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HYDROLOGY

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TYPE II. QUARTERLY REPORT

I. INTRODUCTION

The main objectives of the Mekong Committee investigations using Landsat data are as follows:

A. Short-term objectives

By both photo-interpretation and automatic data processing techniques, supported by ground truth data and field surveys, establish:

- Land use, land capability and hydrogeomorphology maps of the lower Mekong basin;
- Maps showing primary forests and deciduous forest areas;
- Maps showing consecutive flood and drainage patterns of Mekong lowlands.

b. Long-term objectives

Organise a research programme for classification of agricultural crops and land use, and for soil moisture monitoring. The test area of the lower Mekong basin covers the whole Laos and Cambodia, the North and Northeast Thailand, and the Mekong delta and the high lands of South Viet-Nam. The whole test area is about 600,000 sqkm.

II. TECHNIQUES

1. Data quality and delivery

The data received during the period under review is attached in Annex I. The quality of the imagery from LANDSAT II has improved very considerably in comparison with LANDSAT I; moreover certain gaps in the LANDSAT I data of cloudy areas, especially in the Annamite mountain chain, are being filled now.

2. Preparation of land use map

This map, covering the entire basin, was completed during the period under review, a descriptive note to the map is attached hereto (Annex II). A copy of the map itself will accompany the next report to NASA.

As an initial step towards land systems mapping, a map showing the major physiographical divisions of the lower Mekong basin was completed in draft form. The legend of the map is attached as Annex III.

3. Research programme for computer processing of remote sensing data

Study of background information in both the development of computer programs for feature classification and the application of the programs or the analysis of the information recorded in the tapes obtained from LANDSAT-2 satellite and others are being done. Study of computer program packages developed elsewhere is being made for possible installation at the Asian Institute of Technology (AIT). Now that AIT will enjoy an access to large computer like the IBM 370/145 it is planned to install the LARSYS package developed by Purdue University as well as the RECOG package developed by Colorado State University with initial emphasis will be given to LARSYS. The packages will be modified to suit the regional use. Important features will be maintained and additional features which reflect the regional characteristics will be added. It is also planned to install other packages if time and fund are available.

III. ACCOMPLISHMENTS DURING THE PERIOD UNDER REVIEW

1. Preparation of land use map

a. Field work

Field control was carried out in January in Northeast Thailand in collaboration with the Royal Forest Department of Thailand. The main purpose of this final control was to ascertain the correct descriptions of the vegetation units shown on the land use map.

b. Hydro-geophology

The maximum extent of flooding during different periods of the year was mapped for the entire Mekong basin. The validity of this document is rather limited since it comprises both natural flooding as well as areas flooded artificially on banded paddy fields.

c. Land capability

A beginning was mapped in modifying the existing soil map of the lower Mekong basin with the help of imagery of both LANDSAT-I and LANDSAT-II. This approach is promising and is expected to result in a considerably better soil map, in particular for the level areas of the Mekong delta and the Korat Plateau in Northeast Thailand.

d. Future work

The agro-pedological map is expected to be completed by the end of July.

Work has been started on identifying structural alignments in both the plains and mountainous areas of the basin. LANDSAT-II imagery is showing important new information by which major physiographic units in the lowlands can be explained. The work is continuing.

2. Research programme for computer processing of remote sensing data.

Two sites are selected for the ground truth observation:

i. Site No. 1: Along Paholyothin Highway (km 29 - km 65)

This site is selected for possible maximum coverage on the ground during the satellite passes. It is aimed at the collection of general terrain conditions including rice-field, orchard, grass, watershed, etc., and general land use conditions.

ii. Site No. 2: Intensive area.

A site of approximately 800 x 600 meters near AIT is selected for intensive observations on the growth of crops (rice) and ground conditions.

As soon as site survey and mapping have been completed, ground truth observations on both sites are carried out in accordance with the schedule of the passes of LANDSAT-2 satellite. Observation and data collection are planned to be made as close as possible to the schedule except when weather condition does not permit.

Observation and data collection are carried out by two separate teams, one along the highway and other at the intensive area. Observation along the highway is made by a team of 2-3 persons on a car running along the road and conditions along one side of the road are observed and recorded. Photographs are also taken during the observation. Ground truth observation at the intensive area is carried out by 3 groups of observers who go down to the field and take measurement of the plant and ground conditions. General environmental and atmospheric conditions, e.g. temperature, humidity, evaporation, wind speed, rainfall are also recorded.

