THE APPLICATION OF AERIAL PHOTOGRAPHS FOR SOIL SURVEYS IN DEVELOPMENT PROJECTS

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Abstract Aerial photographs are used in four different phases of investigations for development projects. In each phase a particular type of aerial photo interpretation in combination with field investigations has to be applied.
1st phase: overall inventarisation of potential agricultural regions;
2nd phase: investigation in a large project area;
3rd phase: the "avant project";
4th phase: the execution of the works in a project.
Explanations of the procedures, the costs, the man-power and time needed in these four phases will be given. Special attention will be paid to the advantages and limitations of aerial photo interpretation for soil surveys in development projects.

Résumé On se servit des photographies aériennes en quatre stades différents d'investigation dans les projets de développement. Chacun d'entre eux requiert un type particulier d'interprétation photographique en relation avec des levés de terrain.
1er stade: inventaire général des régions à potentiel agricole;
2e stade: recherche de zones susceptibles de faire l'objet d'un projet;
3e stade: avant-projet;
4e stade: exécution des travaux du projet.
Nous donnons dans notre note des précisions sur le déroulement, les frais, la main d'oeuvre et le temps exigé par chacun de ces stades. On portera une attention toute particulière aux avantages et aux restrictions que présente l'interprétation des photographies aériennes dans les prospections pédologiques destinées aux projets de développement.

Zusammenfassung Luftbilder werden in vier verschiedenen Phasen der Untersuchung von Entwicklungs-Plänen verwendet. In jeder Phase muss eine besondere Art der Luftbild-Interpretation im Zusammenhang mit der Gelände-Begehung unternommen werden.
1. Phase: Allgemeine Inventur potentieller Landbau-Regionen;
2. Phase: Untersuchungen innerhalb eines grossen Planungs-Gebietes;
3. Phase: Das "Vorprojekt";
4. Phase: Die Ausführung der Arbeiten eines Projektes.
Erklärungen bzgl. der Arbeitsweise, der Kostenberechnung, der Arbeitskräfte und der für jede der Phasen benötigten Zeit werden gegeben. Besondere Beachtung finden die Vorteile und Beschränkungen der Luftbild-Interpretation in der Bodenkunde im Verbande mit Entwicklungs-Plänen.

Introduction

In various regional and international meetings and congresses, recommendations have been made to the Governments of nearly all the countries in the world to start with special investigations on the physical conditions of the land before starting agricultural development projects. One of the first recommendations is always that a soil survey and land classification should be carried out. This should be done by experts. Another recommendation often concerns the use of aerial photographs.

The principal questions for the soil survey and land classification experts

working on such development projects are always: how to carry out such investigations and how to evaluate the results. Other questions are: the type and technique of soil survey to be applied under the specific conditions in a project, and the most suitable procedure to be followed in aerial photo interpretation.

In this paper we shall try to give a general scheme for the use of aerial photographs in the soil surveys of development projects. It should, however, be understood that in each particular case this scheme has to be adapted to the prevailing economic and environmental conditions and to the purpose of the project.

Phases in development projects

In many countries Governments wish to start on a particular project, which has to be finished as soon as possible. It is often more useful, first of all, to investigate the whole country, or at least a large part of it. Such an overall study, which can be carried out in a relatively short time and at low costs, shows the potential agricultural regions, which seem to be promising for development.

Taking into consideration the various factors concerned, one of these regions may be selected as a development project. Various types of investigation have to be carried out in this project area, firstly on a rather general basis and later in somewhat more detail.

The next step will be an "avant project", a rather detailed study as a basis for a plan of development, a plan of operations, and a rough calculation of costs, outputs and inputs.

The final step is the execution of the project. Here too, many, often quite detailed, studies have to be made for specific purposes.

The four steps or phases mentioned above are:

1st phase: an overall study of the country, indicating the potential agricultural regions,
2nd phase: general investigations in a project area,
3rd phase: investigations for an "avant project",
4th phase: detailed investigation for the execution of the project.

The investigations to be made during these four phases, have quite different characters, this is especially the case for soil survey and consequently also for aerial photo interpretation. Methods and techniques of soil survey and aerial photo interpretation have to be adapted to the type of investigation to be carried out in each phase, to the physical conditions of the terrain, and to the purpose for which the project has to be made.

Soil investigations in the first phase

During the first phase the purpose of the investigations is to select the potential agricultural regions, which seem promising from the point of view of

agricultural development. In some countries this work has already been done. However, there are still many countries where potentials are unknown.

The easiest and most efficient way to select promising areas, is to eliminate the areas which are not promising at all. Various factors limiting future development, such as rough topography, dense vegetation, location, geology, soils and in arid regions also water, can be studied from aerial photographs and mosaics. Without any study in the terrain itself, large parts of a country can often be eliminated for further investigations. The areas not eliminated are often less than 10% of the total area, and are still too large. Therefore a further selection has to be made for these areas.

The work to be done in this phase of the investigations is rather simple. Photographs, and in particular mosaics are studied, and a list of limiting factors is set up. The whole country is classified in regions, and each region is delineated roughly on mosaics or maps, and characterised by some symbols, indicating the limiting factors. Other information, *e.g.* on climate, geology, can also be taken into consideration.

