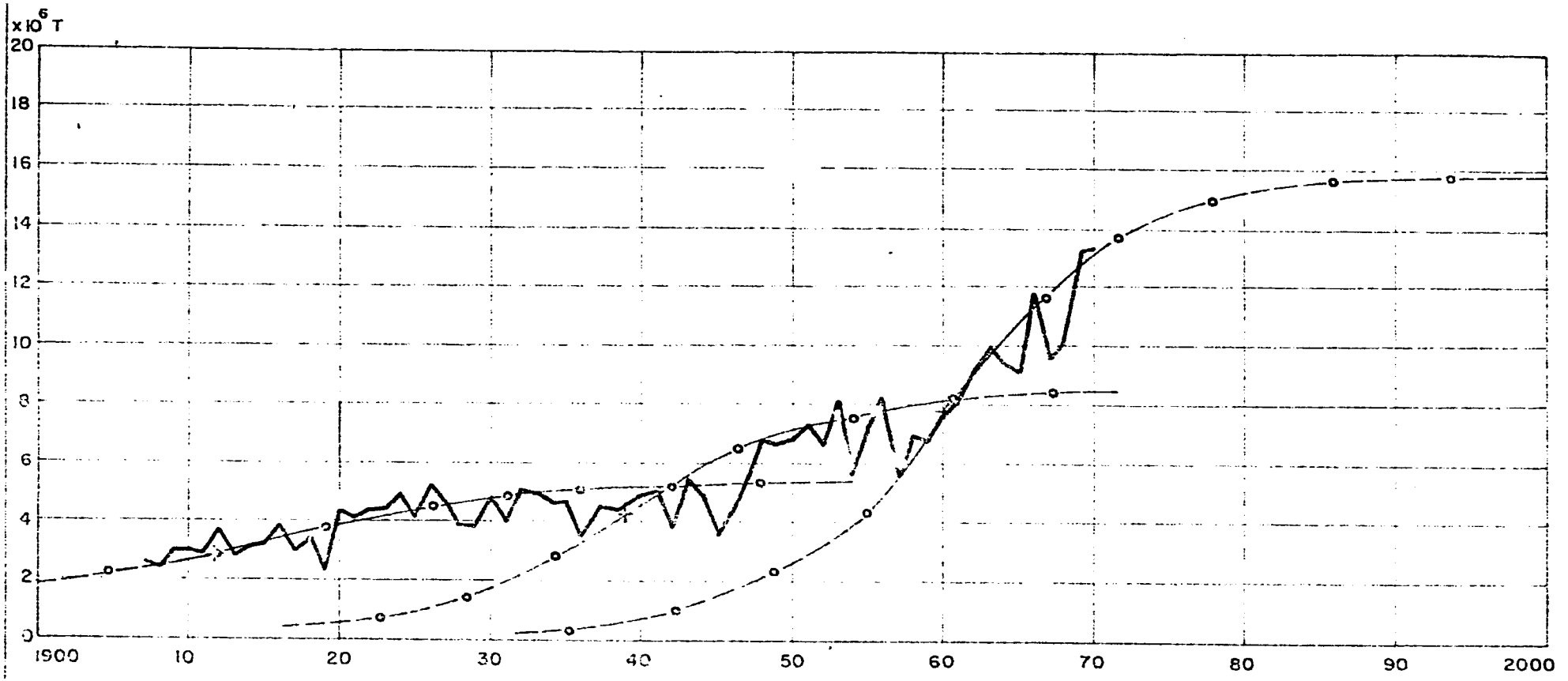
1950 – 1970

FIG. 5 | DATE July 74



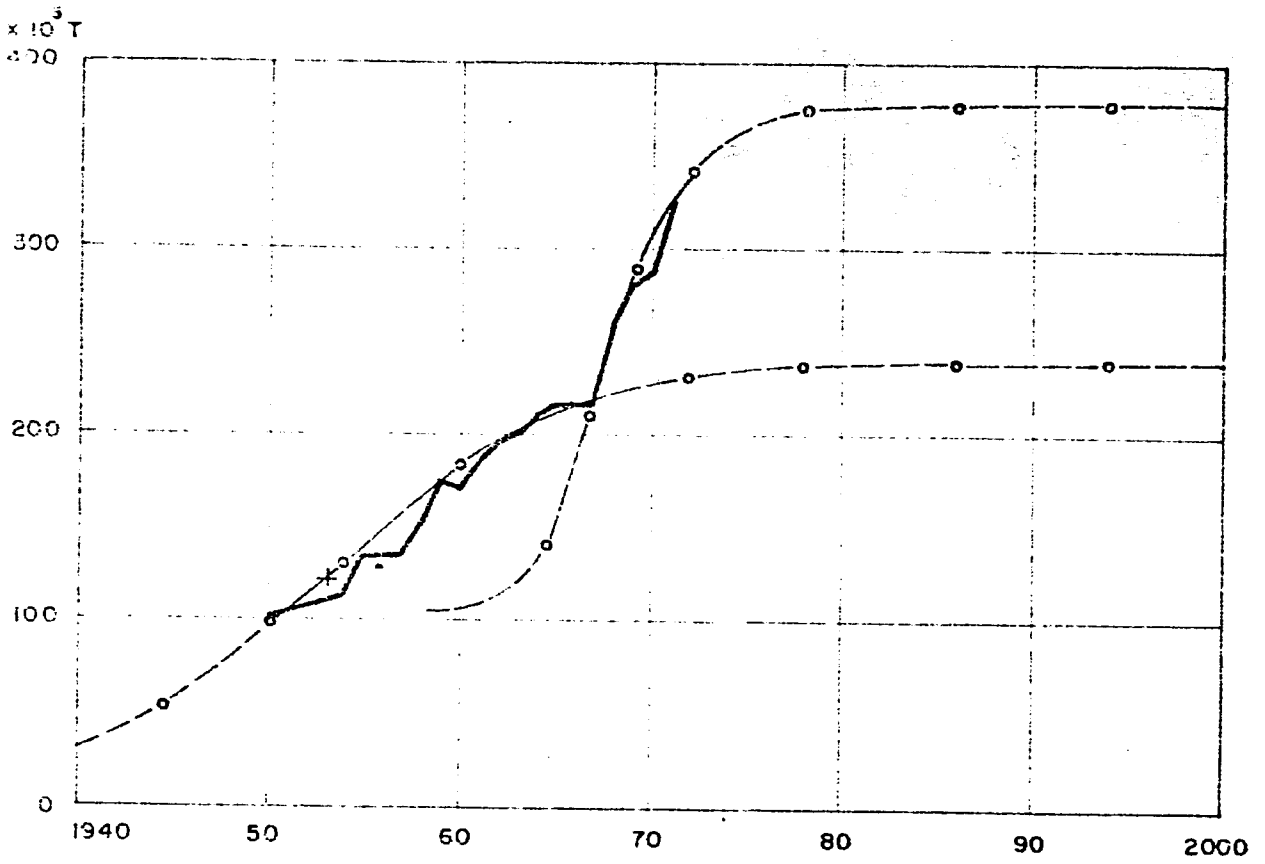
SOURCE : PRODUCTION YEARBOOK, FAO

MEKONG COMMITTEE	
THE PERSPECTIVE OF AGRICULTURE OF THE LOWER MEKONG BASIN	
RICE PRODUCTION 1950 – 1970	
FIG. 6	DATE July 74