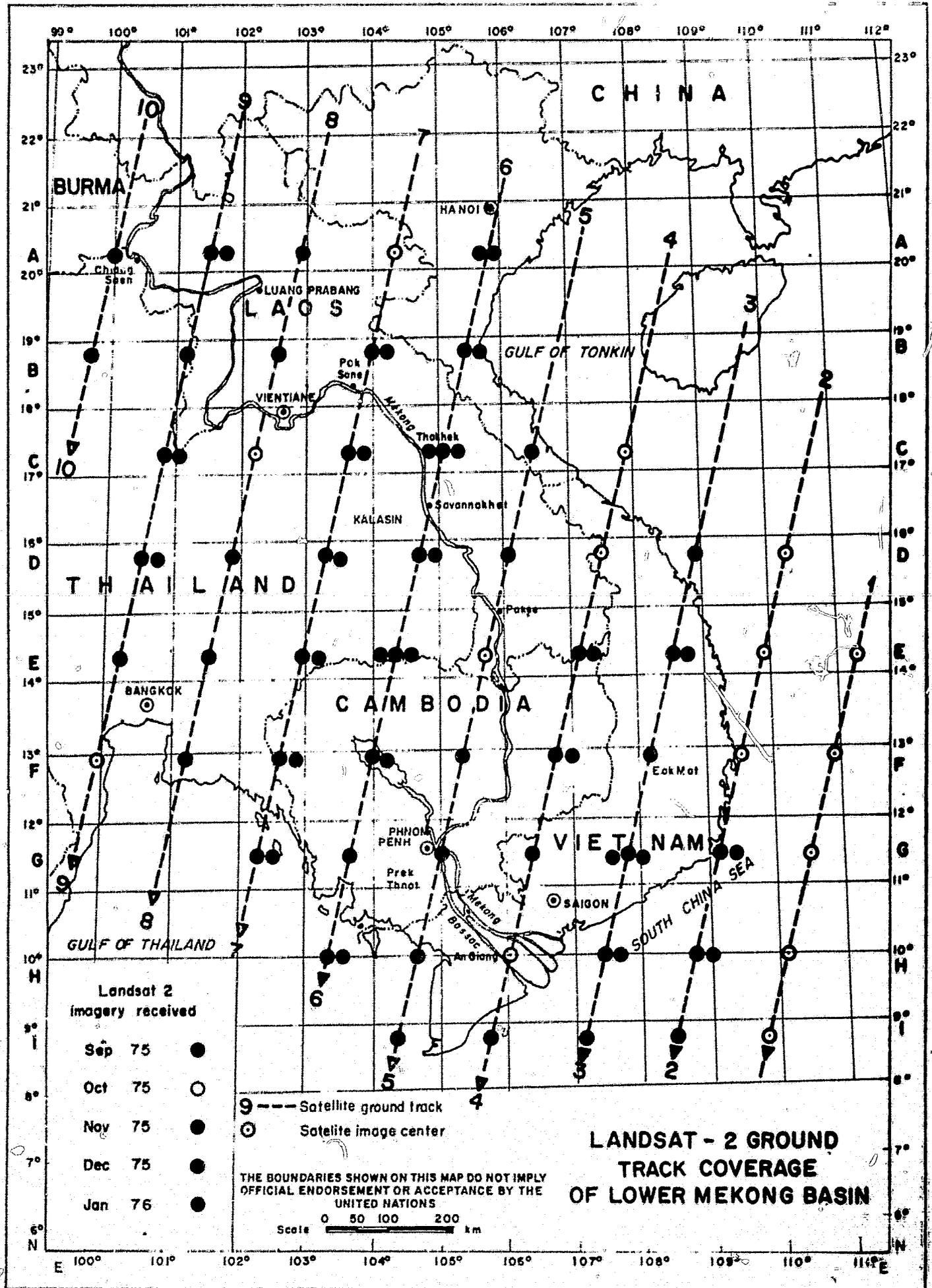
It is planned to edit and process the ground truth data by a computer and establish computer files for the processed data

for applications. To prepare for the processing, the data were edited through the use of the IBM 1130 computer system for the time being and the edited data will be transferred to the new IBM 370/145 system for processing and retrieval as soon as it is in operation.

IV. CONCLUSION

It is to be expected that the general mapping programme of the lower Mekong basin will be completed by July 1976. In further future special studies will be undertaken on LANDSAT data related to specific projects included in the programme of the Mekong. LANDSAT-2 data will be particularly valuable for these special studies because of their high quality.

