SOILS BULLETIN 29

land evaluation in europe

FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS ROME

TABLE OF CONTENTS

INTRODUCTION

The Working Party on Soil Classification and Survey of the European Commission on Agriculture held its ninth and last Session in Ghent, Belgium, in September 1973. It was then officially dissolved in accordance with a decision of the Executive Committee which considered that the main task of the Working Party, i.e. the compilation of the Soil Map of Europe was practically completed and decided that any new activities should be carried out through ad hoc Working Parties.

Accordingly, it was recommended that an ad hoc Consultation of Experts would meet in 1975 with a view to developing methods and criteria adapted to European conditions in order to make use of the data assembled during the compilation of the Soil Map of Europe.

Systematic interpretation of such data, together with other physical and other socio-economical factors of the environment, is required for use as background information in agricultural, industrial and urban extension planning. Under European conditions, such interpretations will generally be made in view of an intensive use of the land and will be aiming at the conservation of the environment quality.

A methodology for land evaluation is being developed in FAO and will be used for the interpretation of the FAO/Unesco Soil Map of the World with a view to making a global evaluation of the land resources available for agricultural development. The present Consultation will study the possibility of using the FAO methodology in European conditions, using the information available on the 1:1 000 000 scale Soil Map of Europe as background information. An initial work programme for the next biennum will be worked out by the Consultation and it is hoped that the first results will be available for discussion at a future meeting of the Working Group on Land Evaluation.

LIST OF PARTICIPANTS

Delegates

Belgium:

Prof. J. Ameryckx
University of Ghent
Rozier 44
B 9000 Ghent

Prof. C. Sys
University of Ghent
Rozier 44
B 9000 Ghent

Prof. R. Tavernier
University of Ghent
Rozier 44
B 9000 Ghent

Bulgaria:

Prof. V. Koinov
Agricultural Academy
Bul. Dragan Zankov 8
Sofia

Dr. S. Krastanov
N. Poushkarov Institute of Soil Science
s. Bankia 5
Sofia

Dr. E. Petrov
Agricultural Academy
Bul. Dragan Zankov 8
Sofia

Dr. S. Savov
Ministry of Agriculture
"Christo Botev" 55
Sofia

Czechoslovakia:

Dr. J. Hrasko
Research Institute for Soil Science
and Agrochemistry
Roznavska 23
818 31 Bratislava

Dr. J. Nemecek
Research Institute of Soil Science
160 00 Praha 6 - Ruzyne

Dr. M. Dzatko
Research Institute for Soil Science
and Agrochemistry
Roznavska 23
818 31 Bratislava

Czechoslovakia (cont'd):

Dr. E. Fulajtár
Research Institute for Soil Science
and Agrochemistry
Roznavska 23
818 31 Bratislava

Dr. C. Juran
Research Institute for Soil Science
and Agrochemistry
Roznavska 23
818 31 Bratislava

Dr. J. Kimák
Federal Ministry for Foreign Affairs
110 00 Praha 1

Dr. F. Kopso
Ministry of Agriculture and Food
of the Slovak Socialist Republic
800 00 Bratislava

Dr. J. Neumann
Federal Ministry of Agriculture and Food
Tesnov 65
110 06 Praha 1

Prof. S. Sotáková
University of Agriculture
Nitra

Dr. M. Surina
Research Institute for Soil Science
and Agrochemistry
Roznavska 23
818 31 Bratislava

Dr. F. Zrubec
Research Institute for Soil Science
and Agrochemistry
Roznavska 23
818 31 Bratislava

Federal Republic of Germany:

Dr. E.C. Läpple
Ministry of Food and Agriculture
Bonner str. 85
D-53 Bonn

Hungary:

Dr. L. Gerey
National Institute for Quality
Testing of Agricultural Products
Kaleti str. 24
Budapest II

Prof. T. Jankovits
Hungarian Academy of Sciences
Mester u. 61
Budapest 1095 IX.

Hungary (cont'd):

Prof. P. Stefanovits
University of Agriculture
Frankel. L. 9.
H-2103 Gödöllö

Prof. I. Szabolcz
Research Institute of Soil Science
Herman Otto str. 15
Budapest II

Netherlands:

Mr. K.J. Beek
International Institute of
Land Reclamation
Post Box 45
Wageningen

Mr. G.A. Oosterbaan
Government Service of Land and Water Use
Maliebaan 21
Utrecht

Prof. L.J. Pons
Department of Soil Science and Geology
Duivendaal 2
Wageningen

Dr. R. van der Schans
Soil Survey Institute
Marijkeweg 11
Wageningen

Norway:

Mr. O. Fjaervoll
Chief, Land Use Section
Department of Agriculture
Oslo 1

Poland:

Prof. J. Glinski
Institute of Agrophysics
ul. Krak. Przedmiescie 39
20-076 Lublin

Romania:

Prof. N. Florea
Research Institute for Soil
Science and Agrochemistry
Bdul Ion Ionescu de la Brad
4 Bucharest, sect. 1

Spain:

Dr. J. Bardaji
Institute of Agrarian Reform
Desarrollo Agrario
Velaz Quez 147
Madrid

Dr. F. Lazaro
Instituto Nacional de
Investigaciones Agrarias
Avda Puerta de Hierro
Madrid - 3

Sweden:	Prof. L. Wiklander Department of Soil Science Stenbergsv. 2A 752 41 Uppsala
United Kingdom:	Dr. B. Wilkinson ADAS Shardlow Hall Shardlow Derby
Yugoslavia:	Prof. N. Miljkovic Agricultural Faculty Akademska 2 Novi Sad
	Prof. A. Skoric Agricultural Faculty Rendiceva 28 Zagreb
Observer	
U.S.A.:	Dr. D.E. McCormack U.S. Department of Agriculture Washington, D.C. 20250
FAO Staff:	Mr. G.M. Higgins Technical Officer (Land Classification) Soil Resources Development and Conservation Service FAO Rome
	Dr. A. Pécrot Senior Officer (Soil Resources) Soil Resources Development and Conservation Service FAO Rome
	Miss I. Calcagni Secretary FAO Rome
Organizing Committee:	Dr. J. Hrasko Dr. J. Nemecek Dr. F. Kopso Dr. J. Neumann
Technical Staff:	Miss M. Degnerová, Czechoslovakia Mrs. V. Kollárová, Czechoslovakia Mrs. D. Malacová, Czechoslovakia Mrs. T. Páleniková, Czechoslovakia Miss K. Reznicková, Czechoslovakia

Interpreters:

Mrs. T. Cihelková
International Organization of Journalists
Praha

Mr. A. Cech
International Organization of Journalists
Praha

Mr. T. Azcarate
FAO, Rome

Miss M.E. Bonavia
FAO, Rome

Mr. F. Piraud
FAO, Rome

Mrs. I. Randone
FAO, Rome

Mr. J.M. Sala
FAO, Rome

Mrs. G. Whyte
FAO, Rome

Officers of the Session

Chairman: Dr. J. Hrasko

Chairmen of the technical sessions:

Prof. L. Wiklander
Prof. R. Tavernier
Prof. L. Pons
Prof. I. Szabolcz

AGENDA

Monday, 1 September		
	09.00–10.00	Opening of the Session
	10.30–12.30	Soil Map of Europe
	14.00–16.00	Soil Map of Europe
	16.00–19.00	Visit to the AGROKOMPLEX 75 and film on the Nitra State Farm
	19.00	Opening Cocktail
Tuesday, 2 September		
	09.00–10.30	Review of some approaches to Land Classification in Europe
	11.00–12.30	The Framework for Land Suitability Evaluation
	14.00–15.30	Land Utilization Types
	16.00–17.30	Land Characteristics and Land Qualities
Wednesday, 3 September		
	09.00–10.30	Economic Inputs and Diagnosis of Land Suitability
	11.00–12.30	Regional Correlation of Land Evaluation and Exchange of Information; use of the Soil Map of Europe for Land Evaluation
	16.00–17.30	Conclusions and Recommendations Any Other Questions Date and Place of Next Session Closing Procedures
Thursday, 4 September		Field Trip to Gabcikovo State Farm
Friday, 5 September		Field Trip to Poniky Cooperative
Saturday, 6 September		Departure for Bratislava and the respective home countries

ACKNOWLEDGEMENTS

The Consultation expressed its gratitude to the Government of Czechoslovakia and particularly to the Ministry of Food and Agriculture and the Agricultural University of Nitra for the very kind hospitality offered to the Session.

The Consultation also expressed its high appreciation to Dr. J. Hrasko and his collaborators, Dr. J. Nemecek and Dr. J. Neumann for the excellent arrangements made for the session and for the organization of the Study Tour.

OPENING SESSION

The Technical Consultation on Land Evaluation for Europe was opened by Dr. J. Hrasko, Chairman of the Organizing Committee for the meeting, Prof. S. Sotáková representing the Rector of the Agricultural University of Nitra, Prof. I. Szabolcz, Vice Secretary of the International Society of Soil Science and by Dr. A. Pécrot of the Land and Water Development Division of FAO.

The opening session was honoured by the presence of H.E. the Minister of Food and Agriculture of the Czechoslovak Socialist Republic, Dr. J. Janovic who, in his welcoming address, emphasized the fact that the signing of the Helsinki Summit Conference conclusions by the representatives of the European States opened a new way for multilateral cooperation. Dr. J. Janovic informed the session that:

The Czechoslovak Government has, over a long period of time, devoted its attention to the problem of soil improvement and the increase of soil fertility. Maps of production areas were set up for the purpose of agricultural production management as long ago as 1950-1953. From 1961 to 1970 a complex investigation of soil was carried out resulting in a detailed soil map (scale 1:10 000) and measures were proposed providing for a continuous increase of soil fertility. In 1971 work started on a system of land evaluation.

In Czechoslovakia, just as in other advanced industrial and agricultural countries where large areas of land are used for building construction and where soil pollution in industrial regions are a matter of concern, great attention is devoted to soil protection and a series of legal measures were adopted by the Czechoslovak Government. Large sums of money were allocated for soil fertilization thus providing for a real socialist management of the soil. That such an orientation on soil management had been correct, was further confirmed by higher crop yields, an increased agricultural production and by the improvement of agricultural workers' standard of living.

In its endeavours for self-sufficiency in food production, Czechoslovakia has formulated new objectives and set up new tasks for the scientific and research workers. Solving of these new tasks will be based mainly on the cooperation with other countries. It was highly appreciated that this Consultation was held in Czechoslovakia and it is expected that it will open new possibilities for the application of knowledge of soil and environment which will lead to a further increase of agricultural production.