Source : Annual reports on rice production in Thailand, Department of Rice, Ministry of Agriculture, Thailand.

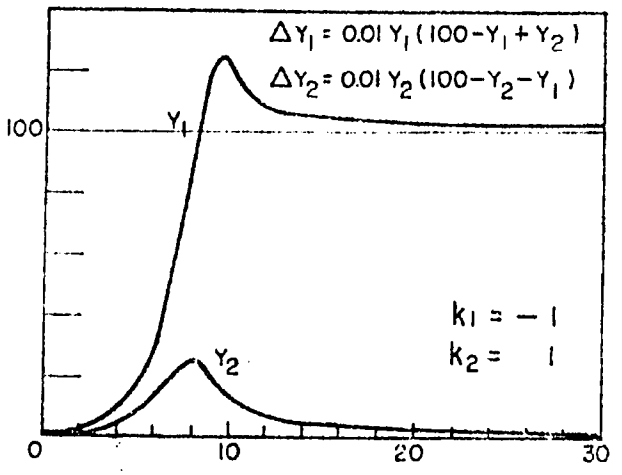
MEKONG COMMITTEE	
THE PERSPECTIVE OF AGRICULTURE OF THE LOWER MEKONG BASIN	
ANALYSE OF RICE PRODUCTION IN THAILAND 1908 – 1970	
FIG. 7	DATE July 74