5a



ANNEX I

LIST OF THE FRAMES RECEIVED

(dated from September 1975 to January 1976)

#	I D number	Cover the Mekong basin	Outside the basin	Date acquired (month, day, year)	Remarks (localization)
1	2248-02250	x		09/27/75	
2	2264-02135		x	10/13/75	
3	2290-02581	x		11/08/75	
4	2301-02200	x		11/19/75	
5	2301-02193	x		11/19/75	
6	2303-02303	x		11/21/75	
7	2303-02301	x		11/21/75	
8	2308-02573	x		11/26/75	
9	2308-02570	x		11/26/75	
10	2303-02310	x		11/21/75	
11	2304-02373	x		11/22/75	
12	2304-02371	x		11/22/75	
13	2304-02364	x		11/22/75	
14	2304-02362	x		11/22/75	
15	2304-02353	x		11/22/75	
16	2321-02313	x		12/09/75	
17	2320-02255	x		12/08/75	
18	2320-02253	x		12/08/75	
19	2320-02250	x		12/08/75	
20	2320-02241	x		12/08/75	
21	2320-02235	x		12/08/75	
22	2333-03375		x	12/21/75	Bay of Bengal
23	2333-03375		x	12/21/75	Bay of Bengal
24	2333-03370		x	12/21/75	Bay of Bengal
25	2334-03440		x	12/22/75	Bay of Bengal
26	2332-03323		x	12/20/75	Bay of Bengal
27	2326-02581	x		12/14/75	
28	2334-03433		x	12/22/75	Bay of Bengal
29	2332-03320		x	12/20/75	Bay of Bengal
30	2334-03431		x	12/22/75	Bay of Bengal
31	2332-03314		x	12/20/75	Bay of Bengal
32	2326-04401		x	12/14/75	India
33	2334-03424		x	12/22/75	Bay of Bengal
34	2332-03311		x	12/20/75	Burma
35	2336-07211		x	12/24/75	Sudan

#	I D number	Cover the Mekong basin	Outside the basin	Date acquired (month, day, year)	Remarks (localization)
36	2336-07204		x	12/24/75	Sudan
37	2323-02410	x		12/11/75	
38	2323-02403	x		12/11/75	
39	2341-02414	x		12/29/75	
40	2341-02411	x		12/29/75	
41	2341-02405	x		12/29/75	
42	2341-02402	x		12/29/75	
43	2341-02400	x		12/29/75	
44	2341-02393	x		12/29/75	
45	2365-03150		x	01/22/76	Burma
46	2365-03143		x	01/22/76	Burma
47	2351-07035		x	01/08/76	Red Sea
48	2365-03141		x	01/22/76	Burma
49	2352-08522		x	01/09/76	Niger
50	2351-07032		x	01/08/76	Sudan
51	2365-03134		x	01/22/76	Burma
52	2357-02300	x		01/14/76	
53	2357-02294	x		01/14/76	
54	2357-07381		x	01/14/76	Sudan
55	2357-07374		x	01/14/76	Sudan
56	2359-02422	x		01/16/76	
57	2360-02474	x		01/17/76	
58	2359-02415	x		01/16/76	
59	2360-02471	x		01/17/76	
60	2359-02413	x		01/16/76	
61	2362-02581	x		01/19/76	
62	2360-02465	x		01/17/76	
63	2359-02410	x		01/16/76	
64	2362-02575	x		01/19/76	
65	2360-02462	x		01/17/76	
66	2359-02404	x		01/16/76	
67	2363-04462		x	01/20/76	India
68	2362-04404		x	01/19/76	India
69	2360-04291		x	01/17/76	India
70	2359-04233		x	01/16/76	India
71	2362-02572	x		01/19/76	
72	2360-02460	x		01/17/76	
73	2359-02401	x		01/16/76	
74	2363-04460		x	01/20/76	India
75	2362-04401		x	01/19/76	India
76	2360-04285		x	01/17/76	India
77	2363-03024	x		01/20/76	
78	2360-02453	x		01/17/76	
79	2359-02395	x		01/16/76	
80	2363-04453		x	01/20/76	India
81	2344-04400		x	01/01/76	India
82	2362-04395		x	01/19/76	India
83	2359-04224		x	01/16/76	India
84	2363-03022	x		01/20/76	
85	2362-02563	x		01/19/76	

