TECHNICAL MANUAL

on

INTERPRETATION OF AERIAL PHOTOGRAPHS

The Study on Mapping and Land Cover Assessment

of Mangrove Areas in the Philippines

National Mapping and Resource Information Authority

Department of Environment And Natural Resources Republic of the PHILLIPINES

Japan International Cooperation Agency

Japan Overseas Forestry Consultants Association

Introduction

This manual was prepared as a component of the "The Study on Mapping and Land Cover Assessment of Mangrove Areas in the Philippines"- a Development Study Cooperation Program between the GOVERNMENT of the PHILIPPINES and the GOVERNMENT of JAPAN. The purpose of this manual is to help facilitate assessment of mangrove forest resources in the Philippines using Aerial Photographs.

In preparing the manual, it was envisioned that principal users will be those personnel of the National Mapping and Resource Information Authority (NAMRIA) who are presently at the "beginners stage" in learning how to utilise and interpret aerial photographs to conduct analysis of mangrove forests. Additionally, the manual is intended to serve as a textbook or reference to facilitate utilization of aerial photographs by personnel in the Community Environment and Natural Resources Offices (CENRO) of the Department of Environment and Natural Resources (DENR).

The main topics of the manual are arranged in the sequence of the activities to be carried out when conducting an analysis of field conditions: (i) stereo view of aerial photographs; (ii) pre-interpretation; (iii) field verification; (iv) mangrove forest classification; and (v) mangrove forest distribution mapping.

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1. How to do stereo viewing.

1-1 Basic information about Aerial Photographs

(1) Overlap and Sidelap

Forest surveys using aerial photographs are normally implemented in units that cover broad areas. Aerial photographs consist of a series of images taken by an airplane flying on pre-determined flight paths or lines. These lines are equidistant from, and parallel to one another. Thus, the resulting images (photographs) line up at equal intervals within the flight path. (Figs. 1 and 2)

Fig. -1 A series of aerial photography conditions

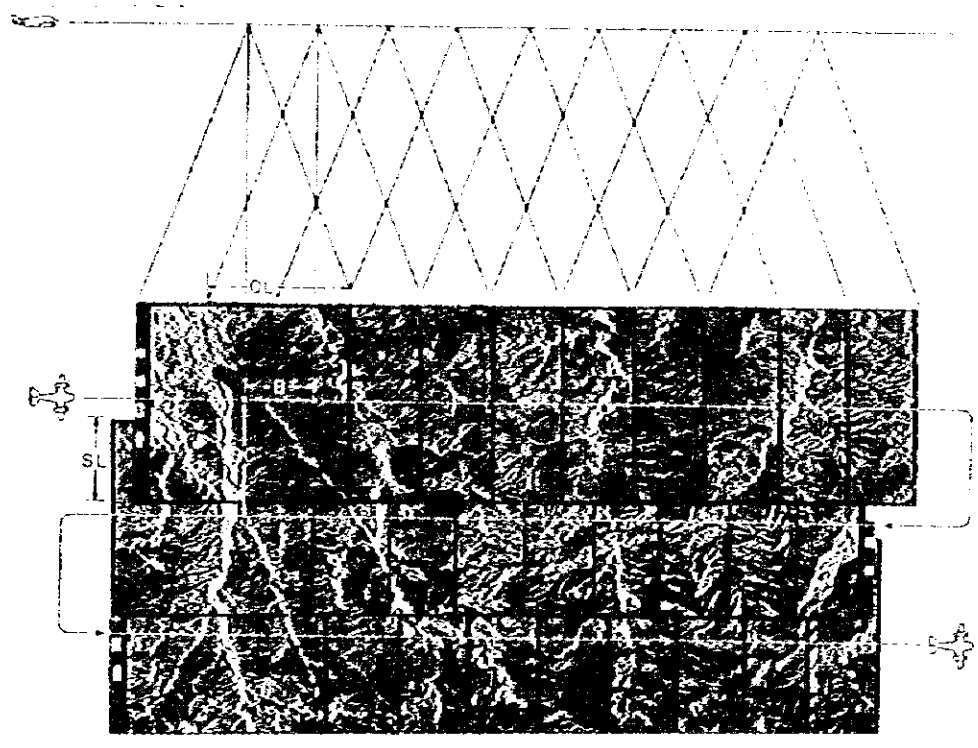
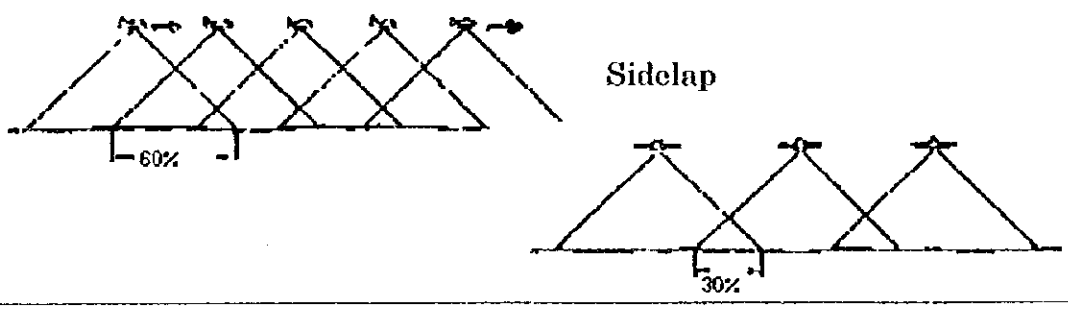


Fig. -2 Sidelap and Overlap



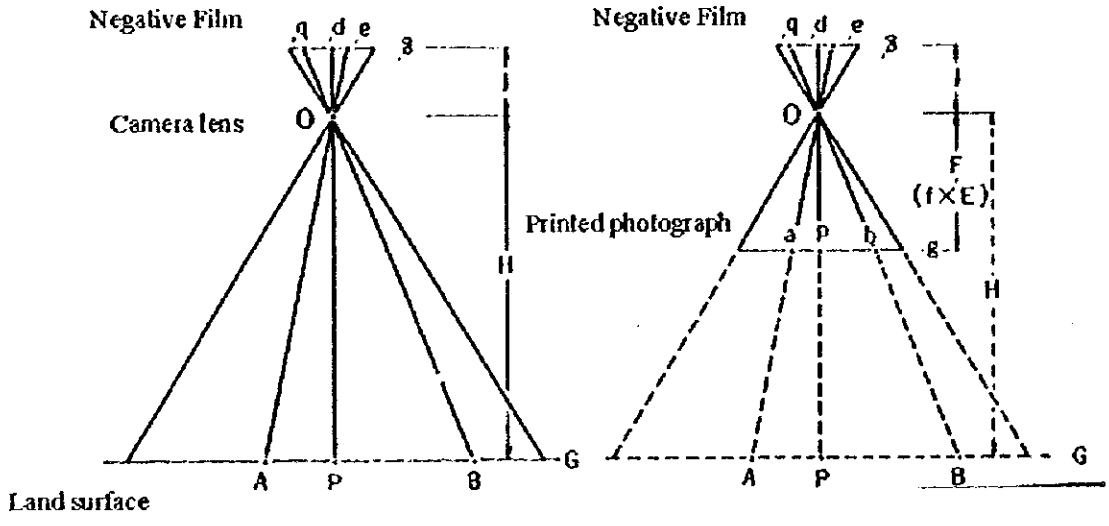
For the stereo view, the aerial photographs have to be shot with sufficient overlap and sidelap to maintain a significant connection between flight paths (i.e. a connection that is easy to recognize). Generally, aerial photographs are taken with a 60 % overlap and 30% sidelap.

(2) Characteristics of an Aerial Photograph

To use aerial photographs, it is important to understand the characteristics of an aerial photo. Photographs taken from high up in the sky look down vertically at the ground. These photographs record everything on the ground through the lens of the camera.

Relationships between a negative film, a printed photograph, and the ground are shown on Figure -3. Triangle ABO, (grand length and real flight height) and triangle a'b'o' (length on negative film and focal length of the lens) are similar triangles. Likewise, triangle ABO and triangle abo (length on printed photograph) are similar triangles. This relationship makes it possible to measure the distance between two points on an aerial photograph and use this data to calculate the actual distance on the ground between the same two points, taking into account the altitude (height) from which the aerial photograph was taken. This is the basis of aerial photography utilisation in land surveys.

Fig. -3 Relationship between figures actually existing on the ground and the image appearing on an aerial photograph



The line marked H on Figure -3 is the altitude (height) from which the aerial photograph was taken. F is the size of the magnified (i.e. enlarged) print of the aerial photograph. Size is equivalent to the product of (E) times the focal length of the camera (f).

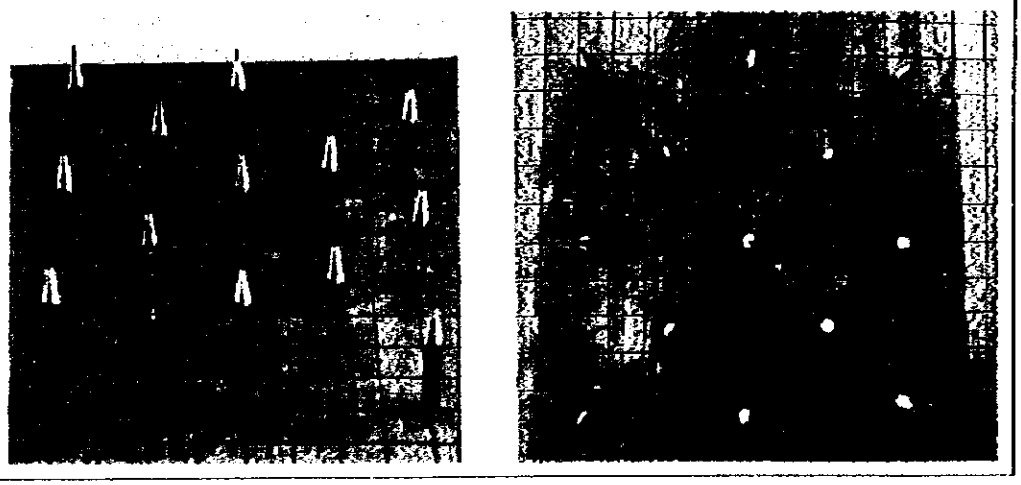
(3) Principal Point

The exact center of an aerial photograph is called the Principal Point. The Principal point is the point on the ground located immediately below the camera lens looking down vertically. If the airplane carrying the camera maintains a straight-and-level flight path, the appearance of objects at the principal point is identical to how they actually appear on the ground. Sometimes however, the aircraft deviates from a straight-and-level flight path due to air turbulence. In this case, the camera lens will tilt slightly and the photograph will show a slightly slanting view of the objects. Nowadays ordinary cameras are able to automatically compensate for the slanting effect so that the photographs show objects exactly as they appear, without the slanting effect. The principal point is defined as the intersection point of two diagonal lines between principal point indicating marks on the outer frame of an aerial photograph.

(4) Perspective Photo Taking and the Slanting Effect

At first glance, an aerial photograph seems to provide an accurate location of objects on the ground. In reality however, this is not always the case. Figure 4 (below) illustrates the features of a photograph taken.

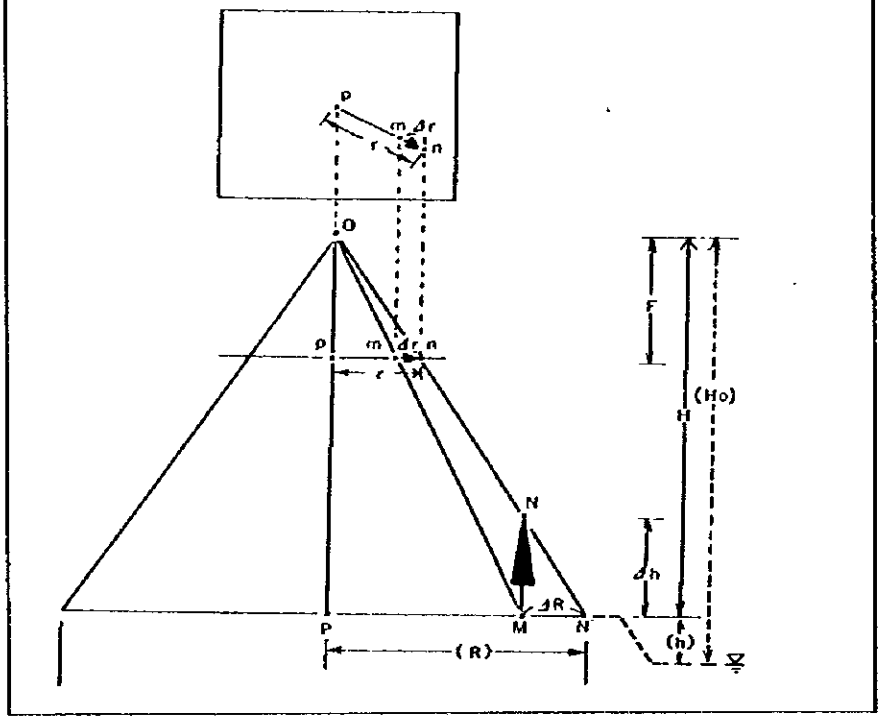
Fig. -4 Sample of the Strained Images



In the middle of the photo (i.e. the Principal Point), objects are correctly presented in their standing (vertical) position, however as one moves away from the Principal Point toward the edge of the photograph, objects appear in a slanting position. In other words, if you compare an aerial photograph and a map showing the same area, objects on the aerial photograph are actually slanting radiallay away from the center of the photograph in the direction of its frame (i.e. the border or edge). This slanting is referred to as the Strained Image. This is why an aerial photograph is taken by perspective image.

Figure-5 illustrates this phenomena. The lower part of Fig.-5 (triangle) shows actual locations on the ground. The upper part of Fig. 5 (rectangle) shows locations as they appear on the photograph. On the lower part of Fig.-5, note that the actual location of the base of a tree is point M and the actual location of the top of the tree is point N. Next, note that on the upper part of Fig.-5 point M on the ground appears as point m on the photo, and point N on the ground appears as point n on the photo. Note further on the upper part of Fig.-5 that points m and n appear to be separated when actually they are part of the same tree. This seems to be a discrepancy but it is not. This is simply the way aerial photographs present information. The tree top is printed at a slant, equivalent to the Δ r found on the upper part of Fig.-5. In other words, on the aerial photograph the tree appears to be down rather than stand-ing up. This is one of the characteris-tics of aerial photos. As one moves away from the Principal

Fig. -5 Condition of Strain and height



Point, objects that are standing vertically (such as trees or tall building) are printed as if they were in a slightly reclining position.

(5) Principal line

As mentioned earlier, aerial photographs are taken with a 60% overlap. Therefore, the same scene is shown on the right half of the left picture and the left half on the right picture. This pair of two pictures is called Paired Photos. Paired Photos show the same scene but from different slants (i.e.angles). This is the basis for obtaining a stereo view.