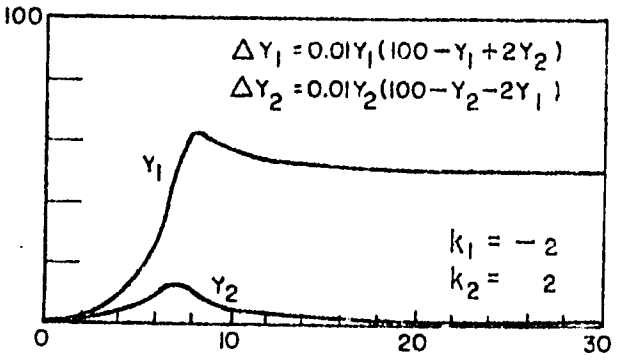
SOURCE: PRODUCTION YEARBOOK, FAO

MEKONG COMMITTEE	
THE PERSPECTIVE OF AGRICULTURE OF THE LOWER MEKONG BASIN	
RUBBER PRODUCTION IN THAILAND 1950 – 1970	
FIG. 8	DATE July 7-

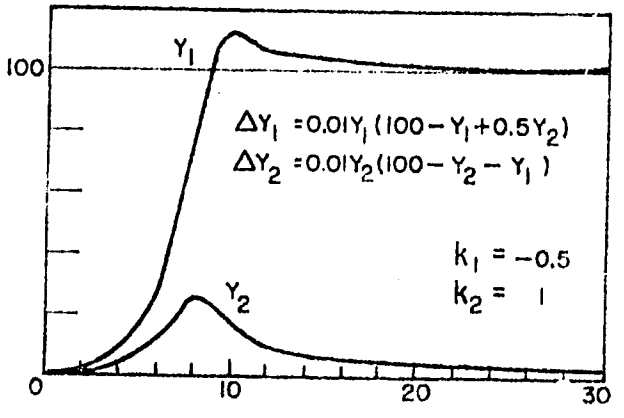
35



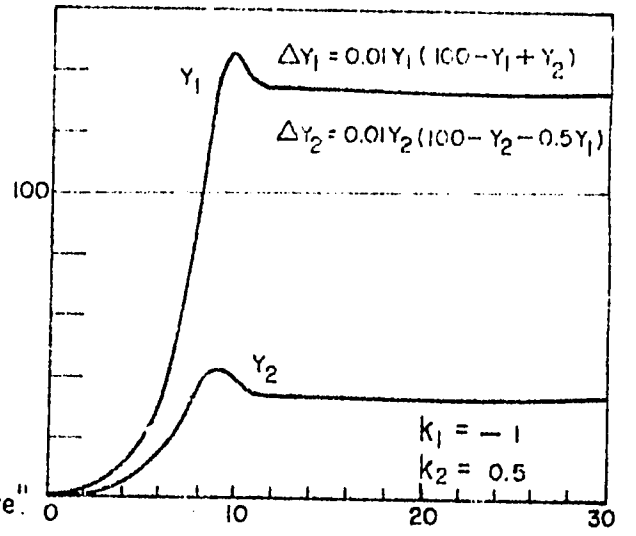
i) Standard case of "traditional tropical agriculture".



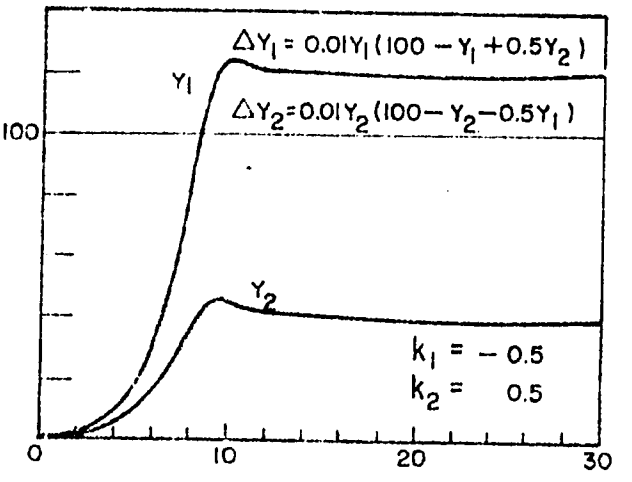
ii) More fertility consuming monoculture than i).



iii) Reduction of k_1 makes no significant change from i).



iv) Reclaimed land is conserved reducing k_2 value with fertilization and appropriate rotation of crops.