#	I D number	Cover the Mekong basin	Outside the basin	Date acquired (month, day, year)	Remarks (localization)
86	2359-02392	x		01/16/76	
87	2365-08235		x	01/22/76	Chad
88	2365-08235		x	01/20/76	Chad
89	2365-08233		x	01/22/76	Chad
90	2363-08120		x	01/20/76	Chad
91	2369-03364		x	01/26/76	Bay of Bengal
92	2367-03262		x	01/24/76	Bay of Bengal
93	2364-03092		x	01/21/76	Burma
94	2361-04350		x	01/18/76	India
95	2367-03260		x	01/24/76	India
96	2364-03085		x	01/21/76	Burma
97	2367-06521		x	01/24/76	Saudi Arabia
98	2361-04343		x	01/18/76	India
99	2364-03083		x	01/21/76	Burma
100	2367-06514		x	01/24/76	Saudi Arabia
101	2364-04512		x	01/21/76	India
102	2361-04341		x	01/18/76	India
103	2364-03080		x	01/21/76	Burma
104	2305-02425	x		11/23/75	
105	2305-02413	x		11/23/75	
106	2306-02481	x		11/24/75	
107	2306-02474	x		11/24/75	
108	2306-02472	x		11/24/75	
109	2306-02465	x		11/24/75	
110	2306-02463	x		11/24/75	
111	2306-02460	x		11/24/75	
112	2330-08300		x	12/18/75	Chad
113	2330-08293		x	12/18/75	Chad
114	2347-06405		x	01/04/76	Saudi Arabia
115	2347-06403		x	01/04/76	Saudi Arabia
116	2361-02525	x		01/18/76	
117	2361-02523	x		01/18/76	
118	2347-03151		x	01/04/76	Burma
119	2361-02520	x		01/18/76	
120	2347-03144		x	01/04/76	Burma
121	2358-02343	x		01/15/76	
122	2358-04172		x	01/15/76	India
123	2347-03142		x	01/04/76	Burma
124	2361-02511	x		01/18/76	
125	2358-04165		x	01/15/76	India
126	2347-03135		x	01/04/76	Burma
127	2361-02505	x		01/18/76	
128	2356-02244	x		01/13/76	
129	2366-08291		x	01/23/76	Chad
130	2370-03433		x	01/27/76	Bay of Bengal
131	2369-03375		x	01/26/76	Bay of Bengal
132	2370-03431		x	01/27/76	Bay of Bengal
133	2369-03373		x	01/26/76	Bay of Bengal
134	2370-03424		x	01/27/76	Bay of Bengal
135	2369-08462		x	01/26/76	Ethiopia

#	I D number	Cover the Mekong basin	Outside the basin	Date acquired (month, day, year)	Remarks (localization)
136	2368-08404		x	01/25/76	Chad
137	2367-08350		x	01/24/76	Chad
138	2370-03422		x	01/27/76	Bay of Bengal
139	2374-02251	x		01/31/76	
140	2374-02245	x		01/31/76	
141	2374-02242	x		01/31/76	
142	2372-09033		x	01/29/76	Niger
143	2373-02191	x		01/30/76	
144	2373-02184	x		01/30/76	
145	2374-07321		x	01/31/76	Sudan
146	2374-07314		x	01/31/76	Sudan
147	2374-04051		x	01/31/76	India
148	2345-08124		x	01/02/76	Chad
149	2348-06464		x	01/05/76	Saudi Arabia
150	2353-03484		x	01/10/76	Bay of Bengal
151	2351-08464		x	01/08/76	Niger
152	2352-07090		x	01/09/76	Red Sea
153	2348-06461		x	01/05/76	Saudi Arabia
154	2353-03482		x	01/10/76	Bay of Bengal
155	2327-04455		x	12/15/75	India
156	2331-03264		x	12/19/75	Bay of Bengal
157	2330-06464		x	12/18/75	Saudi Arabia
158	2337-07262		x	12/25/75	Sudan
159	2330-06462		x	12/18/75	Saudi Arabia
160	2356-07322		x	01/13/76	Sudan
161	2346-06351		x	01/03/76	Saudi Arabia
162	2354-03543		x	01/11/76	Bay of Bengal
163	2346-03084		x	01/03/76	Thailand
164	2356-07320		x	01/13/76	Sudan
165	2354-03540		x	01/11/76	India
166	2346-03081		x	01/03/76	Burma

Total :

71

95

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ANNEX II

NOTE ON THE LAND USE MAP OF THE
LOWER MEKONG BASIN

I. INTRODUCTION

Starting from an interpretation of data given by the Earth Resources Technology Satellite (ERTS 1), we endeavoured to show on a map the actual condition (1972-1973) of the land use pattern in the lower Mekong basin.