Fig. -6 A pair of Photographs

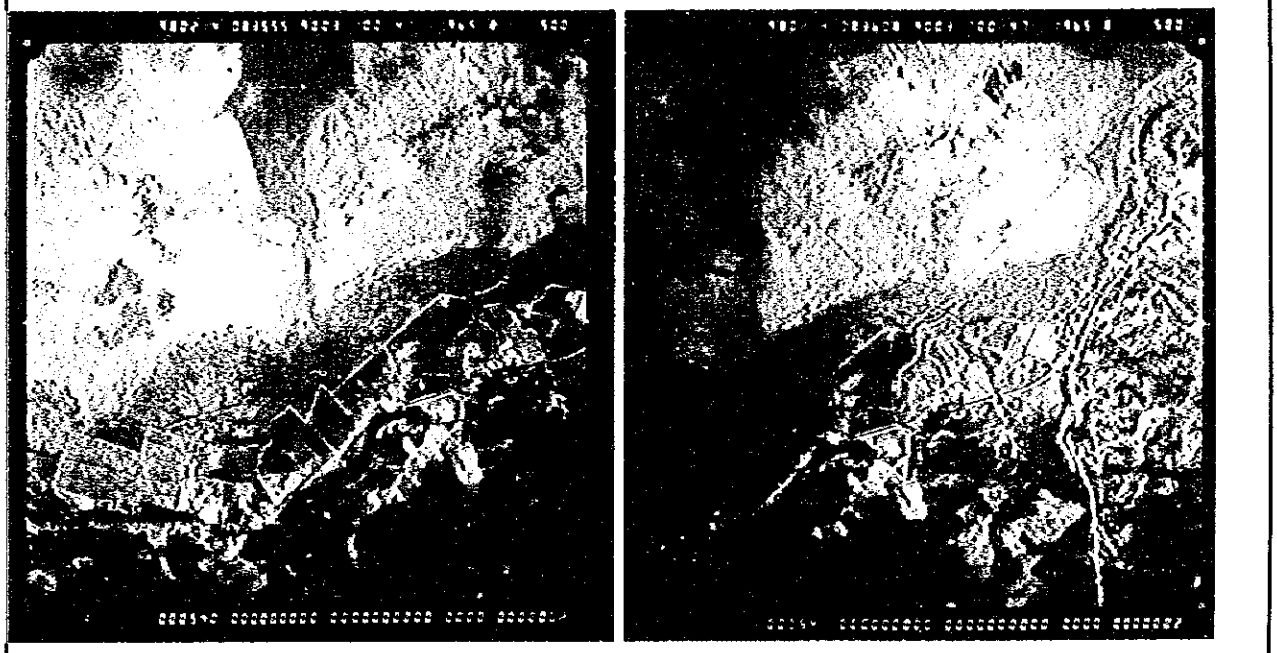
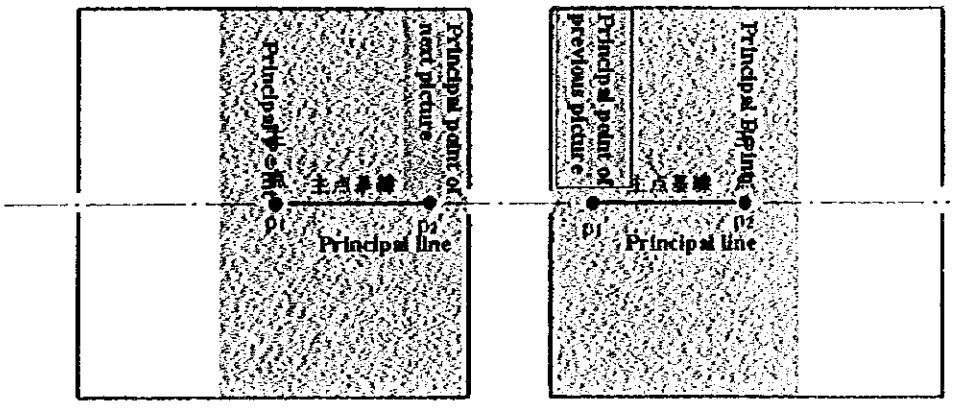


Fig. -7 Principal line



The principal points of each aerial photograph are also shown on the other aerial photographs of the same scene. Note that on Figure-7 there is a line connecting the principal point on aerial photograph (P1) and the principal point on subsquent aerial photograph (P2). This line is called the Principal Line. It shows the flight path followed by the aircraft used to take the aerial photos. This line is important because it is the base line for both obtaining the stereo view and conducting land survey.

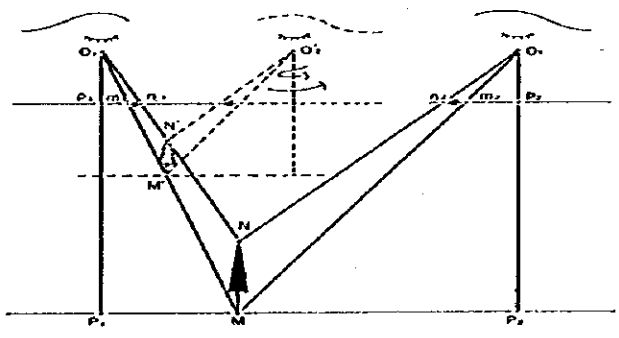
1-2 Practice in Stereo Viewing

(1) Understanding the stereo (three-dimensional) view

For most people, the average distance between the right eye and the left eye is approximately 6 cm. As illustrated on Fig.-8, the right eye and the left eye look at objects from different angles. Points M and N are focused on m1 and n1 (respectively) on the retina of the right eye, and m2 and n2 (respectively) on the retina of the left eye. The points m1, n1 on the right eye, and m2, n2 on the left eye are different. To compensate for this difference, the brain creates a three-dimensional picture; in other words – a stereo view. The same thing happens during stereo viewing of an aerial photograph. Looking through the stereoscope, the right eye and the left eye see different views of the same object or scene. The stereoscope compensates for differences and a stereo view appears.

Fig. -8 How the three-dimensional view is recognized

Fig. -9 How to recognize stereo view of the aerial photographs



(2) Practice in Stereo Viewing

Before interpreting aerial photographs, analysts have to be familiar with the three-dimensional view using Paired Photos. The images of three-dimensional pictures are obtained by focusing on two overlapping pictures through the right and left eyes. Aerial photos consist of two artificial pictures that are the same as natural pictures seen in normal view by the left and right eyes.

A person with extensive experience in analysis of aerial photographs can often obtain a stereo-view using only his naked eyes. Pictures on Figure -10 are prepared to help beginners practice stereo-viewing with the naked eye. Try to examine pictures on the right using only the right eye, and pictures on the left using only the left eye. If this if difficult, try separating the pictures by placing a card standing upright like a wall between the right and left pictures.

Practice naked-eye viewing as follows:

a. Place a card standing upright between pictures on the right side and pictures on the left side. This will block the right eye from seeing the left side picture and the left eye from seeing the right side picture.

b. Bring your face close to the practice pictures sheet (Fig.10) and focus each on its respective picture (i.e. right eye on right picture and left eye on left picture).

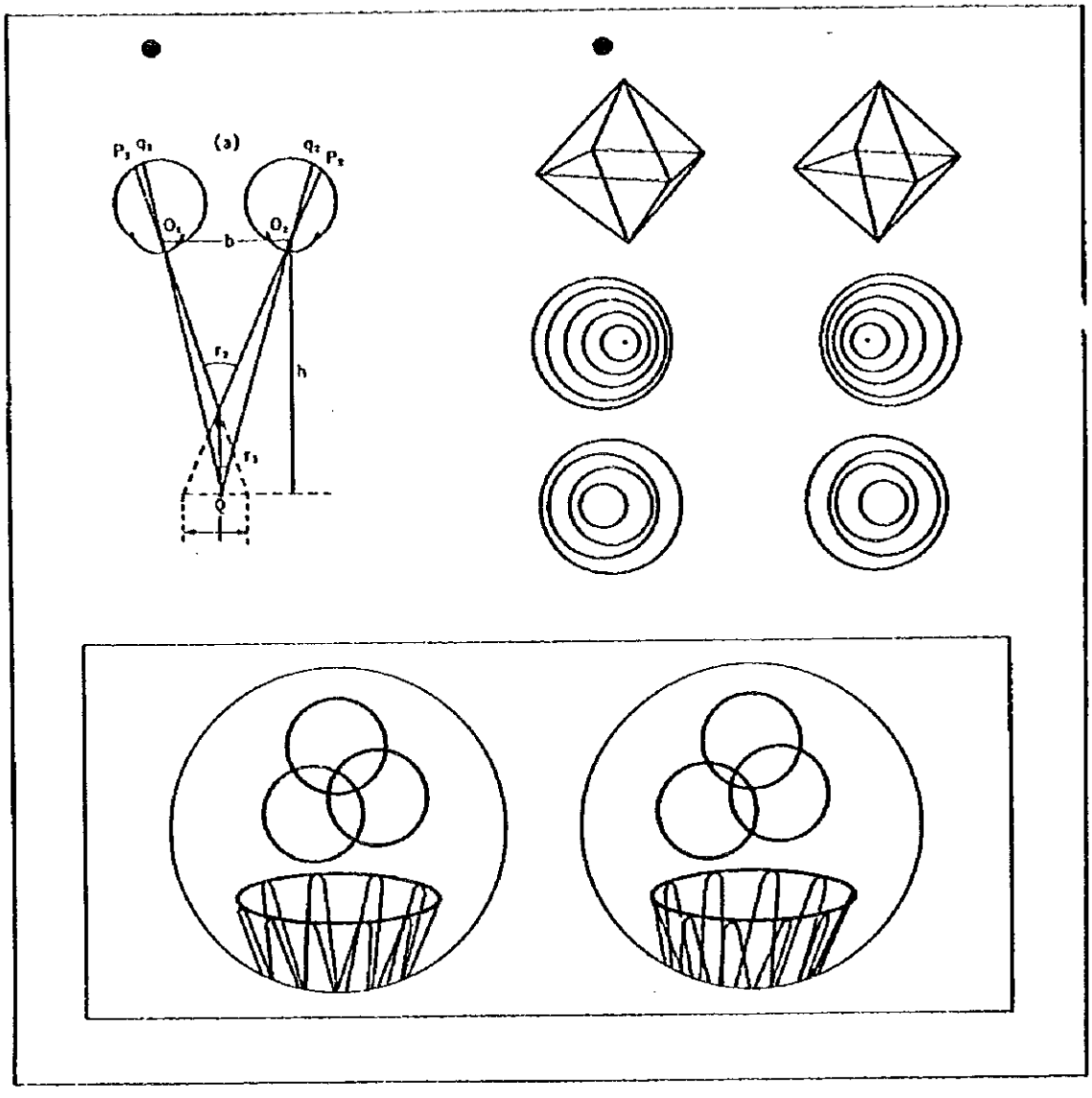
c. Focus intensively. You will note that the pictures move close to one another and finally overlap, producing a three-dimensional image.

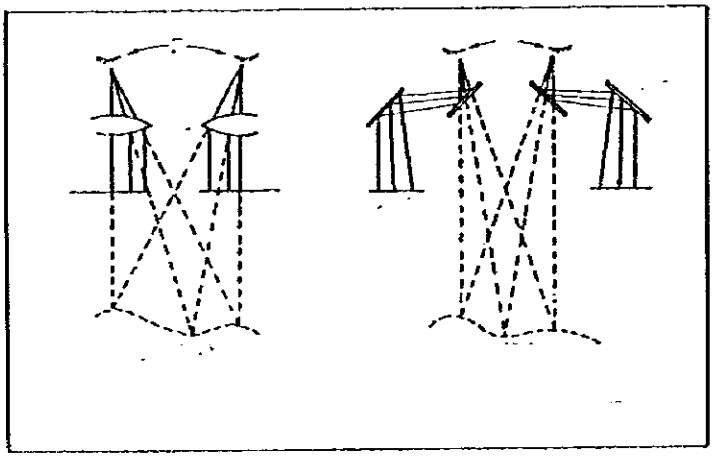
d. Repeat these process, to become familiar with the phenomena of two pictures blending into one image.

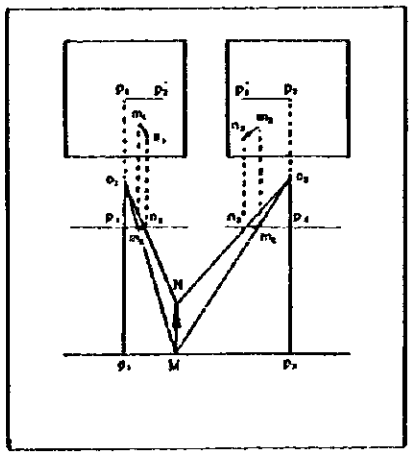
e. Try the same practice without a card between the right and left side pictures.

Familiarity with stereo-viewing by the naked eyes is very helpful when using aerial photographs in the field while carrying out surveying activities.

Fig. -10 Practice pictures on stereo-viewing with the naked eyes



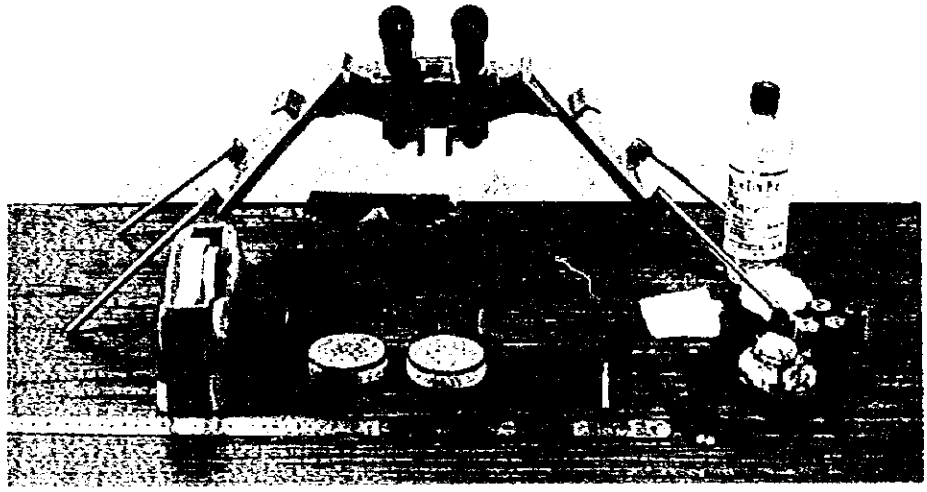




(3) Preparation of materials

For aerial photography interpretation, the following materials are required.