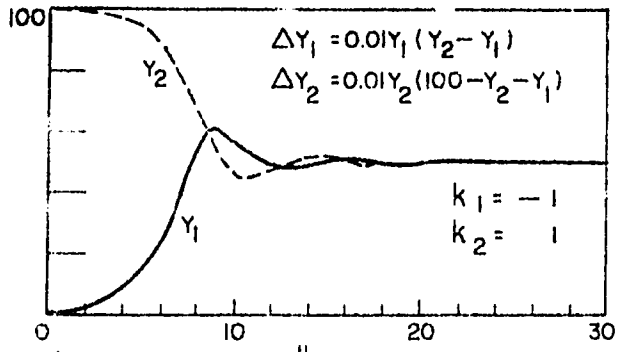


v) Soil conservation (reduction of k_2) results better production Y_1 even in case of reducing k_1. iv) and v) are examples of "sustained yielding tropical agriculture."

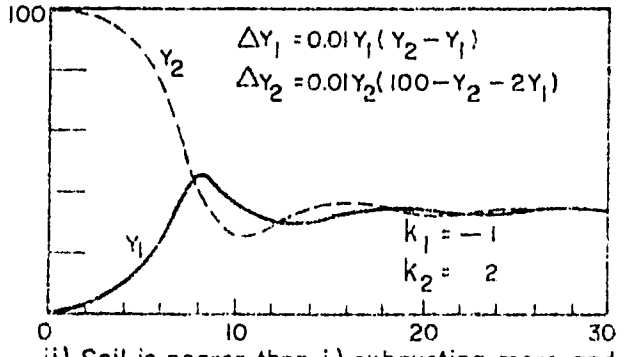
Remark

k_1 : exhaustive rate by Y_2 for Y_1,
k_2 : exhaustive rate by Y_1 for Y_2,
(negative for gain and possitive for loss)
Potential values of Y_1 and Y_2 are 100 when there is no mutual actions. Time scale (horizontal axis) may be corresponded to 10 – 20 years for a unit.

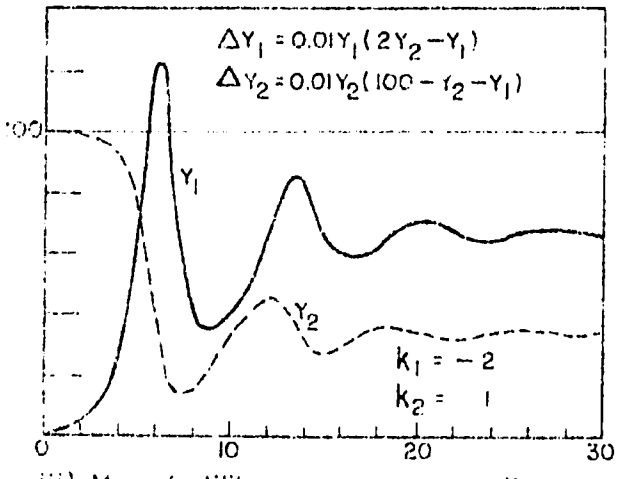
MEKONG COMMITTEE	
THE PERSPECTIVE OF AGRICULTURE OF THE LOWER MEKONG BASIN	
CROP PRODUCTION (Y_1) VS. NEWLY RECLAIMED LAND (Y_2) -- TEST CASE (1) —	
FIG. 9	DATE AUG. 1974



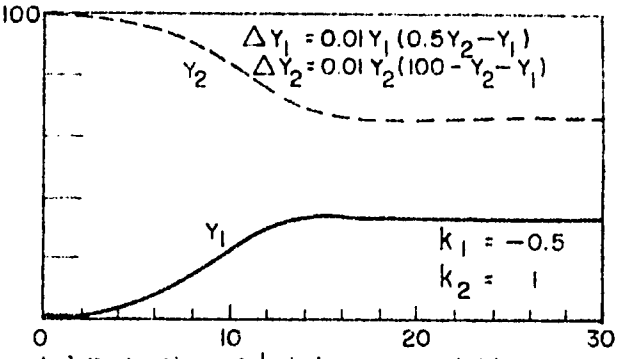
i) Standard case of "traditional tropical agriculture."