At the conclusion of his address, his Excellency invited all the participants to visit the State Agricultural Exhibition "AGROKOMPLEX 75" in Nitra, devoted to soil, soil protection, soil improvement and rational soil utilization.

Prof. Sotáková, Head of the Department for Agrochemistry and Soil Science of the Agricultural University of Nitra, welcomed the participants to the meeting.

On behalf of the International Soil Science Society, Prof. I. Szabolcz welcomed the participants to the Consultation. He reminded that the ECA Working Party on Soil Classification and Survey, which was the predecessor of the recent working group, carried out its activity always in close collaboration with the ISSS. Soil maps of Europe and new classification systems were elaborated with the assistance of ISSS and the European National Soil Science Societies. Meetings and numerous conferences of these societies were often devoted to the particular problems of this joint activity.

The new ISSS programme was approved during the 10th Congress of the Society in Moscow, last year. In this Congress, particular attention was paid to the up-to-date methods of soil survey and classification as well as to the problems of soil utilization and conservation. It is hoped that during the forthcoming years the Society will contribute effectively to the work of this working group in order to elaborate modern methods of soil interpretation and land evaluation in Europe.

He wished good work and much success to the Consultation.

On behalf of the Director-General of FAO, Dr. A. Pécrot welcomed the delegates and observers to the Session. He expressed FAO's gratitude to the Government of Czechoslovakia and the Agricultural University of Nitra for the hospitality offered to the Session and for the organization of the Study Tour. He also expressed appreciation to the European Commission on Agriculture and the U.S. Soil Conservation Service for the continued interest shown in the land evaluation activities in Europe as a follow-up to the activities of the Working Party on Soil Classification and Survey which held its last session in Ghent, two years ago.

Land evaluation will be essentially based on the information and experience assembled during the compilation of the Soil Map of Europe, together with other data on hydrology, climatology, agronomy, as well as social and economic inputs. Land evaluation is therefore a team work which requires close cooperation between resource surveyors and socio-economic specialists.

A standard methodology has to be developed for this purpose and Dr. Pécrot explained that FAO is currently in the process of setting up a general Framework for Land Suitability Evaluation and will undertake global assessment of the world land resources in accordance with a resolution of the World Food Conference (Rome, 1974).

The main object of the present Consultation is therefore to present the FAO Framework for Land Suitability Evaluation, discuss its suitability for European conditions and agree on an outline for a land evaluation programme in Europe.

Soil survey interpretations and land evaluations for various purposes and following different approaches are being carried out in Europe. Exchange of information between countries is difficult owing to the great diversity of methodologies. Land evaluation in Europe is at present at the stage reached by soil survey and soil classification work some 25 years ago. At that time, the soil classification systems and nomenclatures and the field survey methods were very different, and communication between soil scientists from different countries was not easy. The activities of the ECA Working Party on Soil Classification and Survey and the compilation of the Soil Map of Europe based on the FAO legend were the keystones of the standardization of soil nemenclature in Europe.

It will be the main task of the group of specialists participating in the Consultation to define a common approach and basic principles to land evaluation suitable to European conditions. Such an achievement will require time and effort.

PAPERS, DISCUSSIONS AND RECOMMENDATIONS

PART A - SOIL MAP OF EUROPE

1. Progress

a. Reports of the Regional Correlators

Reports had been received from the soil correlators of Regions 3, 4, 5 on the activities which had taken place in their respective regions since the last session of the Working Party on Soil Classification and Survey (Ghent, Belgium, 1973). In a letter received after the Consultation, Dr. R. Glentworth reported that no further correlation activities had taken place in Region 1 during the biennium. No report on Region 2 was available.

Region 3. Prof. Koinov reported that the fifth and final draft of the Soil Map of Bulgaria at 1:1 000 000 scale had been correlated with neighbouring countries and forwarded to the Correlation Centre. As a result of a decision made at the Ghent meeting, where it was decided that the separation between Chernozems and Kastanozems could more adequately be done at a chroma of 2 in the mollic epipedon; no Kastanozems have been recognized.

In addition, after reviewing the available data on the chroma of the Bulgarian Chernozems, it was decided that some of the leached Chernozems should be included in the Haplic Chernozems. These decisions were made in agreement with the representatives of the South Eastern European countries and were reflected in the 5th draft of the soil map of Bulgaria.

Mr. Florea also reported on his correlation activities:

- in 1973 he participated in a field trip in Hungary together with Dr. Stefanovits. Chernozems, Luvisols, Cambisols, Lithosols, Phaeozems and Vertisols were studied.

- border correlation (Romania/Bulgaria) was continued, however some problems still remain to be solved. For instance, Haplic Chernozems and Orthic Solonetz in Bulgaria are mapped as Haplo-Calcic Chernozems and Gleyic Solonetz in Romania. Haplic Phaeozems, Stagno-Gleyic Luvisols and Podzoluvisols are not shown on the map of Bulgaria.

- border correlation (Romania/Hungary) is practically completed.

Region 4. In a report sent to the Correlation Centre before the Consultation by Prof. Mückenhausen, the following correlation activities were mentioned:

- discussions on the soil map of Poland with Prof. Dobrzanski and Prof. Kuznicki.

- correlation along the border with Czechoslovakia with Dr. Hrasko and Dr. Nemecek, the border with Luxembourg with Mr. Wagner, the border of Austria with Prof. Fink.

- for the above countries, the list of associations was again checked.

Region 5. According to the report sent to the Correlation Centre before the Consultation by Prof. Låg, regional correlation meetings were held on 11 March 1974, 21 October 1974 and 21 April 1975. Problems of correlation of mapping units and adjustments along the border between Norway and Finland were discussed. Special problems were: subdivision of the Podzols, nomenclature of immature mountain soils and shallow humus soils on hard rock.

b. Report of Correlation Centre

Although the completion of the final draft of the Soil Map of Europe was scheduled by the end of 1974, the Correlation Centre was unable to adhere to the schedule for the following reasons as explained by Prof. Tavernier and Prof. Ameryckx:

1. The contribution from France, due in March 1974, is still missing.

2. Border correlation between some countries is still a problem; the level of detail of the soil pattern and soil limits has to be uniformized and it was recommended not to show mapping units smaller than 1/2 sq. cm.

3. Considerable improvement of the correlation of mapping units between countries is still required in all regions. The Correlation Centre received a revised draft of the legend and/or the map, of the following countries in 1974/75:

Country	Draft No.
Bulgaria	5
Czechoslovakia	2
Denmark	2
Finland	3
Greece	2
Ireland	2
Netherlands	3
Romania	3
Sweden	2
United Kingdom	2
Yugoslavia	3
Norway	2

However, some drafts do not seem to be final.

2. Technical Discussions

A first draft of the list of mapping units (around 700) in table form was presented to the meeting. It was pointed out that a number of mapping units were practically identical except for very minor differences in slope, texture or distribution percentage of the various soil units of the association. Such small, non-significant and often subjective differences in the mapping units of neighbouring countries should be ironed out in order to improve the presentation as well as the technical level of the map.

It was not possible to review the list of mapping units during the Consultation. It will now be the responsibility of the Regional Correlators to organize regional meetings for correlation of the mapping units between countries. A list of soil units present in the Soil Map of Europe was also provided to the Consultation.

To meet existing problems, the following points were agreed:

Fourth level subdivision: In general, soil units may be subdivided to the third level (e.g. Phf: Ferri-Humic Podzols); further subdivisions at the fourth level should be avoided (e.g. Ckcb: Vermi-calcaro-calcic Chernozems should be Ckc: Calcaro-calcic Chernozems).

Fluvisols: In the report FAO 33/1968, the unit Fluvic Gleysols existed. This unit has been deleted afterwards, and all "fluvic" soils have been grouped in the Fluvisols. Furthermore, in the definitive legend for the Soil Map of the World (Vol. I/1974), the Fluvisols are outkeyed as No. 4 before the Gleysols as No. 6, and it is emphasized that most Fluvisols are hydromorphic. It was agreed that, in the legend for the Soil Map of Europe, hydromorphic Fluvisols can be distinguished at the 3rd level, e.g. Gleyo-eutric Fluvisols. As a result, some Gleysols (on recent alluvial deposits, see definition) may be classified as Gleyo-...Fluvisols.

Lithosols: Subdivision to the second level (Eutric, Calcaric, Dystric Lithosols) should be made in all countries.

Podzols: Proposals for the subdivision of Podzols were prepared by the Correlation Centre in collaboration with the FAO Secretariat and sent to the members of the Working Party. Comments were received from several countries, but no general agreement could be reached. It was finally agreed that the following ranges of the Fe/C ratio would be adopted as differentiating factor of the Podzol units:

Orthic Podzols: spodic B with Fe/C between 0.1 and 6

Humo-orthic Podzols: spodic B in which a subhor. has Fe/C between 0.1 and 0.3

Ferri-orthic Podzols: spodic B with, in all subhor., Fe/C between 0.3 and 6

Humic Podzols: spodic B with a subhor. lacking sufficient iron to turn redder on ignition ($Fe/C < 0.1$)

Ferri-humic Podzols: idem as humic Podzols; furthermore the lower part of the spodic B has a subhor. with Fe/C between 0.3 and 6

Ferric Podzols: spodic B with Fe/C ratio of > 6

Rendzinas: subdivision to the second level (Orthic, Cambic) should be made in all countries.

Shallow, stony high mountain soils: Their classification in the FAO legend was discussed and it was agreed that the best solution would be to show these areas on the map as miscellaneous land units (rock debris) in association or not with Regosols and Lithosols.

Chernozems: Chernozems having hydromorphic properties between 50 and 125 cm. may be mapped as Gleyo-...Chernozems.

Solonchaks: Objections raised on the definition of "High Salinity" in Volume I (Legend) of the FAO/Unesco Soil Map of the World were withdrawn after it was explained that the words "more than" should be inserted before "4 mmhos" in the last but one line of the definition. The depth limits (125-90-75 cm) were also questioned by one delegation having soils with saline subsoil and slightly saline topsoils which in their opinion do not qualify as Solonchaks.

3. Recommendations for further work on the Soil Map of Europe

The following recommendations were formulated by a subcommittee under the chairmanship of Prof. Tavernier for intensification of correlation work and completion of the country maps and lists of mapping units.

i. Each delegate is requested to check carefully the list of mapping units distributed at the meeting and to fill in the lacking data such as composition, extension, climate, etc., either on the list itself or on the legend tables for each country. It was agreed that the complete tables should be sent to the Correlation Centre before the end of the year.

ii. With respect to the classification of Rendzinas and Lithosols, subdivision at the second level should be introduced or, if not possible, a complex of the two subunits may be made.

iii. It is reminded that a maximum of three levels should be used in the soil units.

iv. Use should be made as much as possible of existing mapping units in other countries in order to obtain a more uniform representation of the soil pattern.

v. Regional correlators are urged to take responsibility for correlating some of the associations used in various countries which apparently seem to be very similar in composition.

vi. Profile descriptions and analytical data for most representative soils should be forwarded to the Correlation Centre with copy to the Regional Correlator with comments on the variability of the soils and main land uses.