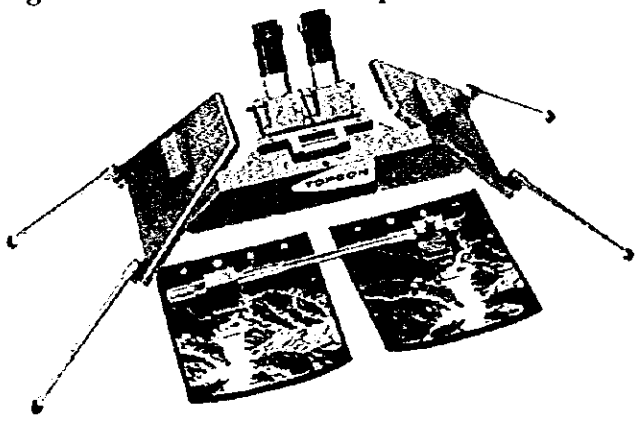
Fig. -11 Instruments and materials for interpretation of aerial photographs



1) Mirror Stereoscope

The Mirror Stereoscope shown on Figure -12 uses mirrors and prisms to help analists observe aerial photographs easily by looking at left and right photos through the left and right eyes respectively. Without the Mirror stereoscope, it is difficult to view and examine aerial photographs that have been enlarged several times.

Fig. -12 Mirror Stereoscope



2) Handy type stereo scope

Fig. -13 shows the handy-type stereoscope for field use. This piece of equipment consists of two convex lens with 3-power magnification capability. The lens are adjustable to match the distance between left and right eyes. The handy-type scope stands eight (8) cm high. It is intended for viewing contact prints of aerial photographs in the field.

Fig. -13 Pocket stereo scope

3) Ruler - This piece of equipment is made of celluloid or steel and is calibrated at one millimeter (1mm) intervals. The ruler is used for locating principal points and setting the principal lines.

4) Color pencil (for all types of surfaces)

5) Gravity or Scotch tape

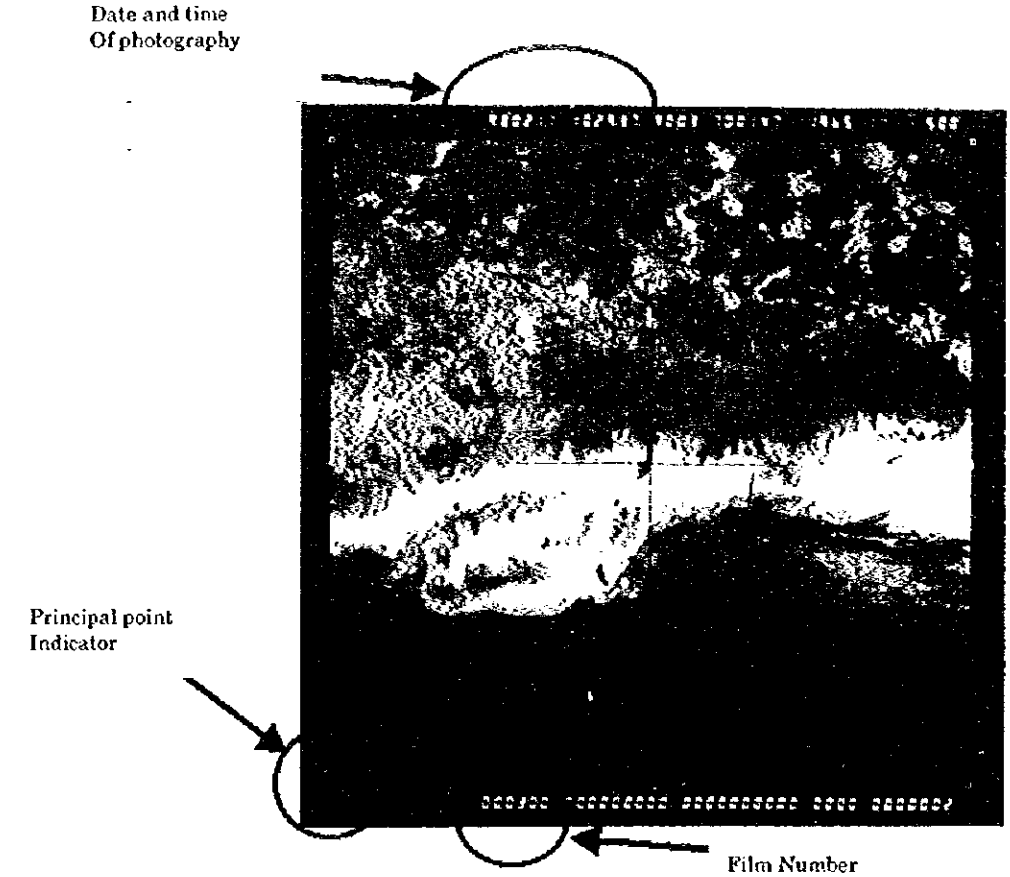
(4) Aerial photograph data

In this Study, aerial photographs were taken with a small-format camera (HIEI SE-II). Specifications of the aerial photographs are as follows:

Scale ..... 1:20,000.
Effective Screen Size..... 115mm×115mm.
Established flight plan
Altitude : 120mm×20,000 = 2,400m
Spacing : 115mm×20,000×0.3= 920m (30% sidelap)
Exposure interval : 115mm×20,000×0.7= 1,610m (60% overlap)

Data recorded on the aerial photographs are shown on Figure -14.

Fig. -14 Sample of a aerial photographs taken by HIEI SEII



2. Preparatory steps for pre-interpretation

The following preparatory steps are necessary for pre-interpretation of aerial photographs:

① marking the principal points (step 1),

② adjusting a pair of aerial photographs for the mirror stereoscope (step 2) and

③ transfer of a principal point to the next photo (step 3). The reader may now practice these steps as illustrated in Figure –15 and discussed below.

2-1 Practicing the preparatory steps

(1) Principal Point Marking (step 1),

1) Fixing a principal point

a. Set a ruler in a diagonal position on the principal point indicator marks found on the frame portion of the aerial photograph. (Figure 16-a)
b. Draw a line approximately 2 cm long on the center part. (Figure 16-b)
c. Repeat the same process as in "a" above on the other diagonal principal point indicators. (Figure 16-c)
d. Repeat "b" above for the principal point indicators covered in "c" above. In other words, draw another line approximately 2 cm. long. (Figure 16-d)
e. The principal point is defined as the intersection point of the two lines

2) Process

Fixing of principal points is essential in order to obtain a stereo view.
Procedures for fixing principal points and for drawing principal lines on the Paired photos are illustrated on Figure -15.

a. fix a principal point on picture 1 (p1)

b. fix a principal point on picture 2 (p2)

c. transfer p1 to picture 2 and transfer p2 to picture 1

d. connect p1 to transferred p2 as principal line b1 on the first photo.

e. connect transferred p1 to p2 as principal line b1 on the second photo.

Processes in Step 1

Fig. -15 Fixing principal line on aerial photographs

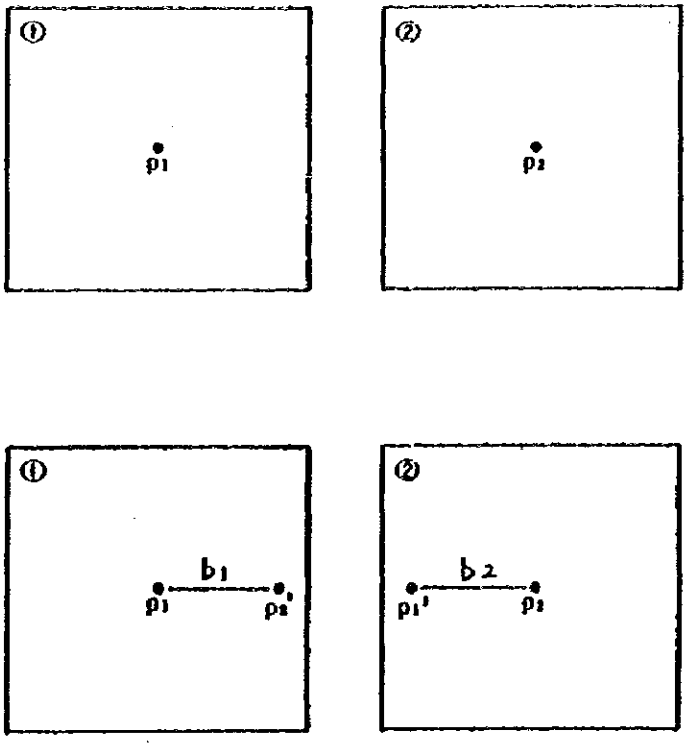
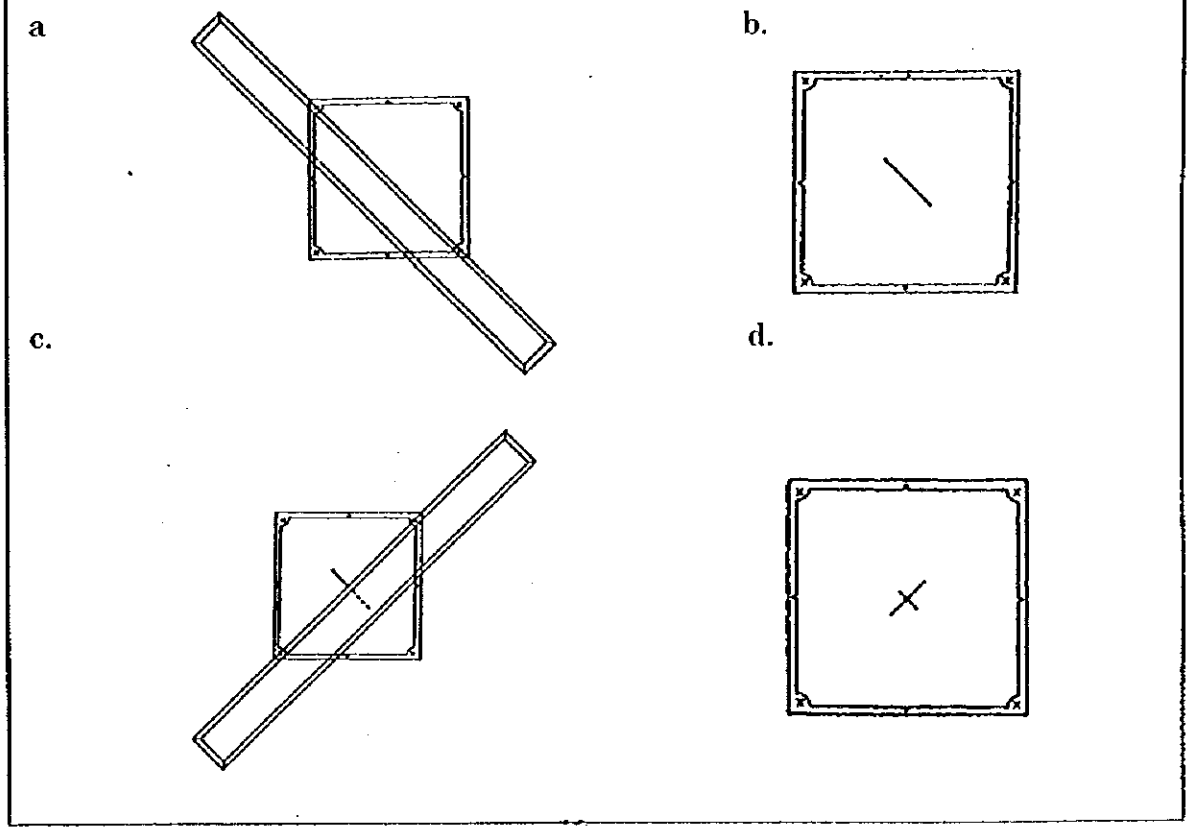


Fig. -16 How to fix a principal point



(2) Adjusting a pair of aerial photographs for viewing in the mirror stereoscope (step 2)

Set a pair of aerial photographs under the mirror stereoscope as shown on Figures -17 and -18.

Fig. -17 Stereo Viewing of an image using the Mirror Stereoscope

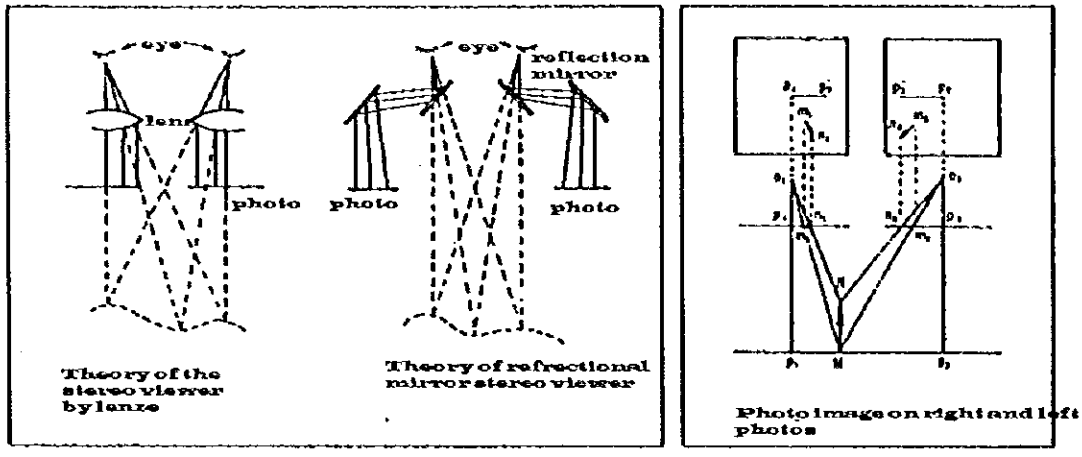
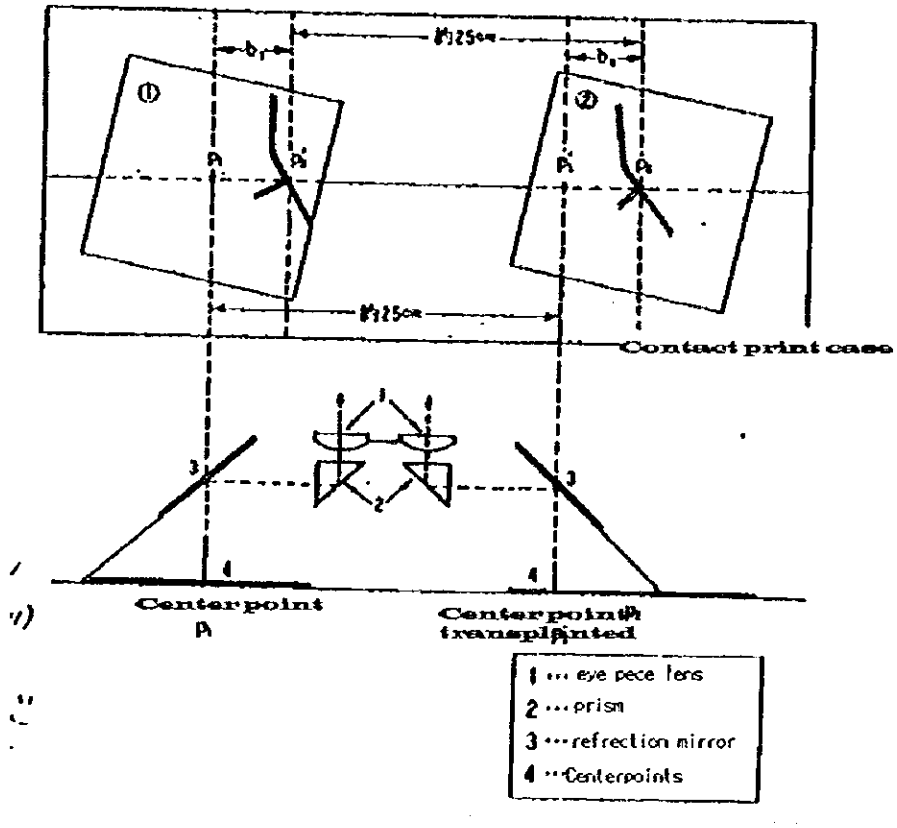


Fig. -18 How to set Mirror Stereoscope and aerial photographs



a. Set the pair of aerial photographs approximately 25 cm distance between the principal point and its conjugate principal point on the next photograph.