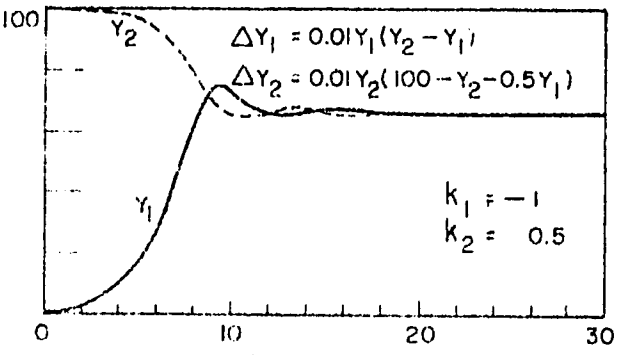
ii) Soil is poorer than i) exhausting more and resulting lower yield.



iii) More fertility consuming monoculture; yield better but big fluctuations.



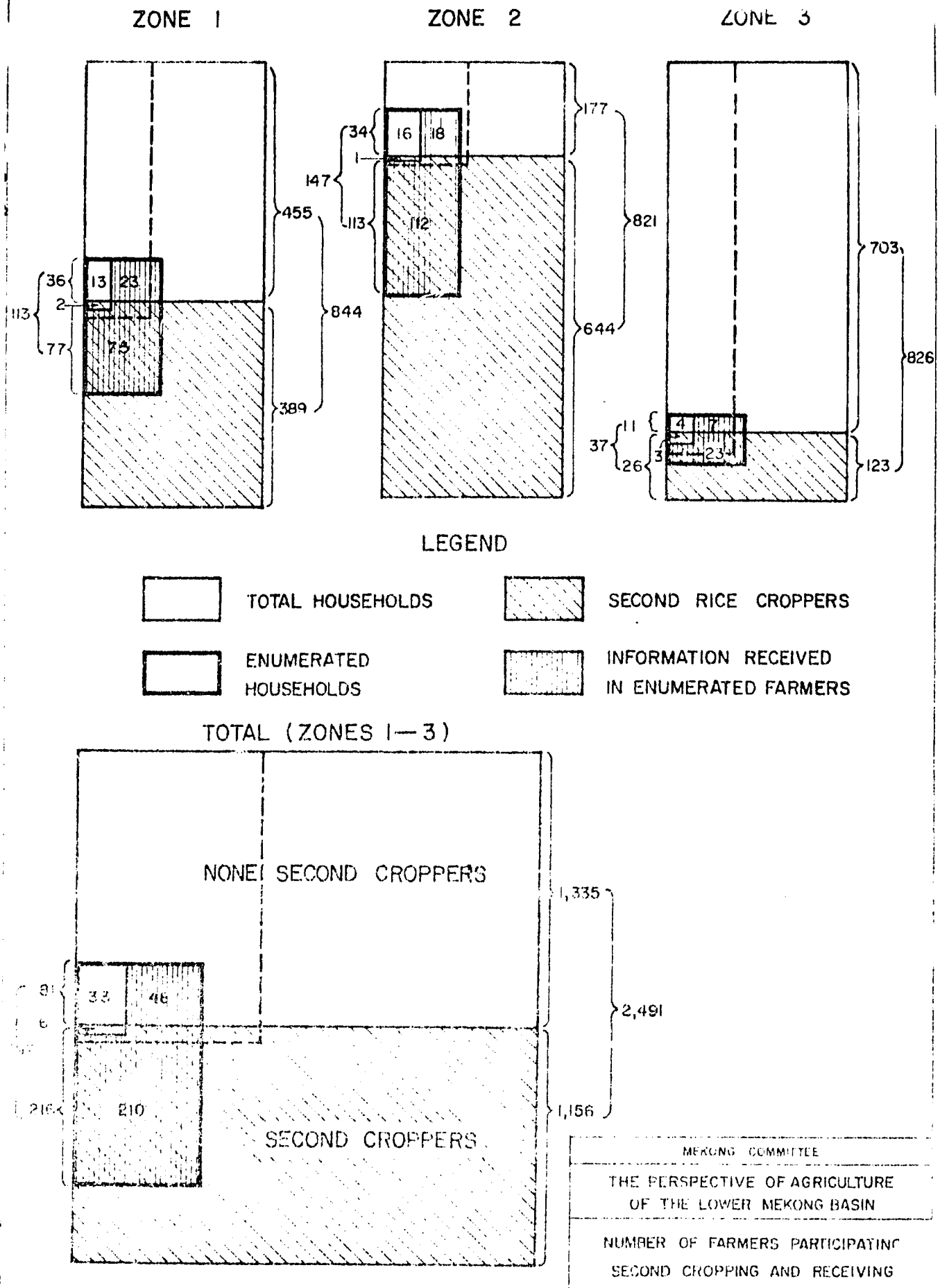
iv) Reduction of k_1 brings poor yield; an extensive agriculture.