An important point is to know the minimum size of the regions to be indicated on the final map of the whole country. Major potential agricultural regions suitable for a development project should have a minimum size of about 10,000 to 25,000 ha. In such a case, all smaller areas can be neglected, and aerial photo interpretation work can be simplified during the first phase.

This has also a great influence on the scale of the aerial photographs, and consequently on the aerial survey. Small scale photography (for example 1 : 50,000) for the whole country will be sufficient from the point of view of selecting large potential agricultural regions.

It is worthwhile preparing a small scale exploratory map *e.g.* 1 : 1,000,000 of the whole country, indicating the various general physiographic regions, their limitations and advantages for development. If it is possible to carry out some field investigations, the promising regions should be visited and some general information on vegetation, geology, water and soils should be collected. The results of the investigations of the first phase should be described in a short report, and handed to the reponsible authorities, who will decide which of the regions shall be selected for further investigation in the second phase of development.

Soil investigations in the second phase

The purpose of the investigations in the second phase is to study the potentials for agricultural development of one, two or three regions, which after the first phase seem to be promising. The area is now limited in size in comparison to the area studied in the first phase which covered the whole country. Often no more than 100,000 to 500,000 ha have to be investigated for one project.

The main point now is to study the terrain and soil conditions, in such a way that the Government can decide whether to start with a development project or not. Sometimes, when more than one region has to be investigated, the

investigations also serve to collect data, which can be used for determining priorities of development. A general soil survey, indicating the most important and most extensive soil associations, with a resultant soil map on a scale of 1 : 100,000 or 1 : 200,000, will be sufficient for this phase.

Such a soil survey can easily be made by means of aerial photo interpretation in combination with terrain investigations. Procedures for this type of work have been described in detail, in CHAPTER 11, appendix A of the Manual of Photographic Interpretation published by the American Society of Photogrammetry in 1960.

Soil mapping is generally done by aerial photo interpretation techniques. Soils are studied in the terrain in a number of sample areas, covering the main soil associations as shown on the soil map. The soil studies in the terrain and the soil analyses to be made in the laboratories are made for information regarding:

a. the soils occurring in the project area,
b. the evaluation of soil conditions,
c. the estimation of real potentialities,
d. the predictions for future agriculture, crops, yield, *etc.*

The main purpose of the soil map in this phase is to show what soil associations occur, where they are located and how they are associated. Although the accuracy of the soil boundaries should be higher than the exploratory soil map of phase 1, there is, even in phase 2, no need for very accurate and detailed soil boundaries. For the same reason relatively small areas (100 ha and smaller) can be omitted, and consequently a general soil map 1 : 100,000 or 1 : 200,000) mainly based on aerial photo interpretation as far as plotting of soil boundaries is concerned, will be sufficient.

If a few potential areas have to be investigated in order to select the most suitable one for further development, it is often worthwhile stopping the field investigations as soon as it becomes evident that one region is much better than the others. A short interim report to the responsible authorities will provide the possibility of concentrating further investigations in the best region. There is no need to do unnecessary work. If all available manpower, material and funds are concentrated on the region with the highest potentials, work can be speeded up and the construction of the project can start at an earlier stage.

In a former publication dealing with this and other types of soil surveys executed with the help of aerial photo interpretation, we introduced the system of carrying out the study of soils in the field in carefully selected sample areas. In regions with a dense tropical forest or with dense tall grass or reed vegetation, this is often rather difficult. It was proved by DE MEESTER in Tanganyika (See I.T.C. Publications, series B, 10) that in these cases a somewhat different technique can be followed. Field observations are made along lines, that are cut in the vegetation at regular intervals on carefully selected sites. A large number of soil profiles are studied along each line. Instead of "sample areas", soils are investigated here in "sample cross-sections".

Soil investigations to be carried out in this phase of development planning are the most difficult of all types of soil surveys. Predictions for agricultural potentialities of rather large areas have to be given, with the aid of only a limited number of field observations and laboratory analyses, while all factors concerned have to be taken into account. Very often no crops on which predictions can be based are grown in those regions, or only a primitive small scale agriculture exists. Much depends on the results of the surveys in this stage and the person who carries out the aerial photo interpretation and the field work bears a great responsibility. It is therefore of great importance that investigations on soil and land potentials in development projects in this phase are made by highly qualified soil and land classification experts. Not all soil experts, who may be extremely qualified for detailed soil studies, are able to carry out this type of soil investigation, which requires the ability of generalization.

Besides the investigations for soil survey and land classification, there should also be general studies on geology, hydrology, and climatology. The results of all these studies have to be incorporated in one report, leading to a number of recommendations.