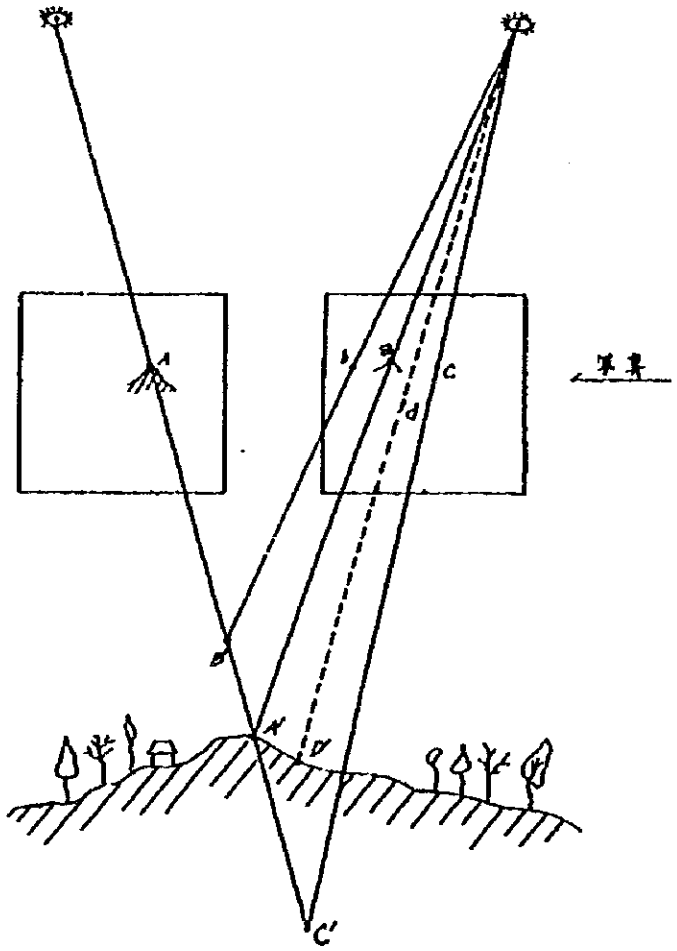
b. Put these together at the center of each eyes view.

c. Adjust the two pictures to focus the stereo view. In this process, placing fingers on both of the principal points will help facilitate the adjustment needed to obtain the stereo view.

(3) Transfer a principal point to the next photo (step 3),

Procedures for transferring a principal point to the other photograph are as follows: (See Figure -19)

Fig. -19 How to adjust the principal point to another aerial photograph



a. Fix a principal point on the left side picture following the processes described above.

b. Arrange a pair of aerial photographs under the mirror scope.

c. Looking at the image in stereo view, mark the principal point on the right side aerial photograph using the color pen.

d. Check the principal point view just on the ground level.

When marking the principal point on the right side of an aerial photograph, the following matters should be taken into account:

a. Transfer the principal point to the position which shows objects as they actually appear on the ground. For example, trees at the principal point will appear in a vertical or standing position.

b. If the transferred point is too far towards the inner side, the point will appear to be floating above the ground level. To correct this problem, adjust the point a little more towards the right side.

c. If the transferred point is too far towards the outer side, the point will appear to be buried below the ground level. To correct this problem, adjust the point a little more towards the left side.

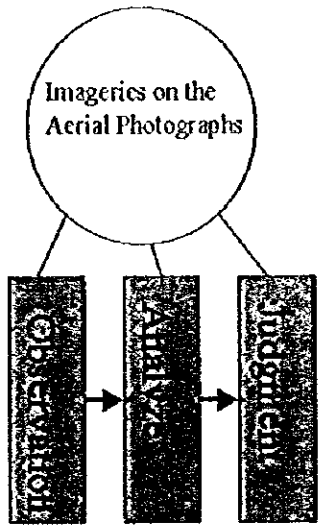
d. If the transferred point appears at the upper or lower side, this means the points have not converged (two points are observed). Re-adjustment is necessary.

3. Pre-interpretation and field verification

3-1 Basic knowledge on Interpretation

The process of interpreting aerial photographs consists of a series of activities implemented to classify the areas covered by the photographs. Classification is based on the conditions prevailing in different areas as derived from observation of the information recorded on the aerial photographs. The process of the interpretation is divided into three steps. (See Figure 20) The first step is observation. By conducting thorough and careful observation using the Mirror Stereoscope, the analysts will be able to find typical patterns and/or groups of similar patterns. The second step is to analyse typical aerial photograph images, paying close attention to shape, the mix of colors and other factors, and then to determine the meaning of each of these various groups. The third step is to judge the groups.

Fig.-20 Aerial Photograph Interpretation Process



Accurate judgement is largely a function of the analyst's experience and knowledge. If the analyst has experience regarding the patterns appearing on aerial photographs that indicate coconut groves, paddy fields, Dipterocarp forest, fallow and so on, he can easily classify these areas without field verification. However, a beginner should verify the aerial photograph pattern and the above groups in the field to be sure that the conclusion he draws from the photographs is correct. After repeating observation and field verification many times, the beginner will eventually become an expert.

(1) Basic conditions for aerial photograph interpretation

Before starting the work, the analyst should attend to the following matters:

a. Be sure about the date and time that the aerial photographs were taken. For example, if analyst wants to observe fishpond areas, the tidal level at the time when the aerial photograph was taken is important information. Date and time of the aerial photographs may also affect other conditions that need

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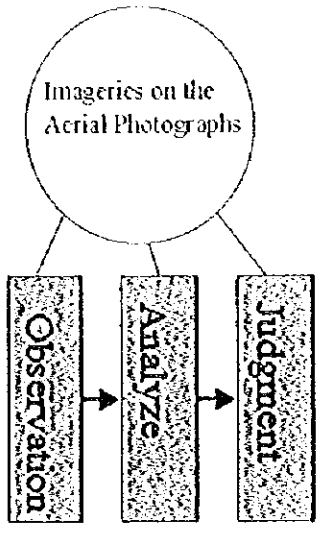

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to be considered such as shadows, and the seasonal differences in the color of deciduous forests. Similarly, the analyst should try to determine the number of years that have passed between the occurrence of forest harvesting, burning, fallow or other events and the time that the aerial photographs were taken. The analyst should collect all available relevant information in addition to the data that can be derived from interpretation of the aerial photographs.

b. Scale of the aerial photographs
Aerial photograph imageries are presented in different colors, textures, shapes and scales. It is very important to know the scale of the photos being interpreted.

c. Observe the three-dimensional view
To classify aerial photograph imagery patterns, the observer should use mirror stereoscope. Information derived from the image of a single picture is significantly different from the information derived through stereo viewing.

d. Gathering technical data and other relevant information
For example, if the observer/analyst intends to classify a Mangrove forest area, he should first collect basic information about mangrove forests, such as location of these forests in the study area, their corelation with the rest of the landscape, mangrove forest distribution, general species composition of mangrove forests in the area based on the different land conditions (e.g. the species usually found on rocky or sandy substrates) and so on. These data/information will help the observer/analyst make accurate decisions on categorization and classification of the area into meaningful groups (e.g. dominated by Nipa [Nypa fruticans] or Bakawan [Rhizophora spp.]).

e. Field verification
The actual status or condition of an area is indicated by different patterns appearing on the aerial photograph. The meaning of these patterns must be verified on the ground to ensure accurate identification of different groups and fixing of boundaries between groups. Thus, field verification is an essential pre-requisite for development of the interpretation technique.

(2) Basic Factors for interpretation

Interpretation of aerial photographs involves the identification of significant differences appearing on the photos, and then determining what these differences mean or tell us about the status or condition of the area being studied. The following factors are important to consider when examining the photos:

a. Shape and size

Shape is usually the most easily-recognized factor that can be used to identify objects. For example, roads usually appear as straight lines, houses may have square shapes, and ponds are usually rectangular or sometimes circular. Many trees also have identifiable shapes. Depending on the crown characteristics of different species, these shapes may be in the form of a cone, a temple bell, an umbrella or spherical. In mangrove forests, the crown shapes of different species are often quite similar. However, through careful examination of the photos, preceded by field observation of crown characteristics, the analyst can often identify unique features appearing on the photo images. This information is valuable in identification and classification of mangrove forests. For obvious reasons, size is also another important factor.

b. Color tone

On a monochrome photo, different objects usually have different colors ranging from white to black. An object that reflects sun light efficiently will appear white on an aerial photograph. By contrast, forests absorb sunlight and therefore have a rather dark appearance. Each object has it's own refraction ratio. This ratio affects the color of the object on the photo. Additionally, color is also affected by conditions prevailing at the time the photograph was taken. Color tones are used to make comparisons between objects.

c. Shadow

Depending on the time of day and/or the terrain, shadows produce copies of the shape of objects on the ground. These shadows reflect the length of the objects. The relative length of objects may be compared by examining the relative lengths of the shadows they produce.

d. Pattern

The patterns of objects being observed is another factor that can assist in identification of groups. Patterns may appear in the form of lines. They may also be recognized by their density, length, height, etc. For example, the crown alignment of man-made forests usually appear in straight lines.

e. Texture

By carefully examining the surface of the photos, the analyst may acquire certain perceptions such as hard, soft, rough, tender, warm, cold.

Aerial photographs show all of the five (5) factors just discussed: (i) shape and size (ii) color tone, (iii) shadow, (iv) pattern and (v) texture. The interpretation

process consists of assessing and evaluating the combination of these factors and the refraction of distinct and separate objects. The interpreter has the responsibility to judge field conditions based on observation of these factors on aerial photographs and observations conducted in the field. This knowledge and skill can be acquired through careful observation and field verification, combined with diligence in the study of relevant information regarding forest types, characteristics and other data pertinent to the area being studied.

3-2 Pre-interpretation of Mangrove Forest

As mentioned earlier, the task of the analyst begins with accumulation of general knowledge and specific data. In this study, general knowledge regarding Mangrove species and forests was acquired from the results of previous research and studies. These results provide information on many relevant topics such as the ecological or vegetative features of Mangrove forests in the Philippines. The main report of this study ("The Study on Mapping and Land Cover Assessment of Mangrove Areas in the Philippines") summarizes the kinds of mangrove associations, how they are recognized and where they are located in various parts of the country.

Pre-interpretation is carried out through following three steps:

Step 1 Identification of mangrove areas
Step 2 Obtaining typical aerial photograph imageries
Step 3 Delineation of tentative lines to divide mangrove forests into different groups.

(1) Identification of Mangrove areas (Step 1)

(1-a) Land use categories and Mangrove areas

The objective of this first step is to arrive at a preliminary (tentative) delineation of land use categories by separating Mangroves from other types of land use such as Farmland, Coconut groves, Grasslands and Fishponds. The degree of accuracy required in sub-classification or categorization of areas other than Mangroves will depend on study objectives. In this study, the areas outside Mangroves were not a major concern. Therefore, the prevailing land use conditions were divided into four (4) simple categories as shown on Table 1. It is important to point out that in pre-interpretation work, categorization should be based on well-known and generally-accepted criteria. A good rule-of-thumb is to conform with the standard categories used in other land use studies.

Designation of new categories should be avoided, as this may lead to confusion. Remember that the objective of pre-interpretation is not to establish final dividing lines, but rather to understand overall conditions in the study areas.

Table -1 Land Use Category (Sample: Used by the Study)

Land Use Category	Code	Observing Points on Aerial Photograph
Mangrove forest	M	- Distributed on seashore and riverside (estuarine) flat areas - Crown shapes are usually spherical or circular - Crown sizes range from small to big depending upon height of the stands - Color tone is light to medium black
Nipa stands	N	- Distributed principally on riverside areas - Crown shapes are difficult to identify one by one, in totally flat and clustered stands - Color tone is medium dark black
Fishpond or Abandoned fishpond	F	- Distributed on seashore and river mouth areas - Shape is clearly indicated by dikes and bunds. Mangrove and/or nipa stands are growing on or along the banks. - Within the fishponds, some are filled with water, and some are dry, uneven, and/or partly covered by mangrove stands.
Others	O	Other land uses such as Coconut groves, Rice paddies, Grasslands, Upland forests, Sand hills, Bushes, etc.

(1-b) Field Verification

Pre-interpretation of photos is done in an office using a mirror stereoscope. Since analysts may not always be familiar with conditions in the study areas, they may not be sure about their conclusions regarding the status of some portions of the areas. This problem is especially true in the case of mangroves where the appearance on photos of high inter-tidal mangrove forests is almost similar to bush vegetation on adjacent land above the high tide line. While the intention is to divide into categories, it is sometimes necessary to merge

categories. For example, the high inter-tidal mangrove forest may be large, and the adjacent bush vegetation area above the tide line may be very small. Decisions on whether to divide or merge depend on the size (no. of ha.) being covered and the final objectives of the study.

After careful examination of the photos, the analyst/interpreter should use a color pencil to mark those parts where is not sure of the category. Then, field verification should be done to determine the categories of these parts. Field verification activities are very important not only to ensure accurate categorization, but also to obtain information about the entire area and to broaden general knowledge. This experience is essential in developing the skills required to become a qualified interpreter.

The field verification process includes careful checking of the unsure parts marked on the photos in the office, and appropriate adjustment to conform with actual field conditions. In this process, the analyst/interpreter must concurrently pay attention to the factors cited earlier (i.e. shape, size, color tone, etc.) as these will be the basis for final interpretation. Field verification procedures are as follows:

a. Keep in mind the scale of the aerial photographs
Surveying skills are need to accurately locate on the ground those unsure parts marked on the photos. Thus it is imperative to know the scale of the photos. Without this knowledge, survey work to locate the unsure parts will be difficult or impossible.

b. Trace the way, and put marks on the aerial photographs.
Start from a good reference point. From this point, proceed to the exact place where the unsure part (object) is located. Check the route followed in comparison with the photo. Mark the photo to show the route (bearing and distance).

c. Check and mark the reference point
Reference points should be easily-distinguished on the aerial photographs such as a structure or a large tree. If there is no such reference point available, place a mark on the photo and repeat the process to be sure about bearing and distance.