PART B - LAND EVALUATION FOR EUROPE

1. Present Position

a. APPROACHES TO LAND SUITABILITY EVALUATION IN EUROPE

An Introduction to the Approaches to Land Suitability Evaluation in Europe

by

L.J. Pons

Summary

One of the first steps needed for the establishment of a common system for land classification for Europe is an inventorization of present systems in use in the different countries. For this purpose the FAO framework is taken as a basis for comparison. In two tables several aspects of a selected number of European land suitability classifications are compared with four main topics of the FAO framework. Table 1 is descriptive and in table 2 an evaluation of these aspects has been attempted in a very simple way. The four topics are: 1) socio-economic and physical assumptions; 2) types of land use; 3) soil or land characteristics or qualities; 4) systems of classifications.

In topic 1 a distinction is made between approaches with: a) socio-economic and physical assumptions; b) socio-economic assumptions only; c) physical assumption only and d) no or very limited numbers of assumptions. The classification of this topic is rather unsatisfactory because in many publications about land suitability, these data are lacking.

In topic 2 the approaches are evaluated according to whether they distinguish major types of land use (e.g. arable land, grass land), subdivisions of the major land use in more detailed types (e.g. intensive and extensive grass land) and land use for specific crops (e.g. wheat, sugarbeet, etc.). If, in the approaches, suitabilities for irrigation are provided, this fact is also noted. A distinction is made between approaches with a clear description of the requirements for a certain land use type and those lacking such descriptions. Topic 3 records whether the approaches use soil characteristics only or soil characteristics and some land characteristics, or land characteristics. A further subdivision is made between approaches using only land characteristics, using characteristics combined to some kind of qualities, or using land qualities comparable with those of the FAO framework.

In topic 4 the system of classification is considered. Distinctions are made between a categoric system, a numerical system or some mixed systems. Judgment is also given whether the indexes (if used) are calculated by multiplication and correction factors or by adding and subtracting. Included in this topic is also a distinction in qualitative systems and semi-quantitative systems. The number of generalization levels is given and the number of main classes.

In conclusion, it is considered that the differences between the European approaches seem greater than they are in reality.

Approaches to Land Evaluation in East European Countries

by

S. Krastanov and I. Kabakchiev

Summary

Three main concepts are differentiated in the land evaluation methods used in almost all East European countries: soil assessment, land productivity evaluation and economic evaluation of land.

The comparative evaluation of soils as regards their natural properties is known as soil assessment.

According to the terminology of East European countries the concept of "land" is, to a considerable extent, covered by that of "ecologic conditions". In this connection, land productivity evaluation embraces a complex of physico-geographical and natural factors determining the objective (ecological) conditions when using land as means of production (soil, climate, geographic location, water status, etc.).

Economic evaluation of land is an approach used to make an economic evaluation of fertility as a specific economic form of appearance of the actual soil fertility or, in other words, evaluation of social and economic conditions such as: intensification, mechanization, profitability, etc. The latter defines the social profitability of physical parameters of land.

The three main concepts given above for land evaluation show that soil assessment is the first stage to start with when evaluating land. The following stage is land productivity evaluation which is, in fact, a correction of soil assessment by means of the respective correction coefficients for climate, humidity, etc. At the end, the economic evaluation of land comes as a final, concluding stage of the complete evaluation of land as a means of production.

Specificity of land evaluation is another feature of the methods used in East European countries for evaluation of land. The land is, in fact, evaluated specifically for each crop and not as regards suitability (for agriculture). A common feature of the approach to land evaluation in all those countries is the combining of land evaluation and land budget. A general concept, known as "kadastar" is, in fact, both qualitative and quantitative assessment of land used in agriculture.

The conventionality of the evaluation is also a common feature. Soil assessment and land productivity evaluation are actually valid only at a definite level of technology of crops.

Irrespective of the large number of common features in the approaches to land evaluation in the different East European countries there is something specific characterizing each one of them. This is due to different reasons: degree of development of the problem, specificity of physico-geographic conditions, climatic factors, level of agriculture, etc.

No common method has so far been accepted in the USSR for land evaluation. Different methods are used in the different republics and the research work carried out on the problem varies to a really great extent, respectively. Only recently a draft project was made at the Institute of Soil Science for a common method to be valid for the cereal crops growing regions in the USSR. It covers the zones of chernozems and podzolic soils in the USSR, as well as the most widespread crops in those zones such as: rye, wheat and potatoes. The main principles in the project are the division of the territory into homogeneous climatic-economic regions and establishing a correlation between productivity of the above three crops and soil properties.

The methods accepted in Romania for soil assessment are based upon analysis of the separate elements of environment. Soil assessment is made on homogeneous areas, the so-called ecologic units. Each one of the factors possesses invariable quantitative parameters in the boundaries of those units.

Four categories have been assumed for a conventional grouping of factors of ecologic environment, in a closed scale of 100 grades where each category can move inside certain boundaries (soil: 0-50 grades; climate: ±20 grades; relief: ±15 grades; and hydrology: ±15 grades).

The essence of the methods used for a relative evaluation of soils in Bulgaria is actually the evaluation of the factors determining soil fertility as regards certain crops. Fertility is determined by the rate at which transformation of nutrients takes place in forms available to plants, as well as the velocity of their transportation to plants. Under the conditions of an intensive agriculture when large amounts of fertilizers are used, the soil properties that assure its most efficient use are of primary importance. The method developed for a relative evaluation of land is based on this.

The land evaluations, calculated from natural indices, are the basis on which economic evaluation is made. The following indices of economic evaluation were approved in Bulgaria:

i. Total production per 100 leva direct working expenses.

ii. Total production per hectare.

iii. Net income per hectare.

The economic evaluation is made at a definite level of development and productive forces: tools and equipment, skill and ability of people engaged and form of organization of the agricultural enterprise. It is separately made for the present structure of crops and for the future structure, being calculated from land productivity evaluation.

The methods used for land evaluation in the other East European countries consist of elements from one or other of the methods used in the USSR, Bulgaria or Romania.

b. COUNTRY REPORTS

BELGIUM

Professor Ameryckx reported that in land evaluations carried out by the Soil Survey Centre, the mapping units (soil series of the 1:50 000 soil map) are classified in 5 suitability classes, according to their actual production (under normal management: use of fertilizers, pesticides, tillage, etc.) as follows:

Class 1: giving a production of > 90% of the optimal production—very suitable;

Class 2: giving a production of 75-90%—suitable;

Class 3: " " " " 55-75%—moderately suitable;

Class 4: " " " " 55-30%—poorly suited;

Class 5: " " " " < 30%—unsuitable.

The suitability classes are established for all the important crops that are grown on a given mapping unit.

For reallotment purposes, a numerical land suitability evaluation with a range of 0-1 000 points is used, taking into account not only pedological factors, e.g. economical considerations.

Additionally, 5 capability classes are distinguished, based upon limitations imposed by the soil:

Class I: no limitations - normal management is possible;

Class II: some limitations, e.g. slight erosion hazard on weak slopes, need for use of important quantities of fertilizers (on sands);

Class III: limitations are important, e.g. serious erosion hazard, tile drainage needed, etc., but all measures to relieve them can be taken by the farmer himself;

Class IV: limitations are severe and of the kind that require special measures by the authorities, e.g. extensive drainage works including evacuation canals, anti-erosion protection, etc.;

Class V: limitations are so severe that they make any agricultural use impossible, (e.g. very steep slopes).

BULGARIA

Prof. Krastanov reported that the essence of the methods used for a relative evaluation of soils in Bulgaria is actually the evaluation of the factors determining soil fertility as regards certain crops. Fertility is determined by the rate at which transformation of nutrients takes place in forms available to plants, as well as the velocity of their transportation to plants. In the case of an extensive agriculture system, there should be most reliance on natural soil fertility, this being mainly estimated by nutrient supply in the soil. Under the conditions of an intensive agriculture system, when large amounts of fertilizers are used, the soil properties (that assure its most efficient use) are of primary importance. The method developed for a relative evaluation of land, is based on this. Indices considered as exercising the strongest effect on the development of arable crops under the conditions of a comparatively high intensification, are: a) soil texture of arable layer for field crops and subsoil for orchards, forest trees and vineyards; b) depth of humus horizon; c) depth of soil profile (for soils formed on solid rocks only); d) texture coefficient; e) pH of arable layer; f) humus content in arable layer; g) level of groundwater table.

When selecting soil indices, the availability of data for the respective indices has also been taken into consideration.

As regards the effect of the above soil properties on soil fertility, they are normally graded from 0 to 100. Each soil type is evaluated for the major crops grown in the country (or in some of the regions in the country being characterized by specific natural conditions), namely: wheat, maize, sunflower, alfalfa, sugarbeets, cotton, tobacco, orchards (apples, pears and plums), vegetables (tomatoes and pepper), vineyards, natural meadows and pastures, Virginia variety of tobacco, fibre-yielding flax, rice, peaches and cherries.

The final evaluation values of soil, as regards a specific crop, are obtained as an arithmetic mean of the assessments given for soil properties and are expressed in grades from 0 to 100. When some of the indices are 0, the total grade is also 0. This is in agreement with the law of indispensability of soil fertility factors.

Besides soil conditions, climate also strongly affects plant development. It is evaluated separately. Requirements during vegetation periods have also been considered of primary importance when evaluating suitability of climatic conditions as regards growing different arable crops in the different climatic regions. According to the availability of those requirements, the country is divided into regions variously suited to the growth of certain crops.

With crops requiring high temperatures (cotton, vineyards, tobacco), when temperature deficiency is a limiting factor both as regards growth and quality of produce, temperature is the most important factor for evaluation of climatic conditions. The total temperature for the whole vegetation period is used as an index of evaluation and characterization of temperature conditions.

With crops which have no special requirements as regards high temperature (wheat, maize, sugarbeets, sunflower), for which the existing temperature conditions are adequate up to a high altitude above the sea level, conditions of humidity are considered to be the major factor in evaluating climatic conditions. Conditions of humidity are characterized by different indices with the different crops - hydrothermic coefficients, coefficients of moistening, water balance, etc.