The areas thus studied cover the whole of the territory of Cambodia (except for the Southwest regions), the whole of Laos (except for its northern zone for which no satellite information is available), the north-eastern and northern provinces of Thailand, the Mekong Delta region and the Viet-Nam upland region (Ban Me Thuot, Pleiku, Kontum).

The lower Mekong basin extends over an area of some 600,000 square kilometres.

II. APPROACH

1. The land use map of the lower Mekong basin has essentially been established by interpretation of shades given by channel 5 of the ERTS 1 satellite. It gives the best gradations and contrasts for the study of the vegetational cover. Channel 7 has additionally been used to plot vegetation units in humid areas.

The operation is based on the interpretation of 1:500,000 photographic enlargements of bands 5 and 7 images and the use of positive 1:1,000,000 transparencies and corresponding composite colour transparencies. Colour images used are obtained by superimposition of colour transparencies of 1:1,000,000 positive transparencies of bands 4.5 and 7 (4: yellow; 5: magenta; 7: cyan).

As far as land is concerned, the best results are given by interpretation of ERTS images corresponding to the months of January and February. It is in February, when the percentage of leafless trees and shrubs is the highest, that the best contrasts appear

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between sempervirens and caducifoliae. It is during this period of the dry season that the cloud and the smog cover is the lightest.

2. Interpretation of ERTS images

The characteristic of chlorophyll being a very high absorption at 0.64 μ , shades appearing on band 5 satellite images (0.6 to 0.7 μ) correspond essentially to the density and the nature of the vegetational cover. Vegetation patterns are therefore mapped on the basis of a density criterion.

The periodicity of available images makes it possible to study how the vegetational cover evolves from one season to the other.

Being especially useful for the determination of humid soil areas, band 7 has been used to differentiate vegetational group usually associated with hydromorphic soils.

Vegetation units are essentially classified according to their aspect. Their description has been made on the basis of existing documents and aerial photographs and of a few ground truth observations.

Since these observations were not always possible, we very often referred to aerial photographs made available by the national departments concerned in the four riparian countries. In spite of their age (most of them were taken in 1954 and 1960), it was, as a whole, possible to update them with a good precision by comparing them with band 5 photograph enlargements and composite colour transparencies. This approach enabled us to identify data given by ERTS 1 and to check previous results. Aerial photographs have moreover been used to delimit vegetational units of areas for which only bad quality images were available. The updating in this case lacks precision. This is, in particular, true for the Province of Loei and for the areas located west of the Mekong between Luang Prabang and Paklay.

In some areas the absence of any documentation and the impossibility of carrying out ground truth observations made it difficult

to describe vegetational formations. Thus the validity of mapping units corresponding to the northwestern region of Laos and to the region located to the northeast of Thakhek, is uncertain.

3. Reference documents

To describe the vegetational units, we relied upon the fundamental research work of J. Vidal (La végétation du Laos, 1960), M. Schmid (Végétation du Viêt-Nam, 1974), P. Legris and F. Blasco (Notice de la carte du tapis végétal du Cambodge, 1972).

Results of our interpretations were plotted on a 1:500,000 topographic base map prepared on the basis of the US Air Force 1:500,000 TPC maps. These maps were generalized and corrected.

III. DESCRIPTION OF VEGETATION UNITS

1. Dense and mainly evergreen forests, practically undegraded

This unit corresponds to the darkest shades given by band 5 and which do not correspond to dense and evergreen vegetational formations associated to hydromorphic areas. These shades appear without great variations on all photographs taken, whatever the season.

This type of forest is so dense that crowns touch and form a continuous canopy above the ground.

It is composed of leafy trees constituting fully evergreen stands (dense evergreen forest) or partially or temporarily deciduous stands (semi-deciduous dense forest).

In the latter case, Vidal notes that in spite of a possibly high percentage of deciduous trees (it can reach 41%), the forest as a whole always retains an evergreen characteristic since on the

one hand the period when trees are without leaves is short and, on the other, species shed their leaves at different periods in the course of the dry season.

Slight variations in gray tones may be caused by either a different floristic composition, or a lower natural density of the vegetational cover, or a beginning of forest degradation. These variations cover too limited areas and have too uncertain borders to be represented. In the same manner, differences in illumination conditions, due in particular to topography, bring about variations in the shades given by satellite pictures.

2. Mainly evergreen forests, degraded

This unit has been established to show evergreen forests that have been degraded by cuttings or by recent or old clearings.