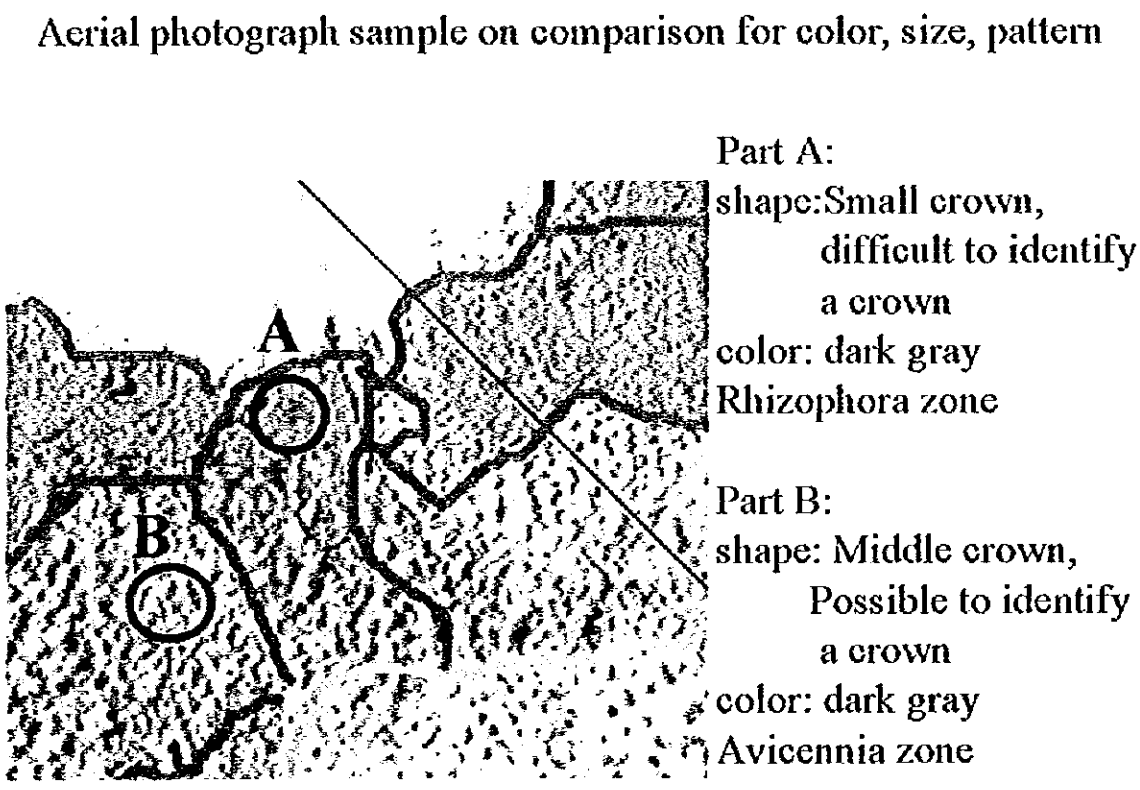
d. Verify the objects
Upon arrival at the target location (i.e. the unsure part/object), check back

again to confirm that you are in the right place. Then examine the object/part to verify its status/identity and also the surrounding/adjacent areas. While implementing field verification, the analyst/interpreter should examine the stereo photo using the handy stereo viewer or the naked eye. Careful examination and observation are necessary to adjust categories on the aerial photographs with the real conditions in the field.

e. Amendment

Amend the pre-interpreted lines or categories to conform with actual conditions in the field.

Fig. -21 Example on Aerial Photograph Interpretation Factor



(2) Typical Photo Imagery Selection (Step 2)

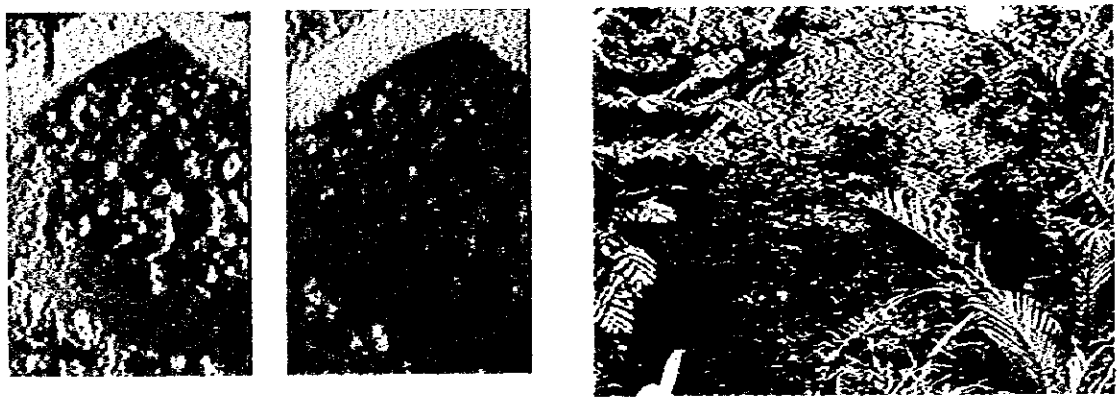
To facilitate pre-interpretation, the analyst/interpreter should obtain samples of aerial photographs taken previously which cover the same type of land use that is being studied – in this case Mangroves. Results from work done in the past can provide guidance when dividing the new study area into different groups. Previous references and criteria should also be used. In this Study, the criteria found on Table 1 were applied. Bear in mind however, that conditions vary from one region to another. For example, the appearance of grasslands covering one province may be different from the appearance of grasslands on another photograph covering a different province. Thus it is sometimes necessary for the analyst/interpreter to make his/her own decision about the photographic appearance of specific groups, patterns and categories, based on local conditions.

(2-a) Sample aerial photographs of mangrove forests

The following aerial photograph imageries and color photographs provide several samples of typical land use groups and mangrove forest groups that were used for pre-interpretation in this Study. Clear aerial photographs are shown on the Aerial Photograph Interpretation Cards as a separate data book of the Study.

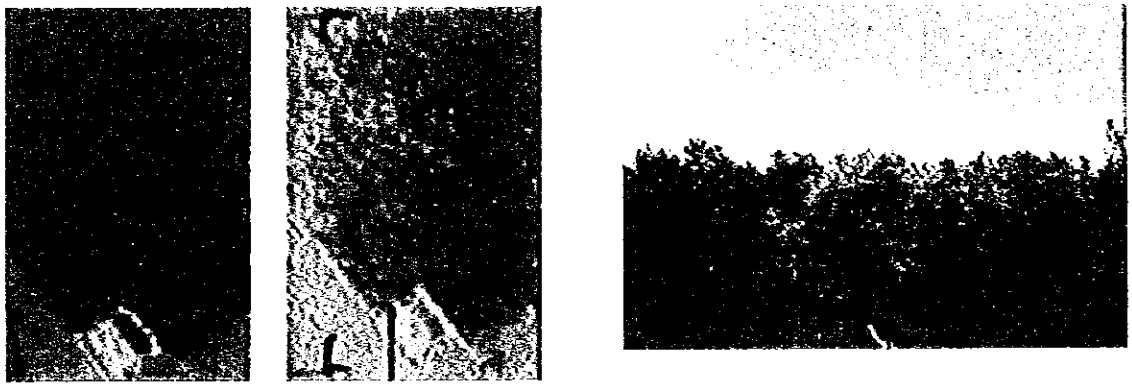
Typical aerial photograph images reflecting some vegetation types or initially categorized groups should be marked on the aerial photographs. After field verification, decide on the grouping methods, then choose suitable sample parts and prepare Aerial Photo Interpretation Cards.

Fig. -22a Sample Aerial Photographs of Mangrove Areas

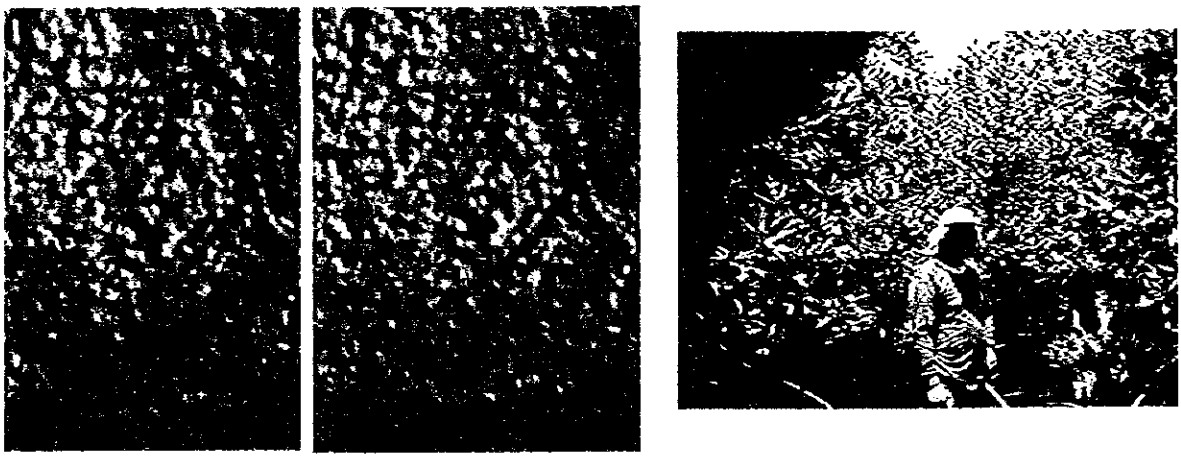


Mangrove stands in Aparri Zone (Big crown of *Avicennia officinalis*

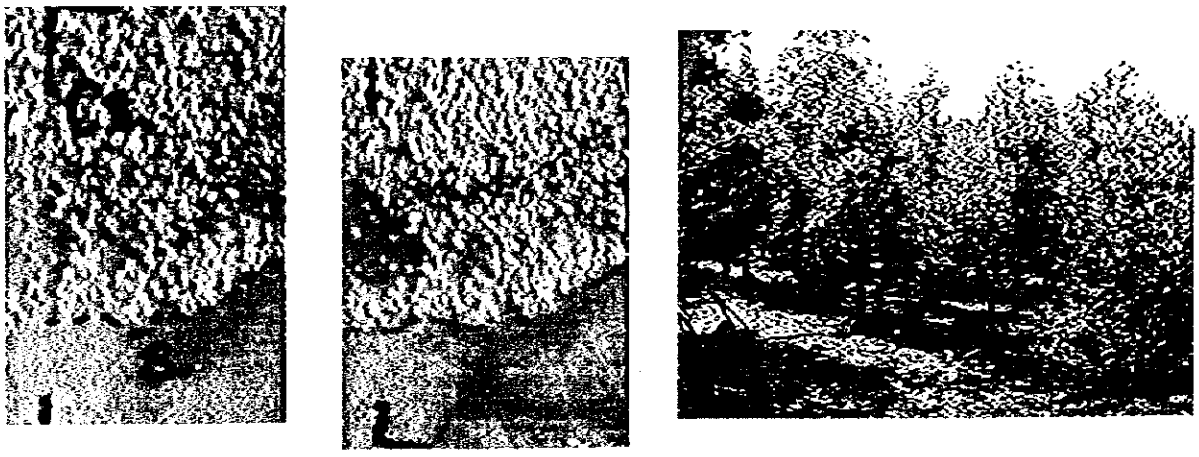
Fig -22b Sample Aerial Photographs of Mangrove Areas



Mixed stands of Mangrove and Nipa in Aparri

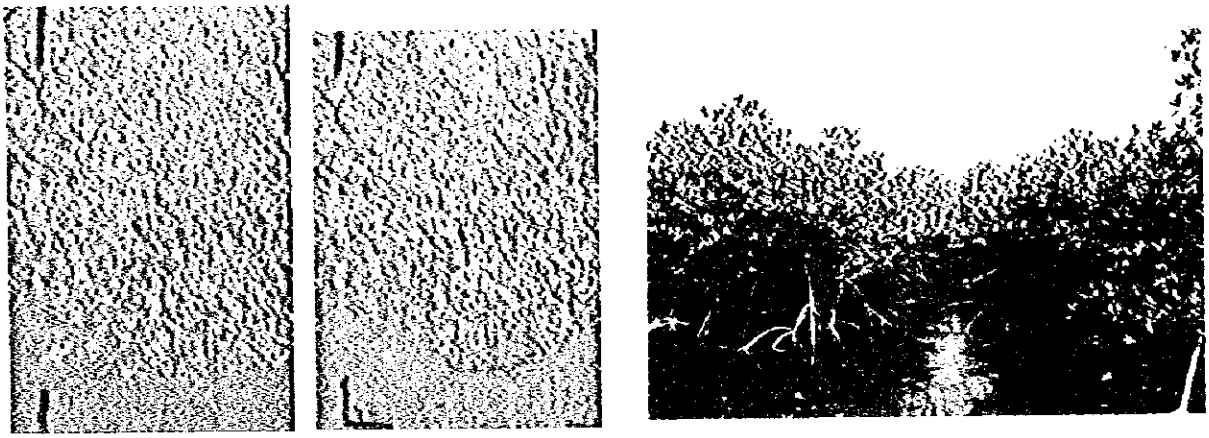


Mangrove forest on tidal flat in Lamon. (*Rhizophora apiculata* and *Ceriops tangal*)

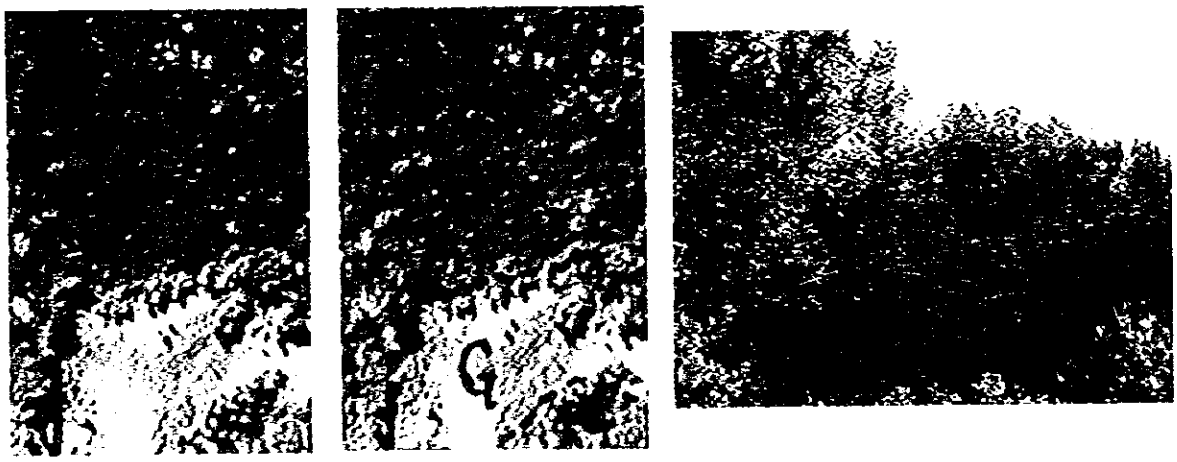


Mangrove forest on wider sea side flat in Lamon. (*Sonneratia alba, Rhizophora apiculata*, and *Ceriops tangal*)