The evaluation of climate is expressed as a coefficient from 0 to 1. It is used to correct soil evaluation grades and to calculate the final evaluation of ecologic conditions, called field assessment number.

The advantage of the method accepted for evaluation of ecologic conditions lies in the fact that such an evaluation is relatively constant. The changes occurring in soil, as a result of major amelioration practices or any other changes such as erosion, salinization, etc., can be included by correction of the already established main grade using the respective correction coefficient.

Coefficients of irrigation, stoniness, erosion and salinization are also established.

The land evaluations calculated from natural indices, are the basis on which economic evaluation is made. The main principles of economic land evaluation in Bulgaria are as follows:

a. Systems of indices are used;

b. Indices must give expression to both differences in natural conditions and differences in economic conditions at the same time;

c. Indices must not consider elements of subjectivity;

d. Indices must ensure the measuring of the effect of land quality on bulk of production primarily, as well as size of income and efficiency of labour and means.

The above principles being taken into consideration, the following indices of economic evaluation were approved in Bulgaria:

i. Total production per 100 leva direct working expenses.

ii. Total production per hectare.

iii. Net income per hectare.

When evaluating land from an economic point of view some natural indices are also used such as: slope of land, resistance of soil to tillage, length and configuration of plot.

The economic evaluation is made at a definite level of development and productive forces: tools and equipment, skill and ability of people engaged and form of organization of the agricultural enterprise. It is separately made in the present structure of crops and for the future structure, being calculated from land productivity evaluation.

CZECHOSLOVAKIA

Prof. Nemecek reported the following approaches used since 1945.

"Geonomical" land classification -
Delineation of individually evaluated tracts of land: cadaster, agro-ecological zone.

Diagnostic land criteria:

Climatic data, soil texture class and depth; matching of land conditions with crop requirements based on empirical qualitative data.

Land evaluation classes:

a. maize, sugarbeet, potatoes, mountain production types, regions (reflecting main climatic conditions). Wheat, barley, rye and oats production subtypes, subregions (reflecting the above mentioned soil properties).

b. suitability zones, 4 suitability classes for each of ca 40 crops (some economic factors also taken into account).

Application:

This land classification system has been widely used for state and regional planning purposes and for comparing the results of agricultural research and practice.

Land classification for economic aims, economic land evaluation - Delineation of individually evaluated tracts of land: cadastral area (cooperative and state farm area).

Diagnostic land criteria (characteristics/qualities):

Climatic parameters (especially the sum of positive temperatures - >10°C, mean temperature in the growth period, duration of the growth period, annual precipitations, probability of the occurrence of dry periods and drought hazards in growth period), soil-relief complexes referred to cadastral (farm) areas - relevant for economic evaluation. Readily available stores of crop yields and economic parameters in a computerized data bank (areas under particular crops, data about market production, recurrent and non-recurrent inputs).

Land classification units:

The land is classified at two categorical levels:

- 7 great groups of land units reflecting the main climatic and geomorphological conditions in the CSR and in the SSR;
- 74 land units in CSR and 63 in the SSR defined by the specific soil and relief patterns (associations).

Economic land evaluation classes:

A lot of particular economic land classification systems can be derived from the stored data.

Land tax assessment classes (zones):

This system involves 30 classes of a fixed land tax rates for better environmental conditions and sale surcharge rates for worse environmental conditions. The rates (in monetary form per ha) are derived from an economic analysis and they refer to land classification unit groups. They serve as an economic tool for equalizing different land productivity, caused by variations in physical land qualities.

Application:

After the tax and economic assessment system had been applied the differences in profitability ($\frac{\text{net income}}{\text{costs}}$ x 100 in KCS) among the land zones of the country (due to natural environmental conditions) were levelled as shown in the following table:

Land zone	Profitability rate before application of system	Profitability rate after application of system (1973)
1.	25.2	17.0
2.	21.9	15.5
3.	18.4	13.9
4.	18.5	14.9
CSR 5.	19.1	17.7
6.	16.2	16.8
7.	15.8	16.2
8.	13.1	16.6
9.	10.8	17.7
10.	6.0	15.7
11.	2.9	13.8
2.	22.0	16.2
3.	22.2	16.6
4.	18.7	15.1
SSR 5.	17.8	18.2
7.	12.7	13.0
9.	7.1	12.5
10.	3.0	11.6
11.	- 2.9	10.4
12.	-14.6	11.4
CSR	17.4	16.2
SSR	6.0	13.1
CSSR	13.2	15.1

The land tax assessment system was put into practice in 1967; the tax rates were changed in 1974. The land classification with reference to a computerized data bank, is widely used in economic research.

Soil survey interpretations -
Delineation of individually evaluated tracts of land: large scale (1:10 000) soil mapping units and their groups.

Diagnostic land criteria:

Mainly soil profile properties and some land qualities; matching of environmental data with crop and cultural requirements based on qualitative empirical data.

Land classification classes:

Groups of large scale soil mapping units.

Land evaluation classifications:

Land capability c., (land suitability c.), agro-ecological regions.

Application:

Elements of the above mentioned classifications are included in explanatory texts to soil maps. They are also used in farm and project organizations because a qualitative empirical soil survey interpretation does not satisfy present day needs.

<u>Modern approaches to agricultural land classification and land evaluation -</u>
Delineation of individually evaluated tracts of land:

i. elementary pedo-ecological units as a reference basis for quantitative matching of land properties and qualities with agro-economic responses;

ii. pedo-ecological associations referred to farm plots and to farm areas for the application of the land evaluation system.

Land classification units:

The land is classified at three categorical levels:

- main pedo-ecological units (ca 80 both for the CSR and the SSR) reflecting a) significant units of soil taxonomy, defined by specific sets of diagnostic horizons including their essential lithologic variants; b) expression of slope steepness, gravel and presence of stones and limited soil depth; c) complexes and catenas (microcombinations) in areas of hydromorphous soils;

- similar land units occurring under different climatic conditions are separated; 10 climatic classes are used;

- the above mentioned units are subdivided in accordance with the angle of slope, slope aspect, stone and gravel content classes.

Mapping of pedo-ecological units, storing of physiographic characteristics in a data bank:

Soil-ecological units are being mapped (1973-1977) at a scale of 1:10 000 (topographical maps at scale 1:5 000). Location, area, area distribution pattern, relationships to adjacent units, and additional characteristics (soil improvement, cultures) are stored on magnetic tapes. The digitizing of land maps for successive interpretative purposes is anticipated.

Sampling of economic data from representative and homogenous farm plots and their storing in a data bank:

A selection of more then 6,500 farm plots in the CSR and 3,500 in the SSR has been made, representing approximately one quarter of the land classification units. The following data are now being obtained and stored on magnetic tapes:

- for 30% of selected farm plots, yields of the main crops (11) and fertilizer costs;
- for 70% of selected farm plots, a more extensive set of data: yields of the 11 main crops; preceding crops; weather conditions and recurrent inputs (labour and material costs required for production, fertilizer consumption, practices in preparing, cultivating and conserving land, services and equipment). Yield data and fertilizing costs are additionally sampled from crop variety testing stations.

Envisaged processing of the crop yields and recurrent input data in relation to environmental factors:

- assignment of the main crop yields/costs data to pedo-ecological units, inter and extrapolations, grouping of elementary units;
- examination of the relations between particular factors of the environmental conditions set (climatic, main edaphic, relief factors and properties) and of crop yields with characteristic groups of farm practices and labour costs. Search for diagnostic criteria. Grouping of pedo-ecological units from different points of view. Making use of simple and multiple correlations and regressions, factor and discriminant analysis.

Anticipated quantitative economic land evaluation systems:

- for arable land (without reclamation and improvement);
- for grassland (with reclamation and improvement);

i. Crop yield and cost ratio classification of arable land based on grouped pedo-ecological units. This classification is considered a fundamental output of the processing of the stored land physiographic and economic data (land information system). When applying this classification for the farm area evaluation, the economic consequences of land units distribution pattern and their degree of contrast (land ecological heterogeneity) will be taken into account.

ii. Grassland productivity rating:

Because of the lack of relevant productivity response data for meadows and pastures, primary attention will be given to land characteristics and qualities affecting grassland production including climate (4 major groups), predictable soil moisture fluctuations, slope classes and slope aspect, soil depth. The grassland evaluation ratings will be expressed by hay yields obtained from small-plot trials at different fertilization, farm practices and cost levels.

Application:

- further steps in the solution of economic consequences of the differentiated land productivity, due to physical land properties and qualities;

- optimal location and specialization of plant production;

- agricultural land protection measures;

- agro-ecological and economic research.

Simulation models, using mathematical methods based upon theoretical and established relationships, will be used to solve the above problems.

Prof. Dzatko also reported that Czechoslovakia belongs to the States having a small area of agricultural soils. Per 1 inhabitant, there are 48.2 ac of agricultural and 33.9 ac of arable soil. Therefore, the question of evaluation and rational exploitation of soils belongs to the primordial tasks of agriculture. This is anchored in the corresponding decisions of the Czechoslovak Federal Government and the National Governments according to which, on the whole territory of Czechoslovakia, a new evaluation of agricultural soils is realized.

Land evaluation in Czechoslovakia is understood not only as a single action of estimating and classifying grounds, but also as a purposeful appreciation of the ecological and economic factors which influence the specific character of sites. This is a qualitatively higher degree of recognizing the natural and ecological conditions of the agricultural production, which directly makes use of the results derived from the pedological survey, as well as of the findings on natural environment.

To solving questions on land evaluation, activities start from the fundamental thesis that soil is but one of the environmental components, that the production capacity of soils depends upon a whole complex of natural and economic factors. The specific character of these factors is expressed in particular territorial units which are called Pedo-Ecological Units (Land Units).

In general, the Pedo-Ecological Units are defined as relatively homogeneous territorial wholes, having a special character of ecological conditions and bioenergetic potential. They are determined by the evaluation of soil properties, parent materials, climate and relief of the terrain. The fidelity of these units is successively justified by data on their hectare yields and gross agricultural production.

The pedo-ecological delineation of territory does not replace land evaluation, but it is the first presupposition for the next working phase, in which bases are already acquired on the quantitative evaluation of territorial wholes. This phase is accomplished by the corresponding institutes for the economics of agriculture and public nutrition. The final system of evaluating agricultural soils in Czechoslovakia will be the common attainment of a large team of pedologists and agricultural economists.