Degradation may be more or less serious. In some cases, woodland predominates over crops or on the contrary crops predominate over tree formations. Depending upon the crop system in use and its intensity, variegated secondary formations (grasses, bushes, bamboos, shrubs and secondary tree formations) occupy more or less extensive areas. Their density depends upon their stage of development. The presence of evergreen species and the gradation in the defoliation of deciduous species give these secondary formations an evergreen aspect which is more evident during the rainy season.

It is therefore not always easy to distinguish on satellite pictures undegraded dense and evergreen forests from this substituted vegetation unit which moreover always appears under similar ecological conditions. The distinction is all the more difficult when the degradation is less accentuated and the secondary vegetational cover is important and dense.

On satellite pictures, this vegetational unit is characterized by an heterogeneous range of generally dark grey shades which correspond to the various phases of forest degradations, the various stages

of extension of secondary formations and the importance of crop land. Areas corresponding to crop land are sometimes characterized by very specific lighter spots.

3. Open and mainly deciduous forests, practically undegraded

Woodlands corresponding to this unit are characterized by a layer of trees with rarely touching crowns and a grassy strata with reduced or inexistent shrubby growth. As a whole, these informations can compare with light density forests although some tree can be grouped into small thickets with touching crowns. They may appear as dwarf tree forests or tall tree forests.

These are formations which are generally deciduous over long periods of time. Vidal notes that as a whole, 86% of this forest are composed of deciduous species. The period of defoliation varies according to species but in general the highest percentage of species without leaves is reached in February (85%) and March (60%). For 70% of the deciduous species, the period of defoliation extends over more than a month.

Because of these two characteristics, these formations which are generally deciduous over a lengthy period, can easily be identified on dry season satellite imagery.

Since five out of six of these characteristic species belong to the Dipterocarp family, they are usually known as "dry deciduous Dipterocarp forests" in the classification used in Thailand.

According to the characteristics of the forest: light, dense, dwarf trees or tall trees, these formations appear as light to dark grey shades on satellite pictures. Shade contrasts between these types of forests and the evergreen forest are more evident on photographs taken in February, when the percentage of leafless trees in the open forests is higher.

It is sometimes difficult to determine the degree of degradation of such a type of forest with open foliage through a single study of satellite pictures.

4. Open and mainly deciduous forest, degraded

All stages of lumbering and agricultural takeover can appear in open dipterocarp forests.

This unit corresponds to areas having a sufficiently important tree cover to give a visible and map-able imprint on satellite pictures, even when fully occupied by crops.

A beginning of human exploitation may be revealed by small light spots corresponding to crops. Being of rather limited size, they could not all be plotted on the map. In the case of limited numbers, they were linked to the preceding units.

The delimitation of this area has involved a large part of subjective evaluation.

5. Semi-dense forest or mixed deciduous forest

The various studies made on the vegetation of the Mekong basin distinguish an important vegetation unit which, in view of its aspect and its floristic characteristics, stands as an intermediary between the dense evergreen forest and the open deciduous forest. This formation is named "mixed deciduous forest".

These are woodlands composed as a whole of deciduous trees shedding their leaves over a short period. Vidal notes that 88% of vegetal species lose their leaves and that the leafless period of 59% of these is shorter than a month. The monthly rate of defoliation reaches a maximum in February (85%).

Because of these characteristics, the shades given by this vegetational unit on satellite pictures tend, progressively and until

February, to merge with the lighter shades of the dipterocarp forests. During this period, the dark shades of the evergreen forests remain unchanged and the dipterocarp forest, because of its protracted period of defoliation and its open tree cover, gives lighter grey tones which quickly take a constant value right from the beginning of the dry season. Made in a number of regions, this observation could however not be extended to the whole of the basin. A full set of high quality dry season pictures would be required to this effect.

Since its aspects can correspond to the various stages of degradation, it is in general not possible to differentiate this formation from degraded dense forests.

6. Savanna and shrubs

The vegetation is mainly composed either of grassy formations which may compare to a steppe, or of scattered shrubs, or of a mixture of these two formations. Tall or dwarfed tree formations are scattered or non existant.

In this unit, savanna and shrubs occupy well drained lands.

On ERTS photographs, this unit corresponds in general to the lightest shades; since greyd tones are similar, it is not possible to evaluate the extent of croplands in this area.