Soil investigations in the third phase

In this phase of the preparation of a development project more specialists (agriculture, engineering, irrigation, drainage, economy *etc.*) have to join the team. The main purpose is to make a development plan (avant project), which is detailed enough to inform the Government on some alternative plans of development; their costs, inputs, outputs, farm economy, marketing *etc.*

Compared with the first and second phase, the third phase of planning will take much more time and many more specialists have to co-operate, in order to provide a realistic development plan. It is not necessary that all details are worked out (*e.g.* details such as structures, canals, ditches, drains, inlets, outlets, farm boundaries, farmhouses, new villages *etc*), because this detailed work takes very much time. This is only done when the project is prepared for tendering. The idea of phase 3 is to prepare everything in such a way, that the responsible authorities obtain a good idea of what can be done successfully; how many farms can be established, what can be grown, what may be expected, and what will be the financial consequences *etc.*

As far as soil survey and land classification is concerned a semi-detailed soil survey will be neccessary. Such a survey, as well as additional land classification surveys, can easily be made by a study of soil conditions in the field, in combination with aerial photo interpretation. The well-known methods and procedures developed in the I.T.C. and applied in quite a number of countries (see I.T.C. Publications, series B, 2) and described in the Manual of Photographic Interpretation already mentioned, can be applied. The application of aerial photographs in this type of semi-detailed soil surveys has many advantages and it would be a waste of time, money and manpower, to undertake such a

survey if no recent aerial photographs of good quality and on a scale of 1 : 20,000 or 1 : 25,000 are available. If, for the first step of development, the whole country, or at least quite a large part of it , were covered by an air survey 1 : 50,000, then for the second and third phase an aerial survey 1:20,000 or 1:25,000 would be needed; only for those regions, however, which are expected to have good potentialities.

The application of aerial photo interpretation in soil surveys of development project areas often leads to soil maps showing those soil mapping units, which can easily be recognized and analysed in the stereoscopic photo-image. The study of soils in the field aims at ascertaining the soil characteristics corresponding to the characteristics of the photo-image. Very often, however, the classification of soil mapping units has also to be based on some other soil characteristics, which can only be known if soils are studied and mapped in the field. Soil texture is a good example of such a characteristic. As far as soil qualities are concerned, soil permeability is an example too.

Both soil texture and soil permeability are quite important in drainage studies. There is still a tendency, in publications on aerial photo interpretation in soils, to suggest that soil texture and even soil permeability can be determined by photo interpretation. Such publications are wrong and I deeply regret that even some firms in air survey and aerial photo interpretation continue to make misleading propaganda.

Another serious danger of applying aerial photo interpretation in soil surveys, to which attention was also drawn in the Manual (page 665), is that soil maps and reports are based on insufficient field and laboratory investigations. I have already seen various soil maps prepared in such a way. This problem could easily be solved if:

a. the method of soil survey and the technique of aerial photo interpretation were described in detail in the soil survey report,
b. the results of the detailed field investigations in all sample areas were included in the report,
c. a map, indicating the location of all profile pits and borings was attached to the soil map and report.

Unfortunately these suggestions are followed only in a few soil surveys.

For most "avant projects", the semi-detailed soil surveys made by aerial photo interpretation in combination with an appropriate quantity of field and laboratory investigations give very valuable results. The biggest advantage is still, that the most important information on soil conditions can be supplied in a relatively short time, after starting the project studies. The result is, that having these data available at an early stage of planning, the information on soils is intensively used by all the specialists needing them.

Soil investigations in the fourth phase

For the detailed planning, preceding the execution and construction of the works in a project, much data on soils is needed. For the most part this data

cannot be collected by aerial photo interpretation. A real soil survey in the field has to be made in those sections of the project area where special information on soils is needed. The role of aerial photo interpretation can often be neglected.

Conclusions

Investigations concerning planning and execution of agricultural development of a country are carried out in a number of phases which have a general application. It begins with very general work in large areas, and it ends with quite detailed investigations in certain sections of a project. The general survey executed at the beginning, and covering the whole country, or at least a great part of it, could never be done in an efficient and effective way if no aerial photographs were available and if no proper techniques of aerial photo interpretation had been developed. Soil surveys, which should provide the necessary basic data, would be almost impossible for large project areas, without applying aerial photo interpretation. The costs would be too high, there would be a great shortage of experts and work would take too much time. We therefore conclude, that aerial photographs are not only a very helpful and economic tool in the planning and preparing of development projects, but we can even state that it would be impossible to execute this type of work if no aerial photos and mosaics were available. The most economic use of aerial photographs can be made during the first two phases of planning, whereas their most effective use for soil survey purposes is made during the third phase.

In nearly all countries where development programmes are made, aerial photos and mosaics are available at the present time. However, many specialists, who make use of these photographs, often use them in a rather simple way. Much more could be done if they knew and could apply the various techniques of aerial photo interpretation.

Discussion

Mr. N. Leneuf (France) remarked that, in areas covered by a dense tropical forest, detailed field investigations in pilot areas are absolutely necessary. Dr. Buringh agreed with this.
Mr. Retzer (U.S.A.) agreed with the steps outlined by the speaker and added that it is important to realize that the required soil information cannot be determined from the stereoscope alone. No information about texture, pH, drainage, *etc.*, can be obtained from photographs.
Asked by Mr. Latarche (France) to indicate more precisely the dangers of misinterpretation incurred in phase 3, Dr. Buringh answered that the soils as such are not shown on the aerial photographs. Interpretation is guesswork, whereas soil survey quite definitely is not.