Fig. -22c Cont. Mangrove areas

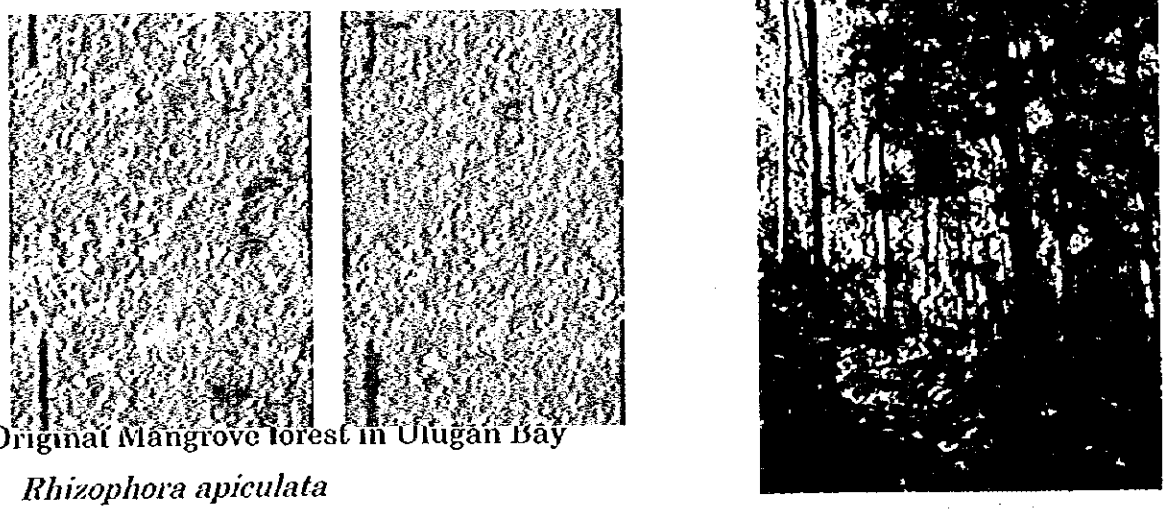


Mangrove on tidal flat in Lamon. (Small and low height *Rhizophora apiculata*)



High-inter tidal zone mangrove area

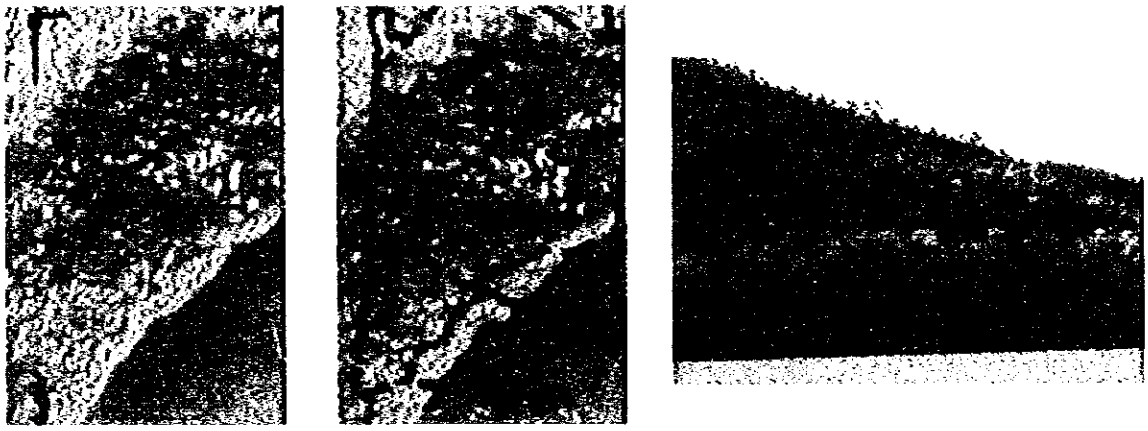
Heritiera littoralis, Scyphiphora hydrophyllacea, and bush species



Original Mangrove forest in Ulugan Bay

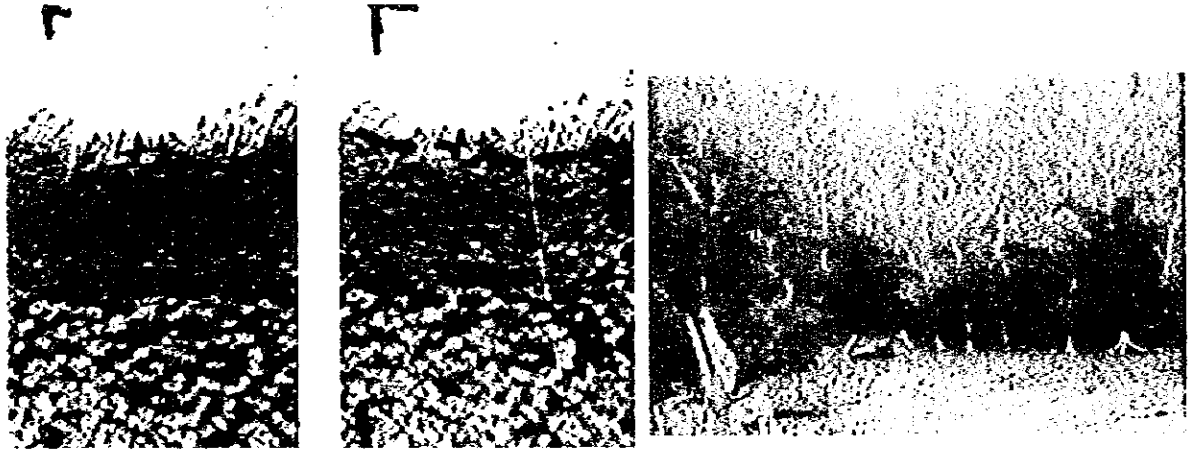
Rhizophora apiculata

Fig. -22d. Cont. Mangrove areas



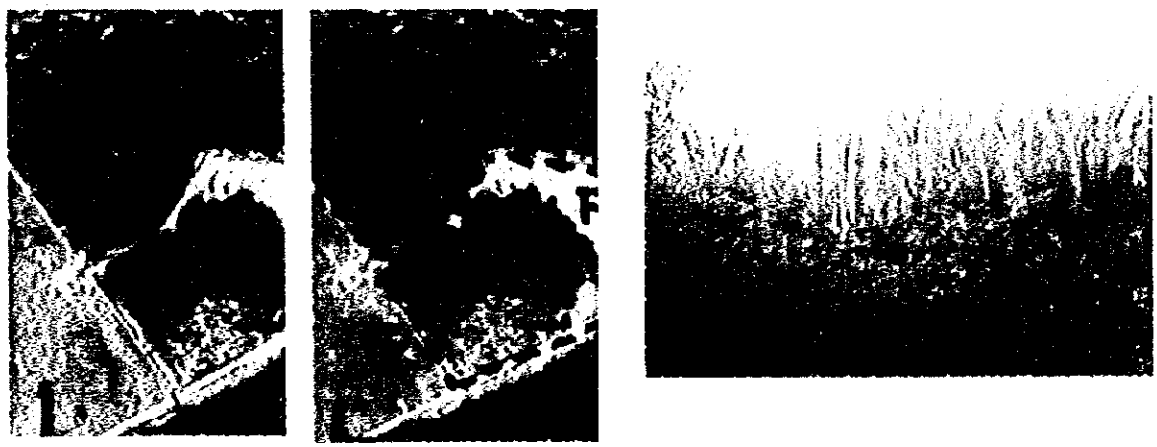
Seaside Mangrove forest in Ulugan Bay

Mixed stands of *Rhizophora apiculata, Rhizophora mucronata* and *Bruguiera gymnorrhiza*



Mangrove on seaside flat in Lamon. (Lopez zone)

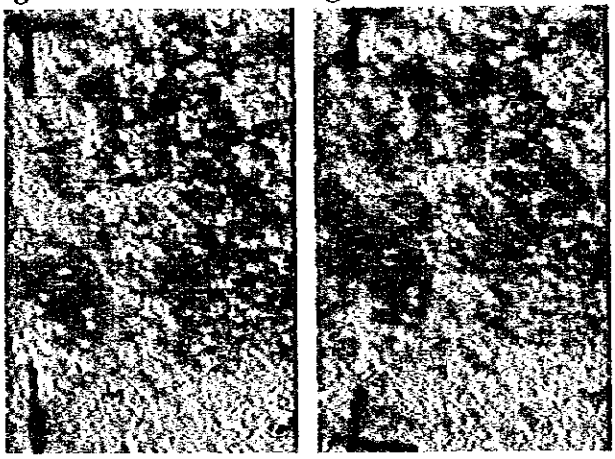
Avicennia officinalis, and *Avicennia marina*



High-inter tidal zone Mangrove area in Lamon Bay (Lopez zone)

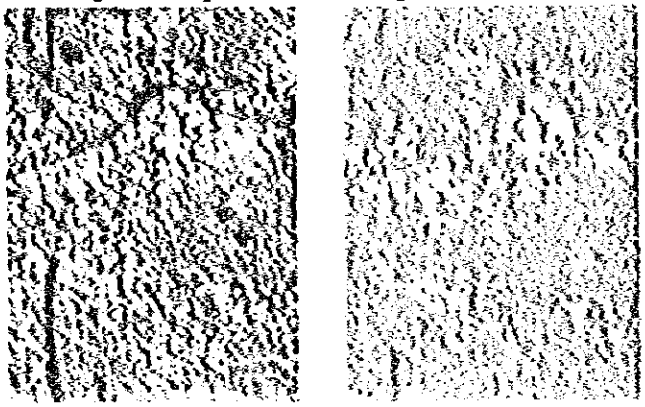
Excoecaria agallocha, Nypa fruticans, Acanthus ilicifolius

Fig. -22e. Cont. Mangrove areas



Original Mangrove forest in Ulugan Bay

Rhizophora apiculata, Bruguiera gymnorrhiza



Original forest in Ulugan bay in middle inter-tidal zone.

Bruguiera gymnorrhiza

Rhizophora apiculata

(2-b) Sample aerial photographs of Nipa and other Land use areas

Fig -23a Nipa areas in Aparri

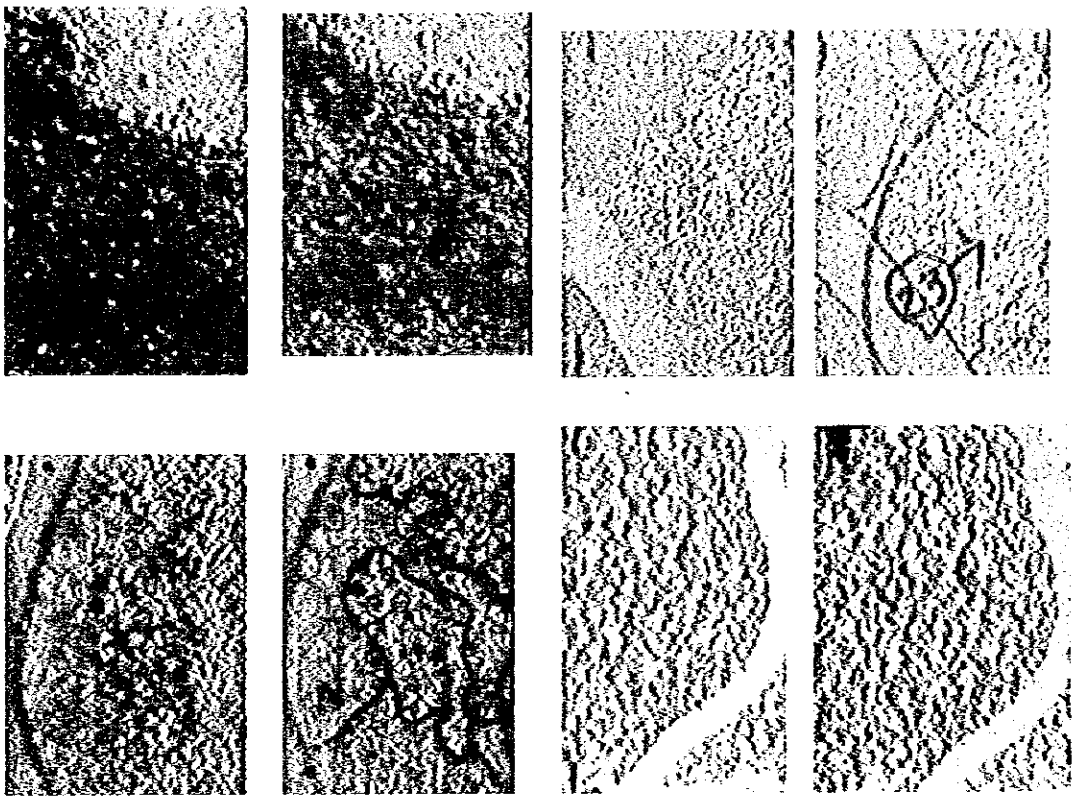
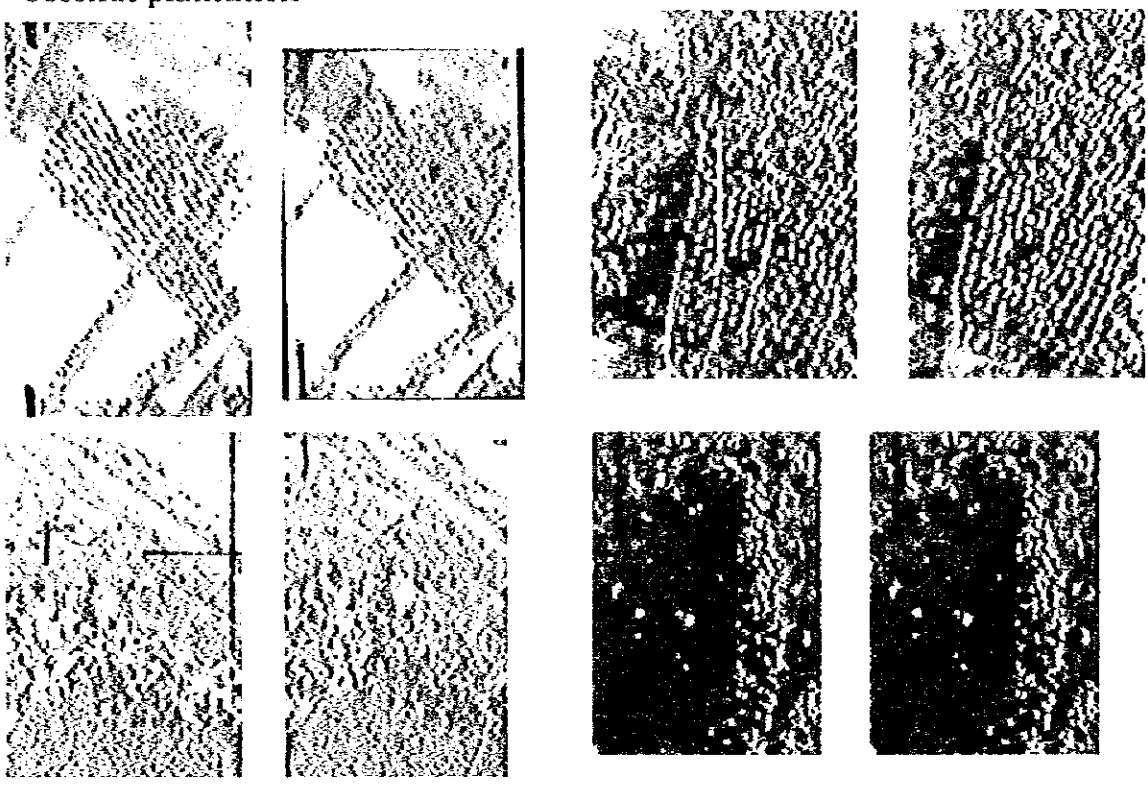