v) Reduction of k_2, with fertilization and rational crop rotation, results both better yield and soil conservation; "sustained yielding tropical agriculture."

k_1, k_2, Y_1 and Y_2 potentials : see remark in Fig. 9

MEKONG COMMITTEE	
THE PERSPECTIVE OF AGRICULTURE OF THE LOWER MEKONG BASIN	
CROP YIELD (Y_1) VS. SOIL FERTILITY (Y_2) — TEST CASE (2) —	
FIG. 10	DATE AUG. 1974

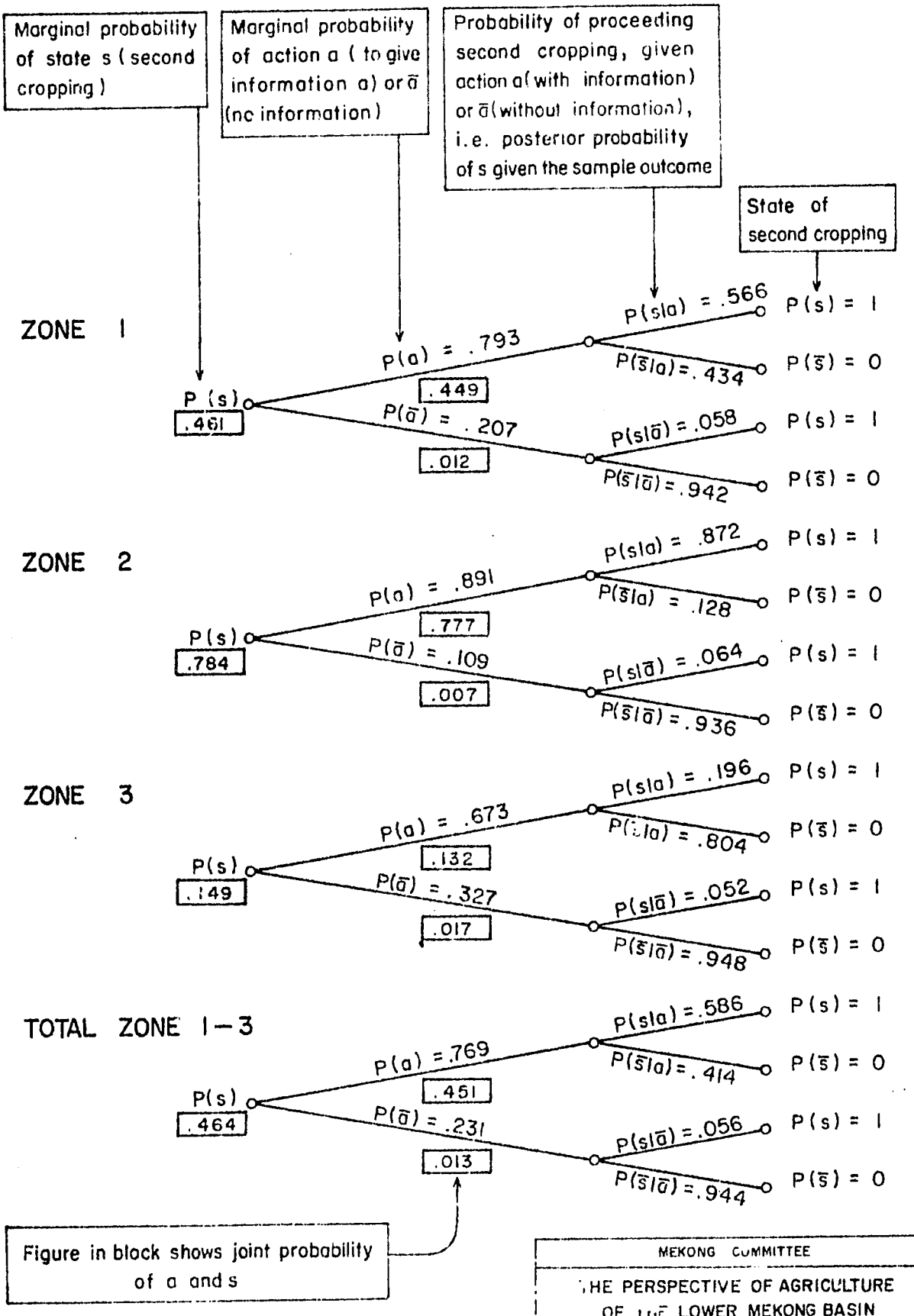