7. Woody and shrubby vegetation (Thakhek limestone area)

In view of its extent and its morphology, the Thakhek limestone area constitutes a remarkable unit. Corresponding shades on satellite pictures are light in band 5, indicating a poor vegetation, and very dark in band 7. In the absence of the reference material required to properly describe this area, band 7 grey tones have been attributed to outcropping or nearly outcropping limestones, which are themselves of a very dark colour.

Vidal, who tried to describe the vegetation of this area, distinguishes two types of vegetational formation:

- A scraggy bush (maquis) on the rocks, which loses most of its leaves during the dry season, thus enhancing the arid aspect of the region.

- A dense forest on limestone screes which have built up at the foot of the cliffs.

The delimitation of this vegetal unit is conditioned by the presence of limestone.

8. Open mosaic vegetation

This class groups a number of heterogeneous vegetational formations which can hardly be distinguished from each another since they give practically similar grey tones on satellite pictures.

Their description is difficult since no ground control could be carried out. According to the few aerial photographs which could be studied, they correspond to a mosaic of woody savanna, open forests of the dipterocarp open forest type, coniferous woodland, forests of the evergreen type but very degraded, secondary forests (bushes, bamboos, shrubs) and croplands.

This unit seems to be characterized by the sparsity of any dense woody cover.

On pictures taken during the dry season, the corresponding shades are generally of a dark grey colour. The various grey tones are quite similar to each other and their limits are far too uncertain to make a detailed plotting.

Remark The permanent misty veil which appears over the north-western area of Laos, i.e. between Luang Prabang and Burma on available satellite pictures, tends to give a similar grey tones to the whole area. In the absence of additional reference material, it was generally considered on the map that the corresponding region comes under this type of vegetational formation.

9. Mainly cropland

No distinction has been made between irrigated and strictly rainfed croplands. The only criteria taken into account were the extent of the land occupation and the absence of woody cover.

According to the regions where the woody vegetation is very open or unexisting, the place occupied by secondary formations (bushes, grasses) after crops can be rather important, especially on uplands.

The corresponding shades on satellite pictures are generally very light and uniform for irrigated crops and somewhat dark and heterogeneous for rainfed crops and secondary formations usually found nearby.

Moreover the grey tone of this vegetational units on ERTS pictures is conditioned by a number of factors such as the nature of the soil and its degree of moisture, the type of the crop and its vegetative phase.

In the same manner, all intermediary characteristics to be found between a mainly cropland area and a truly degraded forest will bring about grey tone variations which will relate to the woody cover.

10. Rubber tree plantations

Large rubber tree plantations are visible on satellite pictures, especially on colour slides. The various shades noted seem to correspond to the vegetative phase of plantation perimeter, to their maintenance or to their degradation.

Available documents show that small rubber plantations established in villages surrounding large industrial blocs are visible on some colour pictures, when highly concentrated.

Note - There are many other tree plantations in the Mekong basin. These could not be seen since they are of limited extent or their characteristics are very similar to those of the surrounding area.

11. Woody vegetation and seasonal flooded areas
(locally known as "inundated forests")

As plotted on the map, woody formations corresponding to this unit are characteristic of hydromorphic soils which seasonally are, partially or totally, covered by a layer of fresh water of varying thickness.

P. Legris and F. Blasco give the following description: "This corresponds to a moderately or feebly dense woodland forming in some places thickets with nearly touching crowns. Because of excessive lumbering, this class nowadays is, in most cases, only represented by bushes".

These formations are in particular well represented in Cambodia, around the Great Lake, and in some depressions along the Mekong.

These forests give in general very dark shade. An evaluation of the variations is all the more difficult since radiances are also influenced by soil hydromorphy.

12. Grassy vegetation and shrubs of hydromorphic areas

In badly drained areas, swampy depressions or hydromorphic soils in general, whether these are periodically flooded or not, appear, besides woody formations considered as belonging to the previous unit, a grassy vegetation and shrubs which could result from a degradation of flooded forests.

In view of the absence or the scarcity of the woody strata, shades are lighter than those corresponding to the flooded forest.

13. Mangrove

The most extensive mangrove areas appear along the Mekong delta coast. They are composed of a vegetational formation which is specific to permanently waterlogged soils (high content of Ca, Na and Mg). Species are highly specialized (rhizophora and avicennia).

In view of the peculiar conditions under which they grow, these are easy to map.

14. Fresh water mangrove

This formation is specific to more or less waterlogged soils with a generally high content in organic and acid matters. It is sheltered from the highest tides and the replacement of waters is a slow process.

The vegetative cover is most of the time composed of shrub or low trees type growth with a high predominance of Malaleuca lencadendron.