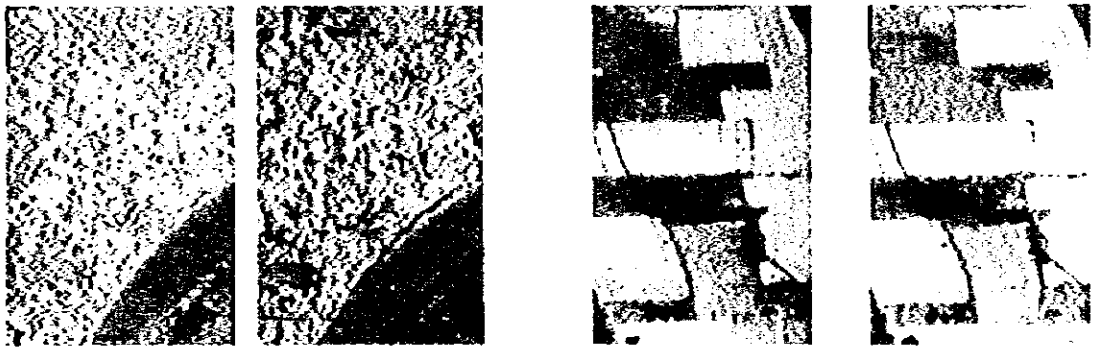
Fig -23b Other Land Use Categories

Coconut plantation

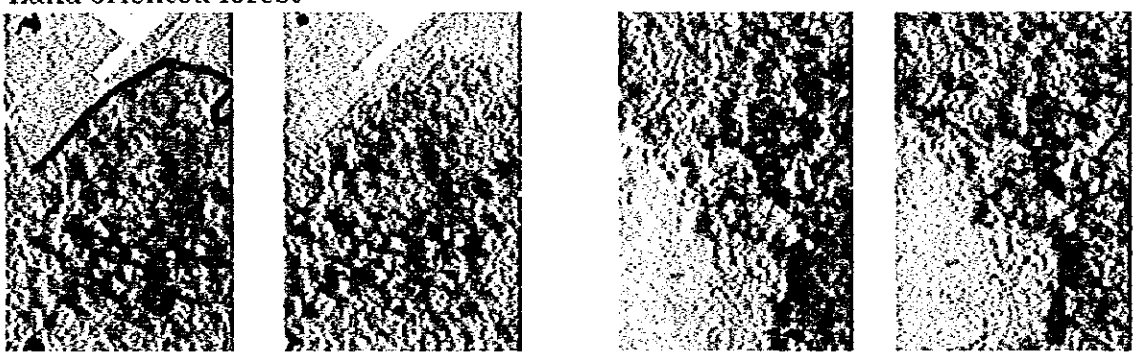


Bush

Paddy field



Land oriented forest



(3) Typical Photo Image on Fishpond

On Mangrove areas large parts are occupied by fishponds. Within these fishponds many are less used or abandoned are observed. To identify these fishpond types is one of the task to grasp the mangrove forest condition for conservation/ rehabilitation planning. The aerial photographs imagery of fishponds are classified into 9 patterns shown in table 2. Following photograph imageries provide samples by each categorized fishpond patterns.

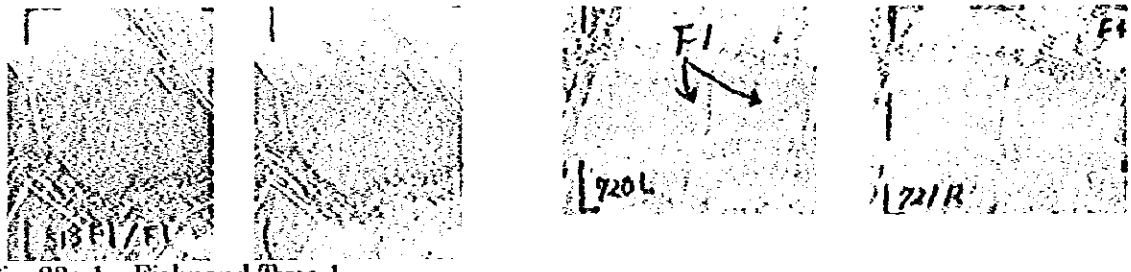


Fig. 23c-1 Fishpond Type 1

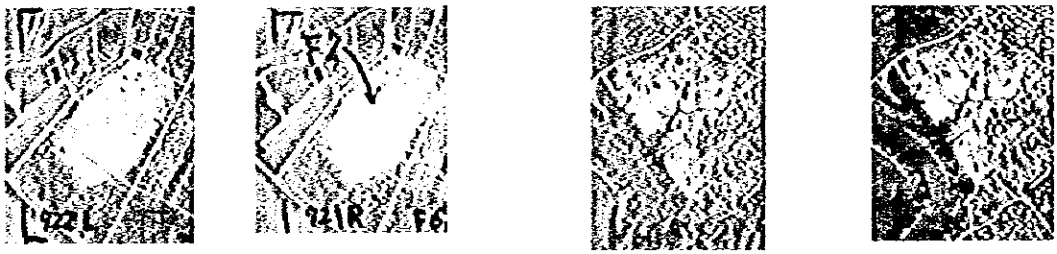


Fig. 23c-2 Fishpond Type 2

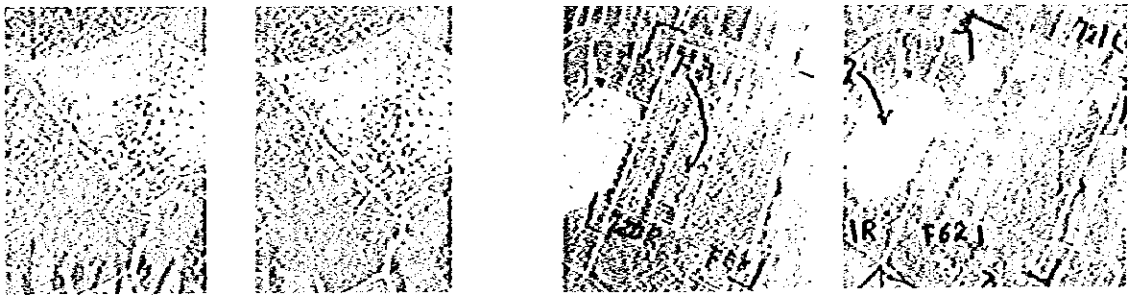


Fig. 23c-3 Fishpond Type 3

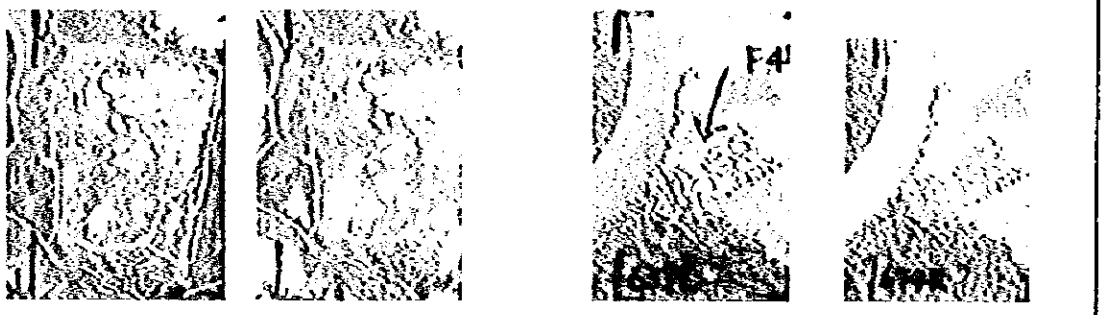


Fig. 23c-4 Fishpond Type 4

Fig. 23c-5 Fishpond Type 5

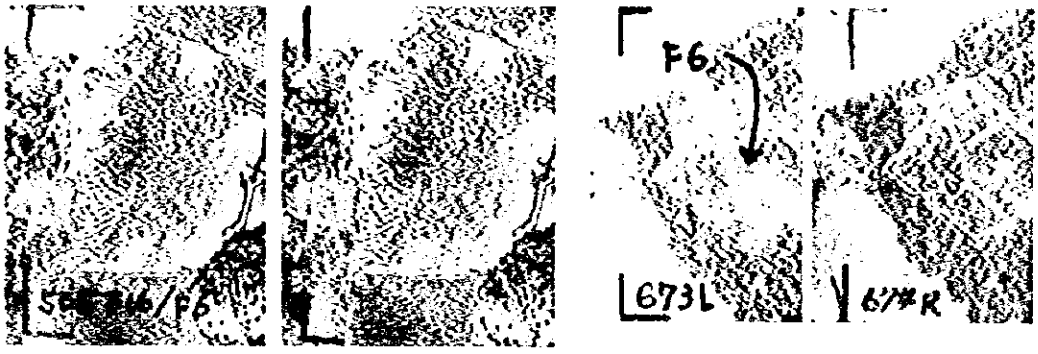


Fig. 23c-6 Fishpond Type 6

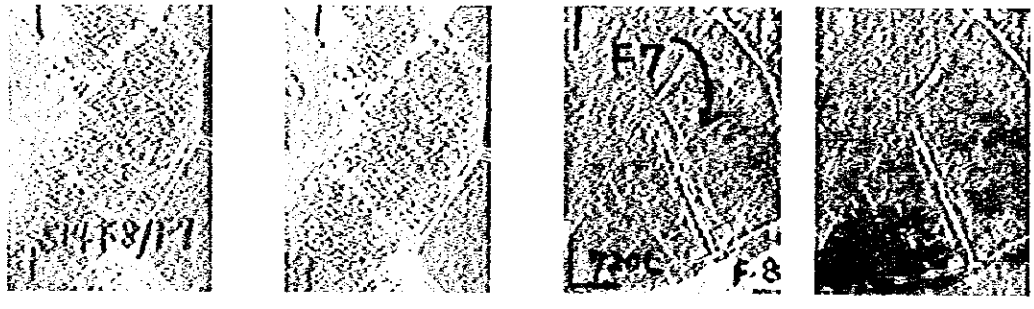


Fig. 23c-7 Fishpond Type 7

Fig. 23c-8 Fishpond Type 8

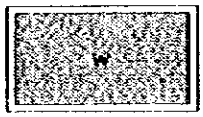
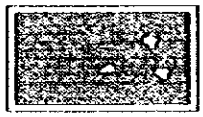
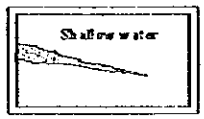
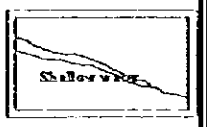
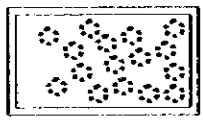
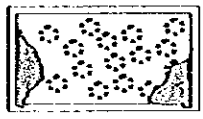
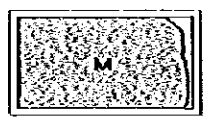
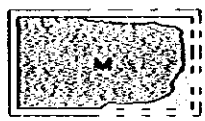
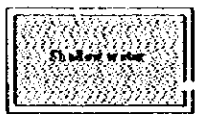
Type	Explanation	Image 1	Image 2	Image 3
F-1	Clear bank around the fishpond exists and filled with water.			
F-2	Clear bank around the fishpond exists but only less than 50% surface is covered by water.			
F-3	Clear bank around the fishpond exists and surface is covered by water but very shallow or mud mounds are developing.			
F-4	Clear bank around the fishpond exists but surface is covered with mud mounds and limited water and partly covered by vegetation.			
F-5	Clear bank around the fishpond exists but more than 50 % of surface covered by thin vegetation.			
F-6	Clear bank around the fishpond exists and water also observed but partly thick vegetation same as surrounding natural mangrove stands is developing.			
F-7	Clear bank around the fishpond exists, but surface is fully covered with vegetation, same as surrounding natural mangrove.			
F-8	Bank is not all around nor clears. Some ponds are dry, shallow water covered, and/or vegetation same condition as surrounding mangrove stands covered.			
F-9	Bank is not all around, but clear water exists in only some part. Vegetation covered is same as surrounding mangrove			

Table 2 Fishpond Categorisation Patterns

(4) Delineation of tentative lines to divide Mangrove areas into different groups (Step 3)

(3-a) Classification of similar areas on the aerial photographs

The objective of this step is to make tentative lines dividing the mangrove forest and the non-mangrove areas. Figure 24 illustrates this process. Using the mirror stereoscope, the analyst/interpreter should implement the following:

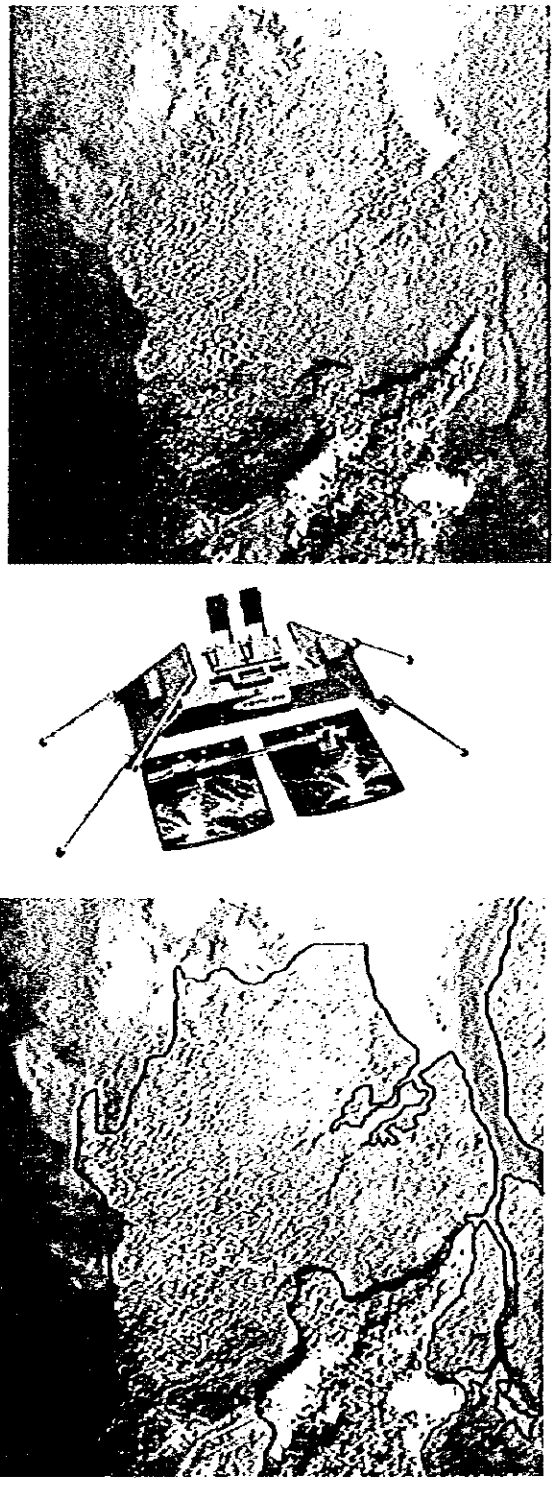
Sub-step 1

- Locate the boundary line between Mangrove areas and other Land use areas.
- Check aerial photographs imagery of coconut groves, paddy fields, grasslands, wood lots other than mangroves.
- Locate where the change in terrain (slope) defines a border between mangroves and dry land. Also locate the border between mangroves and the seas, and the border between mangoves and rivers or other bodies of water other than the sea.