Since, according to the plan, this pretentious task will not be finished until 1980, for the actual needs of practice and, in order to further develop theoretical questions, a map of land evaluation in Slovakia has been constructed in the scale of 1:1 000 000. This map originated on the basis of evaluating statistical data on the hectare yields and gross agricultural production from more than 500 so-called homogeneous agricultural enterprises of Slovakia. This means that the evaluating system did not originate by a mathematical summing of points for various properties of the soil and environment, but by a concrete evaluation of territorial wholes, on the level of pedo-ecological districts, in larger areas even of subdistricts. This principle of the so-called synthetic method of evaluation, i.e. of attributing economic data to exactly defined territorial wholes, to pedo-ecological units, forms the base for the entire methodical process of land evaluation in Czechoslovakia.

According to the obtained results, Slovakia's agricultural soils are rated in the following seven groups:

1. the best ones, 100-91 points (8.8%);
2. very productive, 90-76 points (17.0%);
3. productive, 75-61 points (14.7%);
4. medium productive, 60-46 points (24.7%);
5. little productive, 45-36 points (19.3%);
6. very little productive, 35-21 points (13.4%);
7. unsuitable for agricultural production, 20-5 points (2.1%).

HUNGARY

Prof. Stefanovits reported that classification of soil productivity in Hungary is based on "basal" soil fertility (productivity without soil improvement or irrigation). Each type and subtype of the taxonomic soil classification is characterized by a value between 0 and 100. This value is calculated from soil analytical data (humus %, depth, texture, aridity, salinity, alkalinity, etc.) which receive individual corrected values. The soil value is then adjusted on account of climatic and physiographic data.

Dr. Gerey reported that in Hungary anti-erosion plans are being prepared. This work is being carried out by natural units (e.g. a hydrological unit) or for large farms.

The plans have 3 parts:

1. Soil survey;

2. Methods against erosion:

   a. agricultural methods (change the direction of cultivation, planting of soil defending plants, etc.);

   b. technical methods (building terraces, channels, leading the water from the slopes, etc.).

3. Economical and organizational problems:

   a. recommendations to change the land utilization types. Most frequently it is necessary to change the cultivated lands to pasture or meadow fields;

   b. the costs of soil conservation work;

   c. amortization time.

Dr. Gerey also reported on the Hungarian farm soil maps concerned with land evaluation problems.

These farm soil maps consist of 3 parts:

1. Farm soil maps, 1:10 000 (now available for 3 million hectares). The farm soil map contents show soil types, subtypes, variants, parent material;

2. Cartograms - two types of cartograms are employed:

   a. descriptive cartograms: cartograms of pH and lime status, water soluble salts, exchangeable sodium, ground water table, soil erosion conditions, humus, soil water regime, plant nutrients;

   b. recommendation cartograms: cartograms of land utilization, soil amelioration, and irrigation;

3. Explanatory text.

The last three mentioned cartograms are chiefly used for the solution of land evaluation problems in Hungary.

<u>NETHERLANDS</u>

Dr. Van der Schans reported on the methods which are applied in the Netherlands for the interpretation of soil surveys.

The soil mapping units are defined by means of soil characteristics (features of a soil that can be seen and/or measured on the soil in the field or in the laboratory on soil samples). Thus, the soil map gives direct information about these differentiating characteristics. It also gives information about other, accessory characteristics co-varying with them.

The map user often wishes to know the behaviour of the soil under given forms of land use. Such requirements are met by providing information on the attributes of a soil that cannot directly be read from a soil map. On the other hand, such attributes are connected with the soil characteristics, but additionally depend on the type of land use and the environmental conditions.

In practice, soil suitability (the degree in which a soil, according to its characteristics and qualities, meets the requirements for a particular form of land use) is determined by a relatively small number of soil characteristics and soil qualities. These are called assessment factors. The assessment factors form the backbone of the interpretation system. The aim is to express them in quantitative form. This can only be done on a basis of considerable background information about soils and soil processes (laborious research). Examples are moisture supply based on rooting depth, available moisture content, capillary rise of moisture from the ground water, drainage status, bearing capacity, etc. The weight of a certain factor varies with the form of land use. For each mapping unit the factors are rated in 3 or 5 grades.

The interpretation of mapping units proceeds in three steps:

a. derivation of the necessary knowledge about soil characteristics from the mapping units;

b. determination of the grades of the assessment factors;

c. determination of the suitability class for a certain form of land use by comparing the grades of the assessment factors with the requirements for each form of land use.

At the end of the procedure, the soils are scaled in a suitability classification. This classification is categorical and essentially qualitative.

The highest level of classification has three main classes (well suited, moderately suited and poorly suited). At the second level, each class can be divided in a number of classes, indicating with figures a decreasing suitability.

At the lowest level a class may be subdivided in subclasses on the basis of relevant limiting factors, which are different for various soils.

Soil qualities and soil suitability differ from land qualities and land suitability, because land development is not taken into account in the former classification system.

A programme is now in progress which aims to integrate data about soil qualities and suitability with data about land development and socio-economic factors. This programme will be a contribution to an overall rural development scheme, in which not only agricultural reconstruction, but also nature conservancy, landscaping and outdoor recreation will receive consideration.

NORWAY

Mr. Fjaervoll reported that both for general purpose planning and for agricultural planning, the utility and fertility of the soil are determining factors.

The European Land Registry Map (1:1 000 000) is, owing to the small scale, of comparatively little value for actual general purpose planning. In Norway the production of an economic map on the scale of 1:5 000 is in hand. The particular compilation and presentation offers certain possibilities for "suitability evaluation". One third of the economic important areas of the country have been mapped in this way. Compilation is by Norges Geografiske Oppmaling (The Geographical Survey of Norway) on the basis of air photographies and the boundaries of all estates of more than a half hectare are shown together with the soil classification boundaries.

The soil classifications and land use mapping units comprise the following:

Cultivated land - This is classified as: A-land, having such topography and structural conditions that it can be cultivated by use of four-wheeled tractors, and B-land which, due to slope and form, cannot be worked with such equipment.

Coniferous forest land and deciduous forest land - The coniferous forest is divided into four classes of very high to very poor quality.

Boggy land - Four different classes are recognized according to production capacity.

Shallow land - Shown separately as are rocky outcrops.

Uncultivated land - The boundaries and the map symbol of the arable part of the area are shown. Special map symbols indicate whether the content of stones is especially high, or whether the areas are self-draining.

It is important for agriculture and for human society, that cultivated and arable land are not used for building purposes. In connection with general purpose planning and town planning, in Norway it is the duty of the Agricultural Service to take an inventory and make an assessment of the resources. The assessment is carried out by classifying the areas according to production, agricultural environment and structure and showing the classes by colouring, e.g.,

a. Land which forever should be used for agricultural purposes.

b. Land which immediately - because its production capacity is very low - can be used for other purposes, e.g. building activities.

c. Land which already is used for building purposes.

d. Land which is not assessed, e.g. high mountain land.

e. Land which will be assessed anew in the next period of the general plan and then classified under a) or b).

The economic map in itself makes a register of resources where the resources are indicated by geometrical figures. The Land Register - the way it is now kept in Norway - is a numerical register of resources. In this, all soil classifications for each farm - and then for each urban or rural district and after that for each county and for the whole country - are stated by numerical values in decares. The areas of each estate, and within that of each soil classification, are computed and tape-recorded. The tape recording contains, for each estate, information about the register numbers of the farm and the identity numbers of the owner. This permits data processing of all the gathered information and forms the registered information part of a major data bank.

It is already apparent that the Economic Map and the Land Register, together are very serviceable instruments for land use planning, both for general purpose planning and for a more technical planning for agriculture. In both cases it is possible to make plans from the points of view of soil protection and land suitability.

POLAND

Professor Glinski reported that in Poland soil-agricultural maps at different scales (1:5 000, 1:25 000, 1:500 000, 1:1 000 000) are being compiled for practical use. These maps are based on soil-valuation (soil-rating) maps and on soil maps. The basic contents of the soil-agronomical maps comprise two elements: complexes of agricultural productivity of soils and soil units.

Soils are divided into three categories: arable, meadow and pasture and forests. Within the arable soils 14 complexes of agricultural usefulness are distinguished. On these maps, soil associations, textural classes and land capability classes are also assigned. To each map supplements are attached containing additional information about the properties of the soils and other elements of natural environment of agricultural production. It is anticipated that these maps will be very useful for land evaluation.

ROMANIA

Prof. Florea reported on a complex system now in use in Romania for the ecological justification of agricultural production zoning, using a standard method of data collection, coordination, processing and issuance, required for the finding of technical and economic solutions specific for each of the country's major agricultural zones or for micro zones within each zone.

This ecological documentation requires the compilation of maps of pedo-climatic zones and land evaluations for different crops and land uses. Technologically uniform territorial units are separated on the maps on the basis of the following factors:

Soil
- morphological features
- physical and hydrophysical features
- chemical characteristics
- nutrient reserves

Lithology - nature of parent material
- slope
- exposure
- form of relief

Climate - thermic resources
- water resources
- other climatic factors affecting plant growth

Hydrology - ground water level
- seasonal variation in ground water levels
- ground water mineralization

There are 39 elements for the characterization of the above listed factors, each of which are subdivided into several degrees of intensity or quantitative meanings.

Such a wide range of the territory and soils' feature requires division on the map, of very small areas and the identification of thousands of so-called "Ecologically Uniform Territories" (EOT) in Romania, each having its correct identification formula. For correct and easy recording of the data, each of the indicators (elements) of environmental factors or soil and their subdivisions have been codified. Simultaneously, on each EOT, land is evaluated for 25 crops and land uses, on the basis of a proper methodology (described by Mr. Krastanov) for the determination of the land's production potential. In this way, a primary interpretation of ecological data for the requirements of production is achieved.

In the same work, technological characterization of the agricultural land is undertaken using the following:

- the amount of energy required by soil management;
- accessibility of land in view of mechanization;
- erosion protection and control requirements;
- suitability of land for irrigation;
- drainage requirements;
- embankment requirements;
- prevention and control of salinization and alkalization requirements;
- liming requirements;
- fertilization requirements;
- technological features of current agrotechnical operations;
- problems of soil pollution.

For this characterization, the features of each EOT have to be considered, several land types being established for each category of characterization. The eventual effects of land reclamation need to be emphasized and added to the initial production potential of the land, so as to express the improved production potential of each part of the territory.

This work requires the extensive use of computers without which it could never have been achieved.

SPAIN

Drs. Bardaji and Lazaro reported that land evaluation in Spain is carried out when applicable to specific uses. The present account of the work is not a description of actual progress but rather an account of the progress which could be achieved with the use of adequate techniques. It is considered that the input aspect of this work is the definition of land in terms of agrological capability.