On satellite pictures, these formations are not clearly distinguished from mangroves or inundated forests. Considering their extent and the specific ecological conditions under which they grow, we decided to plot them on the map. The plotting was made by comparing the ERTS data with those of the vegetation map of Viet-Nam (published in 1969 by the Dalat Geographic Service).

On the basis of available photographs, it was possible to distinguish within this unit areas with dense growth of Melaleuca and swampy grassland with Melaleuca.

15. Vegetation and altitude

Altitude brings about changes in the structure and especially in the floristic composition of the vegetational cover.

Mr. Schmid notes that the elevation at which montane formations appear varies with the orientation of the slopes which has a considerable influence on climatic conditions; it also varies according to the importance and the degree of isolation of the mountain ranges on which depends the wealth of the flora and its vitality. According to him montane vegetation in Viet-Nam definitely sets in at an elevation of 1,200 meters. In Laos, Vidal feels that the montane strata starts at 1,000 m.

Being essentially of a floristical nature, the variations thus brought about by altitude are not visible on satellite pictures.

As an indication, the 3,000 feet contour line (about 950 m) of the 1:500,000 TPC topographic map has been plotted on the land use map.

IV. CONCLUSION

Determined by their aspect, the main vegetational units of the lower Mekong basin and the land development conditions have easily been mapped by interpretation of ERTS-1 data.

By interpretation of the various shades observed, it was possible to map the density of the vegetational cover. The study of its seasonal variations makes it possible to distinguish between evergreen formations and deciduous formations. In the Mekong basin area, these are generally related to the density of the vegetational cover.

Man's intervention, through the changes it brings about to the vegetational cover, is visible on satellite pictures. The various phases of his activity are sometimes difficult to make out and can thus be a source of confusion in the mapping of vegetational units.

In view of the absence of documentation, the impossibility of carrying out ground control and the often bad quality of some satellite

/ pictures,

pictures, it was impossible to give the map and the descriptions of vegetational units corresponding to some areas all the precision required.

Considering the extent and the diversity of the lower Mekong basin, we do not claim that available satellite pictures have been fully used. For our study to be more precise and more detailed, more intensive ground truth control would be required.

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Groupements végétaux et flore.

SELECTED MAPPING UNITS

1. Dense and mainly evergreen forest, practically undegraded
2. Mainly evergreen forest, degraded
3. Open and mainly deciduous forest, practically undegraded
4. Open and mainly deciduous forest, degraded
5. Savanna & shrub
6. Woody and shrubby vegetation (Thakhek limestone area)
7. Open mosaic vegetation (cropland, savanna, secondary vegetation and remnants of open evergreen or deciduous forests)
8. Mainly cropland (rainfed and paddy)
9. Large rubber tree plantation
10. Woody vegetation in seasonal flooded areas (locally known as "inundated forests")
11. Grassy vegetation and shrubs of hydromorphic areas
12. Mangrove
13. Fresh water mangrove (dense woody vegetation)
14. Fresh water mangrove (grassy vegetation)
15. Salt pans
16. Water
17. Area of high nebulosity
18. Contour line corresponding roughly to 1,000 m (3,000 feet on the US/TPC map).

6. 13. 6
ANNEX III

PHYSIOGRAPHY

Terrain configuration

- 01 Level or nearly level plain. Local relief between 0 and 15 metres.
- 02 Undulating area. Local relief between 15 and 45 metres.
- 03 Rolling area. Local relief between 45 and 90 metres.
- 04 Rough plains. Variable relief, but less than 90 metres.
- 05 Area consisting of low hills.
- 06 Area consisting of hills.
- 07 Area consisting of high hills.
- 08 Area consisting of low mountain(s).
Altitude mostly ranging between 300 and 700 metres.
- 09 Rough mountainous area.
Altitude mostly ranging between 700 and 1200 metres.
- 10 Rugged mountainous area.
Altitude mostly ranging between 1200 and 1800 metres or feet.
- 11 Alpine mountains. Altitude mostly over 1800 metres or feet.
- 12 Area mostly consisting of escarpments. Varying altitude but difference in altitude between the highest and the lowest parts usually not less than 500 metres.
- 13 Area consisting of a plateau or closely spaced plateau remnants; plateau level usually above 500 metres.

05 Area consisting of low hills, and a fair number of ridges of variable but usually limited length.
Etc.

05 Area consisting of ridges of variable but usually limited length and a fair number of hills.
Etc.

05 Area consisting of hills and ridges in approximately equal numbers.
Etc.