MEKONG COMMITTEE

THE PERSPECTIVE OF AGRICULTURE OF THE LOWER MEKONG BASIN

NUMBER OF FARMERS PARTICIPATING SECOND CROPPING AND RECEIVING INFORMATION, LAM PHRA PHLOENG PROJECT

FIG 11 | DATE JULY 1974

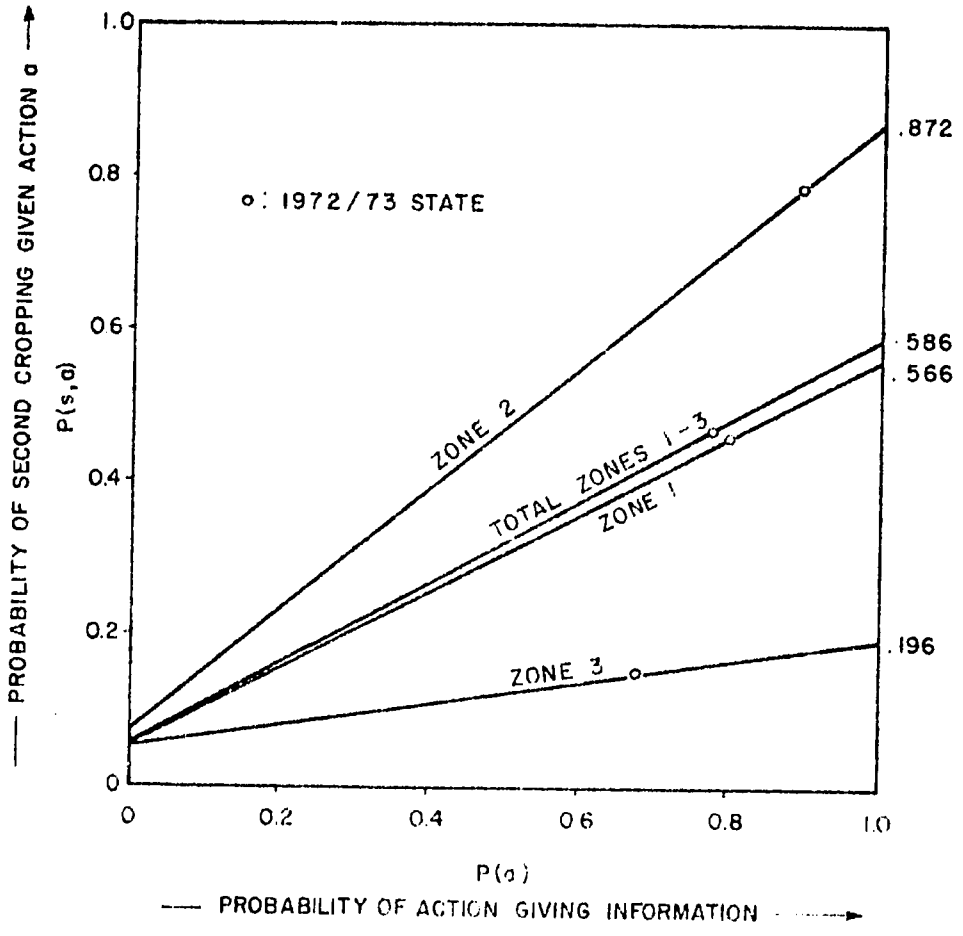


MEKONG COMMITTEE

THE PERSPECTIVE OF AGRICULTURE OF THE LOWER MEKONG BASIN

DECISION TREE OF SECOND CROPPING IN LAM PHRA PHLOENG IRRIGATION PROJECT

FIG. 12 | DATE JULY 1974