In general, the criterion used are the following:

1. Land suitable for permanent farming

Class I — Land suitable for continuous cultivation without special management methods and using no special techniques. The soils are flat, deep, not stony, well drained, good for field work, with no erosion or little erosion and with no flood hazard. The manure, the field work and the rotation of crops are normal. Loamy soil, with good permeability, level and sufficient water are the characteristics of this land class when used for irrigated farming.

Class II — Land suitable for simple continuous management farming methods. The soils are level or nearly level, deep, well drained, not very stony and give good or moderate yields of different crops. They (the soils) require simple measures for erosion control and the slope is less than 10%. The drainage must be good. These lands have a minimum flood hazard. When the flood hazard is dangerous such land should be included in Class III land.

Class III — Land suitable for continuous farming with complex management methods. The soils are well drained, with erodable slopes or are poorly drained with slight erosion. The land is good for field work, deep but stony enough to damage mechanical implements. In many cases complex measures are needed for soil and water conservation. Extensive rotations are necessary and drainage and irrigation are sometimes difficult.

2. Land suitable for incidental agricultural farming

Class IV — Land generally not included in the Classes I-III because of the degree of limitations or deficiencies, e.g. steep slope, strong erosion, etc.

3. Land suitable for permanent vegetation

The degree of restrictions determine classification into three classes: V, VI, and VII.

4. Land not suitable for cultivation, pasture or silviculture

Barren land.

The following maps are necessary to establish the land use capability of a particular tract of land:

a. Soils

b. Climate

c. Lithology (parent materials)

d. Slopes

e. Cultivation or exploitation

The land rating is obtained by the superimposition of the above maps.

Approximately one-third of the agrological surface of Spain has been already mapped at a scale of 1:200 000, mostly areas in the Western part of the territory.

New Irrigation Zones

The guidelines of the Bureau of Reclamation are used in such work, when feasible. As a first step a reconnaissance study, at a scale of 1:50 000, is necessary to ascertain whether irrigation is practical or not. If the zone is a complex one, or has serious problems, a semi-detailed study should subsequently be undertaken at a scale of 1:25 000. In the selected areas and before realization of the project, a second study is necessary at a detailed level and at a scale of 1:5 000 or 1:10 000.

SWEDEN

Prof. Wiklander reported that the government has organized a group of specialists who have prepared a plan, on a broad scale, for the use of soil and water as natural resources. The need of land for industry, various recreation purposes, urban activity (such as enlargement of cities), farming, forestry, etc., is taken into account in this work. Pollution problems are also considered.

New industries, especially if a pollution hazard, are to be located in certain coastal areas. In other coastal areas, no industry will be permitted.

In this work, arable land has been classified according to production capacity, field size and shape and location in relation to farm centre, etc. Regulations have been worked out for the use of arable land for urban needs, based on these principles. Regulations for the use of forest land have also been formulated.

Preparation of detailed maps for the uses of land has been initiated.

UNITED KINGDOM

Dr. Wilkinson presented a brief review of land evaluation work in the U.K.

1. Land Capability Classification

   Details of the classification system are given in the Soil Survey of Great Britain Technical Monograph, Monograph No. 1, by J.S. Bibby and D. Mackney. A review of progress in land capability was also undertaken in 1972/73 and the details are published in MAFF Technical Bulletin 30 "Land Capability Classification" HMSO 1974. The work is on-going and a land capability map will be prepared for every new soil map.

2. Land Capability Map for Great Britain - 1:1 000 000 scale

   With the publication of the soil map at 1:1 000 000 scale, it is proposed to now prepare a generalized land capability map at the same scale.

3. MAFF Agricultural Land Classification of England and Wales

   This is a 5 grade land classification system and is described in the MAFF Agricultural Land Service Technical Report No. 11 "Agricultural Land Classification", London 1966. The whole of England and Wales has now been classified according to this sytem and the maps printed. They are utilized for national and regional planning purposes.

USA

Dr. McCormack conveyed Mr. Johnson's personal greetings and gave some information about the current progress in soil surveys in the United States. The total land area in the US is about 900 million hectares. Detailed soil surveys are completed for 500 million hectares or about 60 percent of the land. Many kinds of land evaluations have been used in the United States. Some are used with generalized soil maps and some with detailed soil surveys, but all are based on information about soil properties obtained from soil surveys.

Without this basic soil information it is not possible to predict the behaviour of soils in the various kinds of land uses for which the soil may be suited. Accurate predictions of soil behaviour are considered essential for land evaluation.

It is considered that soil scientists have an obligation to identify, for non-soil scientists, those land uses or crops for which each kind of soil is well suited. In the past, several schemes used a negative approach by placing emphasis on the hazards or limitations imposed by unfavourable soil properties. A positive approach appears better.

Evaluations of soil suitability should reflect modern technology. In agriculture especially, methods on how to improve soils have been learned. Many prime food-producing areas have been developed in soils that in their natural state were poorly suited. The corn-producing areas of the Central USA were once considered worthless swamps. Likewise, highway engineers have learned to build good highways on Vertisols.

Evaluations should clearly identify the level of management input that is assumed. The skills of the local cultivator are important in evaluation of potentials using common management practices. The soil scientist, working with other disciplines, must help identify adapted additional practices that will enhance the performance of the soil, and determine the extent to which each practice improves production. Thus, the data assembled to evaluate each soil at full application of the latest technologies should be sufficient to evaluate it at any lower level.

Currently, the USA are developing a system of evaluation called soil potentials. Soil potential is defined as the ability of the soil, using latest feasible technology, to produce, yield, or support a given structure or activity at a cost expressed in economic, social, or environmental units of value. There are four basic steps in this system: 1) for each land use or crop, those soil properties that are limitations to the best performance or yield are identified; 2) kinds of practices that may be used to overcome the soil limitations to achieve the best possible performance are identified and their feasibility or cost is evaluated; 3) the level of performance or yield after installation of feasible practices is evaluated and any continuing limitations that exist after the practices are installed are identified; and 4) the soils within the area of study are arrayed from those with the best performance to those with the worst, or the soils are placed into three classes of good, fair, and poor potential.

2. Framework for Land Suitability Evaluation

a. General Outline

A Framework for Land Suitability Evaluation 1/

presented by

G.M. Higgins

Summary

The paper describes a framework for land evaluation developed jointly by two multidisciplinary groups, one in the Netherlands and one within FAO. Land evaluation is defined as the process of collating and interpreting basic inventories of soil, vegetation, climate and other aspects of land in order to identify and make a comparison of promising land-use alternatives in terms applicable to the objectives of the evaluation. A multidisciplinary approach is recommended and basic to the concept is recognition of the fact that land evaluation is meaningful only in relation to a clearly defined use. The framework recommends qualitative and quantitative classifications of land for well defined land utilization types, under unimproved and improved conditions, by suitability orders, classes, subclasses and units. A single stage (physical and socio-economic studies together) approach or a two stage (physical studies followed by socio-economic studies) approach is allowed for. The framework is intended to provide an outline of principles and terminology within which local systems of land evaluation may be formulated.

b. Land Utilization Types

Land Utilization Types in Land Evaluation

by

Klaas Jan Beek

Summary

Land evaluation nowadays includes practically all aspects of utilization of areas of land. It increasingly serves as a basis for making both high level planning and low level implementation management decisions. During the FAO Expert Consultation in Wageningen (1972) the discussion was limited to a physical land classification with economic considerations. The principal means of introducing different economic constants would be by making separate land evaluations for different land utilization types.

1/ Based on the work of the two described multidisciplinary groups.

A land utilization type is a specific sub-division of a major kind of land use, serving as the subject of land evaluation and defined as precisely as is practical in terms of produce, level of management, capital intensity, labour intensity, kind of power and implements used, farm size, land tenure, etc.

Land utilization types are an integral part of the land evaluation procedure. Their selection and formulation may a) take place at the beginning of the procedure representing an input for land evaluation or b) be subjected to modification and adjustment during the procedure, representing both an input and an output of land evaluation.

A distinction should also be made between a two stage and a parallel land evaluation procedure. The two stage procedure is often favoured for small scale inventories for broad planning purposes. The first stage is mainly concerned with physical land evaluation, followed (but not necessarily) by a second stage consisting of some kind of economic analysis: economic land evaluation. In a parallel procedure the physical analysis proceeds concurrently with the socio-economic analysis. This latter procedure will often be favoured for specific problems in connection with development projects. Figures were presented to explain the role of the land utilization type concept in different land evaluation procedures. Two-stage and parallel procedure could be thought of as being situated at either end of a continuum composed of different approaches to land evaluation ranging from a purely physical approach to an approach in which the socio-economic specialists are responsible, the physical disciplines making only indirect contributions.

A further sub-division in four major kinds of land evaluation is proposed based on the number and kind of socio-economic factors taken into consideration:

1. Evaluation of biological production potential.

2. Physical land suitability classification for specific pre-determined land utilization types.

3. Overall "on farm" land suitability classification with farm economic variables.

4. Overall land suitability classification with "off farm" variables.

In each kind of land evaluation the land utilization type has a specific role.

A difficult aspect of the land evaluation procedure is the matching of the land requirements of the land utilization types with the land conditions. Matching represents the essence of the interpretive step following the resources surveys and is based on the functional relationships that exist between the land qualities, the land improvement capacities and the key attributes of the land utilization types. A distinction has been made between qualitative matching which relates predetermined levels of land qualities to different classes of land suitability and quantitative matching based on quantified expressions of the cause-effect relationships between the land qualities and the performance of the land utilization type.

Present land use is a valuable yardstick for assessing the feasibility and profitability of future land utilization types. Land use classifications are discussed with emphasis on the typology of world agriculture developed under the auspices of the International Geographical Union. But such typologies are limited to the description of endogenous characteristics. Land conditions are not considered endogenous in the IGU typology and their influence on the formation of agricultural types is ignored. Typology of land utilization for land evaluation on the contrary should enhance the possibilities for detecting functional relationships between land utilization and land conditions, at present and in a predictive model.

Finally, it is suggested that land evaluation at regional and continental scale, after reaching a basic agreement on methodology, should start with the selection of relevant land utilization types in connection with major kind of land evaluation No. 2: physical land suitability classification for specific predetermined land utilization types. This would eventually lead to the desired international exchange of findings on suitability and management response on comparable land units. Technical knowledge and land productivity will probably continue to increase. Systematic land evaluation and land use planning should be able to assist in the prediction of future land use needs, the modelling of alternative land utilization types and the orientation of research for the benefit of the population and its environment.

c. Land Characteristics and Land Qualities

Land Characteristics and Land Qualities

by

C. Sys

Summary

The general fundamental principles of land evaluation, as they are outlined in the revised framework, are now generally accepted.