Sub-step 2 :

- Examine the photo imagery and divide the areas into similar

Fig.-24 Sample photograph to identify the boundaries of mangrove forest



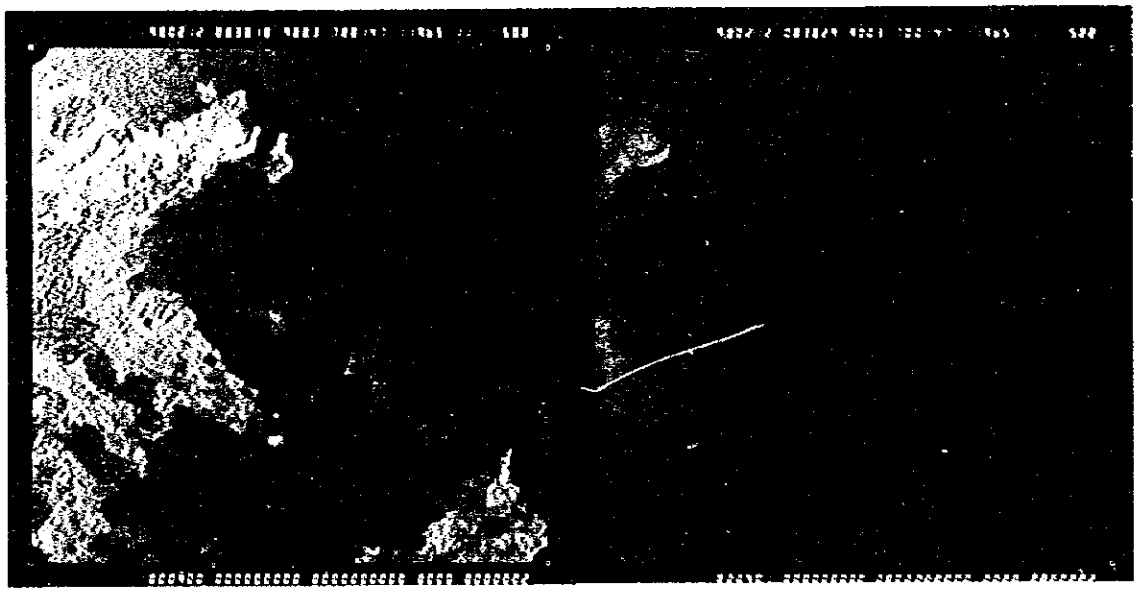
parts based on different features appearing in the photos.

- Draw lines on the aerial photographs dividing the mangrove area into different mangrove forest types based on Color, Crown size and height. The previous phase of this Study involved the running of transects and conduct of plot surveys. This experience and knowledge provided key information for dividing areas by mangrove forest types.

Fig. -25 Setting Boundary lines of the Mangrove forest - Sample 2

a. Using a mirror stereoscope, conduct careful examination of the photos.

Pre-interpretation Sample (Tiniguigiban, Lamon Bay)



b. Find the borders of farmland, forest, and other non mangrove areas. In this sample (Fig.-26 &-27), the yellow line shows where the landscape change occurs due to slope. Basically, the slope divides the flat areas from the adjacent areas that are not flat. Recognizing the change in slope is not difficult when using the mirror stereoscope. But in cases were flat (dry) land is contiguous with the mangroves, it is not easy to divide the bushes and the mangroves. To divide accurately, the analyst/interpreter must carefully compare the mangrove side and the non-mangrove side (i.e. dry land side). Next he/she should draw a boundary line at an approximately intermediate position indicated on the aerial photograph by differences in color, texture and crown shape.

Fig.-26 Pre-interpretation Sample (Tiniguigiban, Lamon Bay)

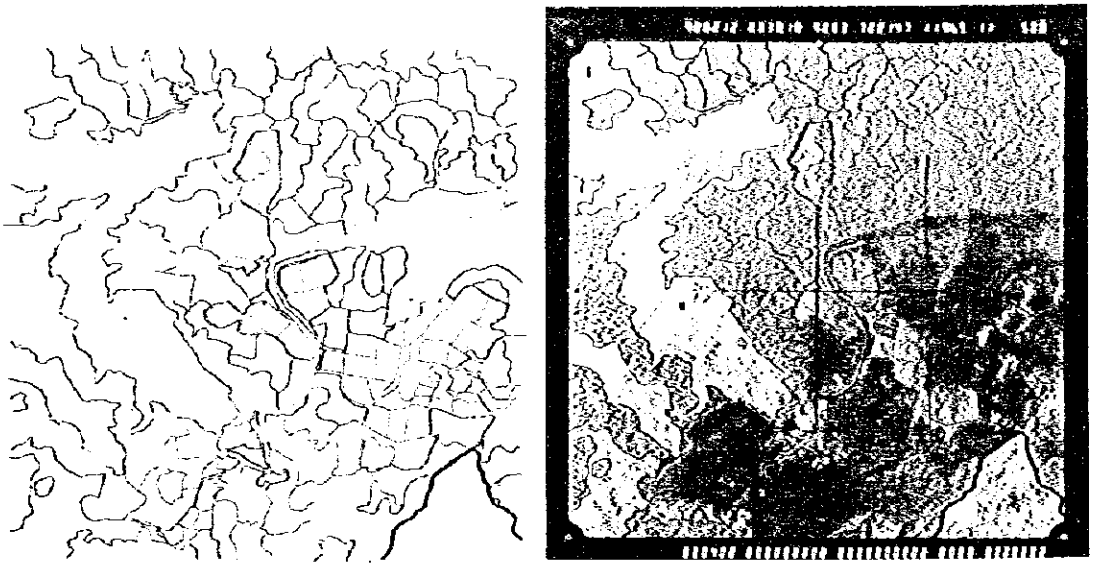
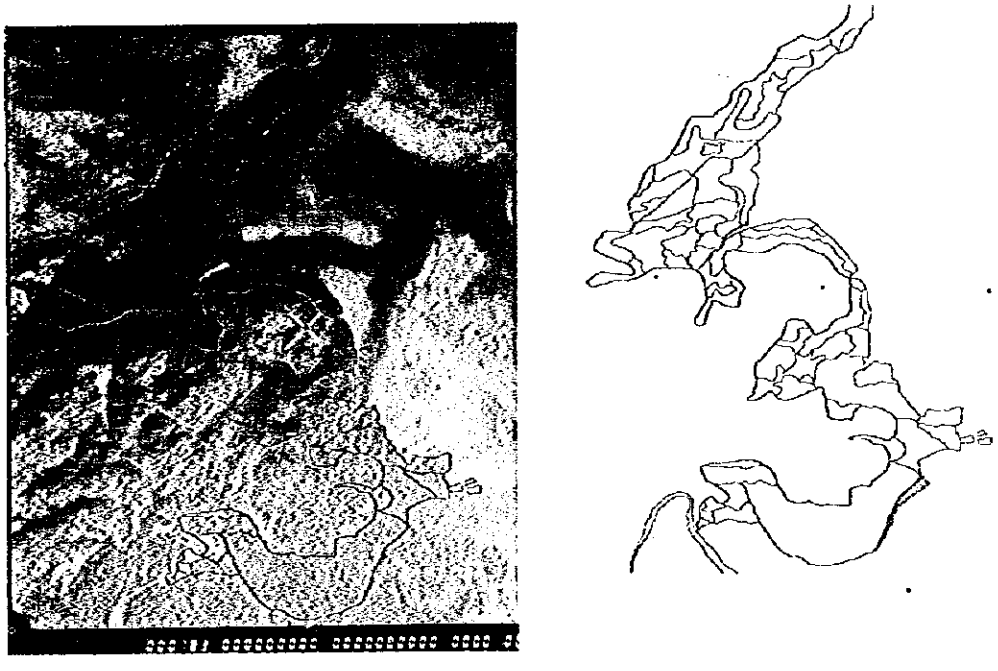


Fig.-27 Pre-interpretation Sample (Ulugan Bay, Bahile zone)



4. Delineating compartment and sub-compartment boundary lines

Fig. -28 Dividing Mangrove areas into groups
(Sample 1: Lamon Bay Lopez zone 536-537)

Divide the mangrove areas into groups based on similarities in color, crown size, and surface condition (flat or uneven). On Fig.-28, green color lines illustrate such grouping. Once again, the need to obtain basic knowledge about the area must be emphasized. For example, previous work in this Study showed that at the Lamon Bay area the seashore is characterized by small groups of *Rhizophora apiculata*. Next, one finds relatively low-height trees of several *Bruguiera* species, some-times mixed with *Rhizophora apiculata*. Within the zone dominated by *Bruguiera*, scattered groups of *Ceriops tangal* may be found alone or mixed with *Bruguiera*. Approaching the middle intertidal area, medium-height trees of *Avicennia officinalis* become dominant. Approach the land ward fringe, the dominant mangrove species change to *Scyphiphora hydrophyllacea, Heritiera littoralis,* and *Avicennia officinalis* with big crowns.

Several samples are shown as follows on Figures -28-- 31.

Fig- 29 Dividing Mangrove areas into groups (Sample 2)
Place is Barangay Lainglaingan
in Lamon Bay area.
Course 9 (407-408)
Compartment 408-410
in Tiniguiban Zone

Fig. -30 Dividing the Mangrove forest in group (Sample 2: Aparri)

Place is Barangay Tabba,
in Aparri area.
Course 1 (567-568)
In Pamplona Zone

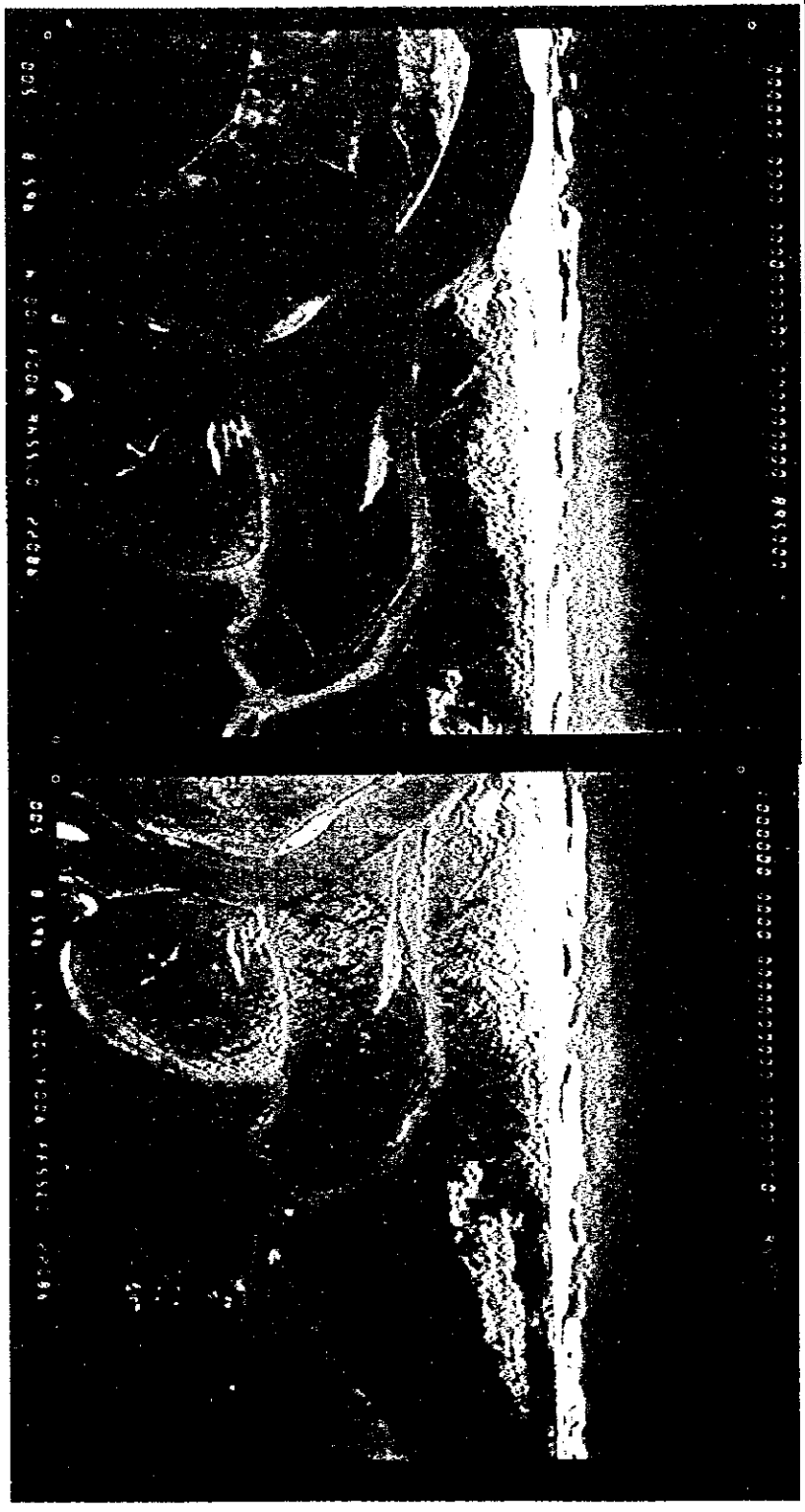


Fig. -31 Dividing the Mangrove forest into groups (Sample 3: Ulugan Bay)

Place is Barangay Macarascas/Bahile,
in Ulugan Bay area.
Course 4 (797-798)
In Macarascas and Bahile Zone