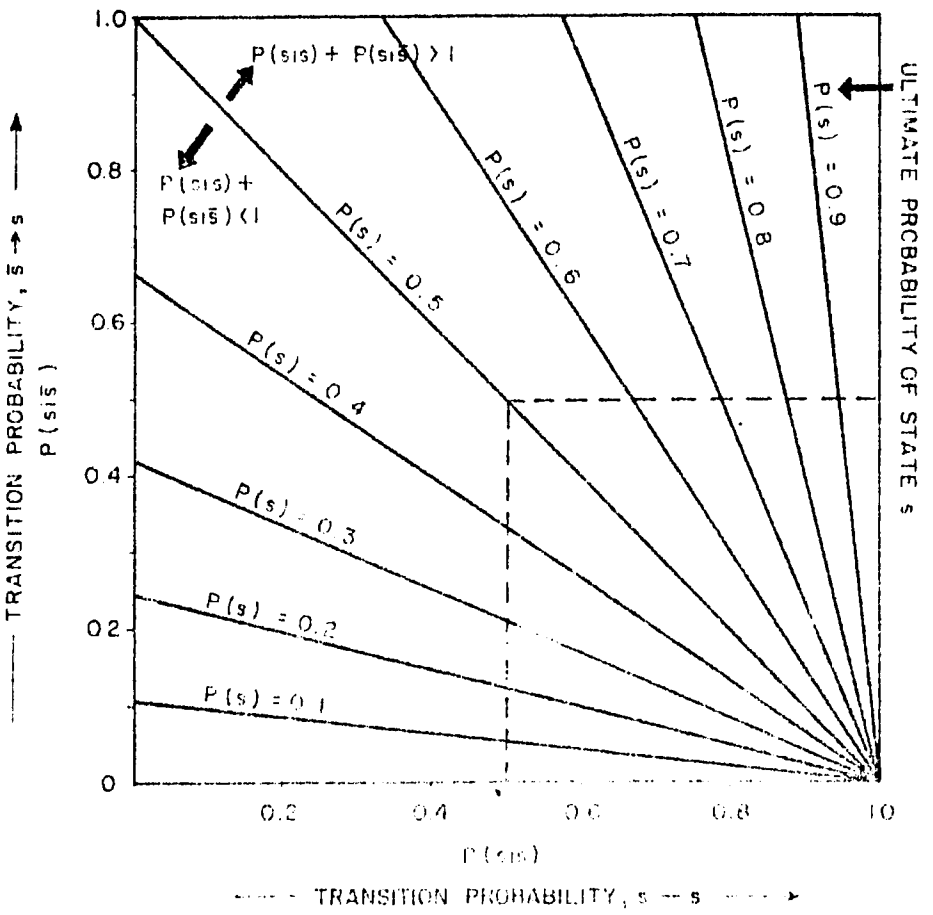


MEKONG COMMITTEE

THE PERSPECTIVE OF AGRICULTURE OF THE LOWER MEKONG BASIN

RELATION OF STATE BETWEEN GIVEN INFORMATION AND SECOND CROPPING

FIG 13 | DATE July 74



MEKONG COMMITTEE

THE PERSPECTIVE OF AGRICULTURE
OF THE LOWER MEKONG BASIN

SECOND CROPPING PROBABILITY
AS SIMPLE MARKOV PROCESS

FIG 14 | DATE July 74

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