An important fact is that separate stages of both qualitative and quantitative land classifications have been accepted.

The guidelines for the interpretation of land properties for the map of Europe, as presented here, have a qualitative aspect.

As the legend of the Soil Map of Europe reflects only soil properties, we have limited ourselves to suggestions of land properties which can be derived from the soil map legend. Related to land characteristics are the land qualities. These are a result of interaction of a series of properties of a tract of land which have a direct influence on land "capability" for a specific use.

In the future, the reconversion of land properties to land qualities has to be discussed.

In this document, we are formulating suggestions for the rating of land properties for some general land utilization types. The following lists the land properties and the considered land utilization type for each property.

Land properties	Land utilization types
Slope	Gravity irrigation, sprinkler irrigation, annual crops, perennial crops, grassland, forest
Flooding	if any
Texture	Gravity irrigation, sprinkler irrigation, exacting annual crops, moderately exacting annual crops, poor crops, perennials
Stoniness	if any (in general)
Soil depth	Cereals, root crops, pasture, perennials, irrigated farming
Gypsum status	Irrigated farming
Calcium carbonate	Irrigated farming, crops that tolerate well $CaCO_3$, moderately tolerant crops, sensitive crops
Sodium saturation	Tolerant crops, moderately tolerant crops, sensitive crops, irrigation farming
Salinity status	Tolerant crops, moderately tolerant crops, sensitive crops, irrigation farming
Drainage	Annual crops, perennials, rice, pasture, irrigated agriculture

The base of any system of land evaluation should be put out in one separate table per land utilization type. This table should list the land properties and/or the land qualities, as well as the range in degree of limitation of each of these properties/qualities in five levels:

0 - no limitations
1 - slight limitations
2 - moderate limitations
3 - severe limitations
4 - very severe limitations

d. Socio-Economic Analysis in Land Evaluation

Socio-Economic Analysis in Land Evaluation

by

C.A. Robertson, H. Luning and K.J. Beek

Summary

1. Approaches to land evaluation

Socio-economic analysis can be conveniently discussed against the background of two rather different land evaluation procedures: (i) a two stage approach in which the first stage is primarily concerned with physical land evaluation, and (ii) a parallel approach in which socio-economic analysis proceeds concurrently with the physical analysis. While these two approaches can be distinguished quite clearly at the conceptual level, in practice the distinction is less clear-cut. They are best thought of as being situated at either end of a spectrum composed of a variety of approaches each of which relates more closely to one end or the other.

i. Two stage approach

This approach, during its first stage, is concerned with physical factors rather than with economic factors and is mainly aimed at broad-based resource inventorying and production of data for general planning purposes. The socio-economic scientist's role in this process is rather limited. He should assist in the initial identification of overall relevant land utilization types to ensure that the field investigations are pertinent in the context of regional and national planning, and check that the suitability assessments to be produced (as a result of the studies of physical factors) are likely to be compatible with basic economic and social possibilities and constraints in so far as these are identifiable and assessable at an early stage of the study, e.g. selection of commodities in view of market prospects, transportation costs, choice of techniques. His main contributions to the land evaluation are made, therefore, about the beginning of the investigation.

Suitability ratings will initially be expressed in qualitative terms based on the physical production potential of the land resources for broad land utilization types which have relevance within a broadly defined socio-economic and institutional perspective.

The above approach is usually favoured by institutes specialized in the collection of physical land data for development planning, e.g. soil survey institutes. These institutes may not intend or have the means to undertake socio-economic analysis and economic land evaluation and sometimes a considerable time lapse occurs before this stage is reached, e.g. national natural resource surveys, executed with OAS assistance in Chile and Dominican Republic.

ii. Parallel approach

Here, land evaluation relates more explicitly to specific development problems and proposals being examined in connection with development and planning projects. In such cases a phased parallel process of land evaluation is called for with socio-economic analysis proceeding concurrently with the physical analysis and at a comparable level of detail.

2. Phases

It is possible to distinguish successive phases of detail in the parallel approach, as follows. The different phases show an increase in quantification and reliance on socio-economic data with increasing detail.

i. Reconnaissance phase

The aim of the socio-economic descipline is to define qualitatively development constraints and possibilities. A general socio-economic context needs to be established, e.g.:

- an inventory of government development objectives and its available macro-economic development tools and macro-economic data;

- demographic data and sociological information;

- an inventory of the technical and institutional infrastructure;

- general information on the present agricultural economy, including recent trends.

Constraining problems identified at this stage might include seasonal labour shortages, adverse tenure conditions and poor access to markets and services. The market prospects of commodities are evaluated as well as the comparative advantages of the area with other regions in relation to these commodities. Conclusions are unlikely to be expressed in quantitative terms unless the amount and quality of existing data justify a quantitative analysis. Much of the information is likely to derive from discussions with farmers, traders, and officials and from publications by government and other development agencies. Sometimes global farm surveys, as described in the next paragraph on semi-detailed land evaluation, may be carried out.

ii. <u>Semi-detailed phase</u> (intermediate phase)

The form taken by socio-economic investigations, during the intermediate phase of a problem oriented land evaluation study, is greatly dependent on the quality and quantity of existing data. Where data are sparse, the analysis will incline towards the approach followed in the reconnaissance phase, but where data are more plentiful the analysis will more nearly approximate the methodology appropriate for the detailed phase.

It will usually be helpful for the economist to carry out cost benefit analysis on a tentative basis so as to offer early guidance on prospects for the land utilization types under consideration. This exercise also helps to raise the general level of analysis and reporting, by forcing the analyst to make his assumptions, including the key attributes of land utilization types, explicit in arriving at a suitability rating.

Where necessary a global farm survey, confined to the structure of the farm enterprise, will be carried out (sometimes applicable also at reconnaissance level). Linkages between land utilization types and farm types will need to be established. Stratified random sampling, based on ecologically and agriculturally homogeneous zones, will allow extrapolation to the required area level.

Where applicable, the global farm survey may be complemented with a detailed farm survey with emphasis on the production process. In this micro-analysis, attention should not be merely confined to production oriented objectives but comprise the other national development objectives as well, e.g. employment, income distribution. The major focus could be on particular target groups, such as on one hand the farmers who are in a stage of transformation, cultivating new crops, using new techniques and other inputs; on the other hand peasants, consisting of the poorest and least successful who remained of the reach of rural services and improvements.

iii. <u>Detailed phase</u>

This phase is often connected with feasibility and pre-feasibility studies and project formulation. Socio-economic analysis is based on data relating to the availability of resources and their allocation by producers, input-output relationships, sales patterns and prices and costs. They also take into account credit needs and availability, tenure arrangements and market systems, the nature of social groupings and the interactions among them and the values and attitudes of prospective producers.

At the farm level optimization techniques may be used beneficially to give guidance in realistic farm planning. Such techniques as budgeting, programme planning or mathematical programming will be selected, depending on the degree of sophistication required.

3. Criteria for socio-economic analysis

The viability of development recommendations is estimated at several levels:

i. First, it has to be determined whether or not the proposed development is commercially attractive to the farmers or firms concerned. This involves calculating expected net returns at the farm or estate level and, depending on circumstances, benefits may be expressed in terms of net returns per hectare, per labour day or per unit of capital employed. The repayment capacity of future beneficiaries has also to be reviewed.

ii. Simultaneously, a social cost-benefit analysis should discover whether the proposed development will benefit society as a whole. This requires adjusting costs and prices where relevant in order to correct foreign exchange deviations and other distortions (taxes, subsidies). This analysis is concerned with the true scarcity value of resources to the society.

iii. Apart from calculation of the returns to scarce capital and other resources, as carried out in the conventional cost-benefit analysis, due attention needs to be paid to the possible trade off with other objectives (employment, income distribution). Appropriate weight should be given to those other objectives. Sensitivity analysis could be usefully applied.

e. Exchange of Information and Use of the Soil Map of Europe for Land Evaluation

Exchange of Information and Use of the Soil Map of Europe for Land Evaluation

by

A. Pécrot

Summary

In Europe where, as a rule, a broad ecological region includes several countries having different socio-economic conditions, exchange of information between countries will be mostly based on physical land factors such as soil characteristics, topography, and climate. For this purpose, a basic requirement is, therefore, a uniform classification of such factors of the environment, a uniform land use nomenclature and a standard methodology of interpretation of these data.

Soil correlation has made significant progress during the last 10 years in Europe thanks to the activities of the ECA Working Party on Soil Classification and Survey and the compilation of the Soil Map of Europe based on the FAO Legend for the Soil Map of the World. The Legend is now widely accepted on a world basis and will be a basic tool for exchange of information not only within Europe but also with other areas of the world.

The meeting was informed that the World Food Conference recommended that FAO undertake a world land capability assessment based on the Soil Map of the World. The methodology developed for this purpose is likely to be applicable for Europe, with minor adjustments to take care of differences of scales and the amount of information available.

Standardization of soil data collection, such as profile description, laboratory procedures and field experimental designs, should be further improved. The need for a uniform land use nomenclature was stressed. Three different approaches to land use classification were briefly reviewed and it was suggested that the Working Group would establish contacts with the Commission on Agricultural Typology of the International Geographical Union (IGU) and particularly with Prof. J. Kostrowicki, author of an outline "Typology of World Agriculture".

Computer processing of data on land factors and land use would be a basic tool in land suitability evaluation and exchange of information. Standardization of computer programmes was necessary and it was explained that an international Soil Information System was being developed by the Soil Resources Development and Conservation Service in FAO.

The use of the Soil Map of Europe at 1:1 000 000 scale as background document for land evaluation in Europe was described. It was considered that the information available on the map supplemented with climatic data would be a suitable basic information for land evaluation.

As by definition, suitability for a specific land use implies the absence of serious degradation of the environment quality resulting from the sustained use, it was felt that in addition to land suitability evaluation, an assessment of soil degradation and degradation hazards at regional and country level should be attempted using the information already available and particularly the work already carried out by the ECA and the Council of Europe. Such assessment would comprise main forms of soil degradation relevant to European conditions such as erosion by water, salinity and waterlogging.

It was explained that FAO, in collaboration with Unesco and with the financial support of UNEP, was now initiating a three year project for a world assessment of soil degradation. A methodology for assessment and mapping of water and wind erosion, salinity, alkalinity, waterlogging is being developed by the project and would be applicable with minor modifications to European conditions.

3. Technical Discussions

In reply to a query on the reported lack of truly quantitative land suitability classifications, it was suggested that improvement could be effected in the Framework through a clearer definition of what is a quantitative classification. Difficulties were envisaged in defining meaningful ranges of numerical socio-economic benefits in such classifications. Additionally, it was accepted that improvement to the document could be achieved by modification of the land characteristics cited as influencing the land quality "moisture availability". Root room was preferred to soil depth, and depth to ground water was also an additional land characteristic which was of importance in this regard. It was considered unlikely that a standard set of land characteristics, with equal weight, could be formulated for all land qualities under all conditions.

The need for a clear definition of objectives, and identification of appropriate land use alternatives, before undertaking survey work, was emphasized. One advantage of the parallel approach was the savings effected in combined supply of equipment and facilities and some considered this approach most appropriate for the majority of current activities.

In general, it appeared that there was room in most national land classification systems, for use of the land utilization type concept. Such was thought to be implied in the USDA system where arable land, grassland and forest land were likened to broad land utilization types. (Later discussion on this point emphasized the need to clearly differentiate between current and potential suitability. The USDA system was considered as an indication of potential suitability, as exemplified by the fact that some of the land presently under forest has a potential for arable cultivation. In the Framework such would be identified as suitable arable land through use of the potential suitability classification.)

Subsequent discussion centred on how to best achieve an early selection of appropriate land utilization types for European conditions, how to relate them to soil regions and land qualities, and to what level of detail the land utilization types should be defined. Appropriate recommendations were requested from subcommittees.

General discussion on land qualities revealed that one of the more difficult problems envisaged in their formulation would involve the relationship between climate and soil, and ascertainment of their interaction for assessment of soil moisture throughout Europe. Previous project proposals in this regard were referred to, but it did not appear necessary to revive these in view of the fact that the explanatory text to the Soil Map for Europe would include an account of the moisture regimes of well drained soils. Later discussion modified this view and resulted in the recommendation on this subject shown on p. 51. Difficulties were also anticipated in defining realistic relationships between the chosen land utilization types and land qualities.

In response to a query on ratings for salinity limitations, it was stated that limitations due to salinity have to be considered with regard to the soil texture (permeability) and sensitivity of the crops. As such, a first approximation can be made as follows:

Utilization type	Degree of limitations (cond. mmhos/cm)				
	0	1	2	3	4
Irrigated farming					
- course and medium textures	<8	8–16	16–30	>30	>30
- fine texture	<4	4–8	8–16	16–30	>30
Very sensitive crops	<2	2–4	4–6	6–8	> 8
Sensitive crops	<4	4–8	8–12	12–16	>16
Tolerant crops	<8	8–12	12–16	16–20	>20

In discussions on soil erosion matters, several speakers emphasized that, for complex questions such as soil erosion hazard estimations, use should be made of land qualities as diagnostic criteria and not single land characteristics. It was pointed out that in Hungary, production costs on eroded soils are, on average, 30 percent higher than on non-eroded soils.

Discussion on specific matters regarding land characteristics and land qualities, was focused on five questions pertinent to future land evaluation activities based on the Soil Map of Europe.

a. A qualitative or quantitative evaluation? A qualitative approach appeared to be the only practical evaluation possibility at a scale of 1:1 000 000; such was agreed.

b. Use of land qualities or land characteristics? In this case the scale did not determine the approach to be adopted and an example from Brazil was quoted where land qualities had been used in small scale crop evaluations. In the context of the proposed European evaluations, the difficulty in the use of land qualities lay in the fact that there was uncertainty regarding the relationships between land utilization types and land qualities. While there was some danger in repeating some land characteristics with the use of a mixture of land qualities and characteristics, such was agreed as the best solution. This combined use of land characteristics and land qualities could be designated as assessment factors.

c. Kinds of characteristics to be used? It was agreed that the kinds of land characteristics and land qualities to be used could only be determined after the land utilization types for the evaluations had been chosen. This was so because of the specificity of the land qualities and characteristics, to particular land utilization types.

d. Current/potential suitability classification? In view of the fact that most areas could be considered potentially physically suitable for any purpose with sufficient inputs, it was considered impractical to use the potential classification. It was agreed preferable to define and use practical and realistically attainable land utilization types, excluding major land improvements involving large investment projects.

e. Numbers of ratings of diagnostic characteristics? The ideal number of classes (ratings) of diagnostic characteristics depends on the kinds of characteristics being considered. While three classes may be optimal for say 'fertility', some ten ratings could be envisaged for a land quality such as 'soil moisture', if sufficient climatic data were available. While an uneven number of classes (e.g. three or preferably five) was a good choice, it was agreed to leave a final decision on this matter until the diagnostic characteristics had been selected.

Finally, in discussion, it was agreed that for European evaluation activities, climatic data would be needed in addition to the data available from the Soil Map of Europe. It was also agreed that while selection of land qualities was very much within the expertise of the present committee, outside assistance will have to be sought for selection of appropriate land utilization types.

Discussions on socio-economic aspects of land evaluation commenced with a request for opinions on the relative advantages and disadvantages of using measures of productivity per unit area, versus net income per unit area, as a measure for outputs.

General agreement was expressed on the need to well consider realistic socio-economic factors in land evaluation activities. A study in Belgium was reported, from 30-40 farms, wherein yields from the same soil varied very considerably (5 000-7 000 kg/ha, wheat) according to farm structure. The skills of the farmer also significantly affected yields and figures of 2 800- 6 000 kg/ha of wheat were quoted depending on farming ability. A good correlation was recorded, in this study, between texture and net benefit per unit area, but no correlation was found between the latter and profile development. The results of this study showed that realistic socio-economic factors have to be taken into account in such evaluations, but such data were found to be difficult to work with. Good results could however be obtained through the use of proven methodology.

The opinion was expressed that it is essential to clearly differentiate between two economic concepts in such studies, namely a) economic assessment of land and b) economic analysis of agricultural activity. Land evaluation must use norm values and this was not considered possible when only individual farms are subjected to economic analysis and the results used for evaluation activities.

Further examples were given where different farming systems, producing the same crop (sugarbeet in one instance and coffee in another), gave markedly contrasting results. These instances were taken as good examples of the vital necessity to fully describe the key attributes of the land utilization types being investigated. Other speakers emphasized the need for the kind of farming system to be clearly taken into account in land evaluations. The variation in production costs and similar economic aspects were anticipated, by some, to be less in comparisons of state and cooperative farms than if the comparisons were between privately owned farms.

Agreement was expressed with the opinion that the ideal approach for land evaluation activities was the multidisciplinary approach. It was, however, recognized that there were circumstances where a multidisciplinary approach was difficult to organize and also where a single discipline approach was pertinent and practical.

In summarizing, it was agreed that a fully economic land evaluation depends on many factors and this undoubtedly makes analysis difficult. In general, the meeting agreed on the approach, but difficulties were anticipated in the formulation of an acceptable standard methodology.

4. Recommendations for Initial Work on Land Evaluation in Europe

The session, recognizing the importance of:

standardization of the nomenclature of land utilization types;
selection and rating of land characteristics and land qualities;
assessment of soil degradation hazard; and
adequate and uniform characterization of moisture availability, as basic data for land evaluation,

made the following recommendations and implementation arrangements.

i. Land Utilization Types

It is recommended that one delegate from each country1/ determine the principal land utilization types (farm types) involved in the present and/or envisaged production of the following crops: wheat, maize, rice, oats, sugarbeet, potatoes, alfalfa, grapes, olives, citrus, pasture, barley, tobacco, rye, cowbeet, sunflower, hops (and silviculture when relevant).

Key attributes and their ratings will be given as far as possible according to the typology of agriculture of the International Geographical Union (Kostrowicki 1974) for the World Land Use Map. Not more than 2 or 3 land utilization types should be selected from the full range of utilization types observed in connection with these crops. The data will be sent to Prof. Pons in Wageningen who will act as ad hoc secretary. The national land utilization types will be combined and adapted into land utilization types of regional significance to provide a specific input for the assessment of land suitability. This activity should proceed in coordination with the implementation of the recommendation concerning land qualities (Ad Hoc Secretariat, Dr. Sys in Ghent) and in consultation with the Commission on Agricultural Typology of the International Geographical Union and the Working Group on Rural Planning and Development also of the IGU.

ii. Selection and Rating of Land Characteristics and Land Qualities for Specific Crops and Land Utilization Types

It is recommended that one delegate from each country2/ will make proposals on the selection and rating of land characteristics for the following crops: wheat, rye, barley, oats, maize, rice, sugarbeet, sugarcane, cowbeet, potatoes, sunflower, alfalfa, hops, grapes, tobacco, olives, citrus, pasture and silviculture.

1/ Delegates already nominated during the meeting are: Messrs. Wilkinson (UK), Lazaro (Spain), Wiklander (Sweden), Krastanov (Bulgaria), Oosterbaan (Netherlands), Dzadko (CSSR), Beek (Holland). Further nominations, from the remaining countries, are anticipated.

2/ Delegates already nominated during the meeting are: Dr. Sys (Belgium) - wheat, barley, rice, sugarbeet and sugarcane, silviculture. Dr. Gerey (Hungary) - wheat, maize, sugarbeet, alfalfa, sunflower, grapes. Dr. Lapple (Germany) - wheat, oats, potatoes, cowbeet, hops. Dr. Glimski (Poland) - wheat, rye, barley, oats, potatoes, sugarbeet, hops, tobacco. Dr. Juran (CSSR) - wheat, barley, maize, sugarbeet, alfalfa, hops, grapes and pasture. Dr. Lazaro (Spain) - citrus and olives. Further nominations, from the remaining countries, are anticipated.

The working document "Guidelines for the Interpretation of Land Properties for Some General Land Utilization Types" will be sent by Dr. Sys to all members of the group.

The document to be compiled, for each crop, should comprise the following:

1. Introduction.

2. Climatic requirements.

3. Soil requirements.

   3.1 Physical.

   3.2 Chemical.

4. Soil management.

5. Fertilization.

6. Selection and rating of land characteristics and land properties.

   6.1 Land characteristics.

   6.2 Land qualities.

   6.3 Combination of land characteristics into land qualities.

   6.4 Selection of the used land characteristics and land qualities, and identification of permanent and modifiable criteria.

   6.5 Rating of the limitations of these characteristics and qualities, with comment and justification possibly illustrated with yield results.

   6.6 Presentation of tables giving the range in degree of limitations for the studied characteristics and qualities.

Interim reports, by crop, should be forwarded to Dr. C. Sys, who will ensure their reproduction and distribution to the different members of the group.

It is recommended that the working group, appointed for the selection and rating of land characteristics, present a first report before the end of 1976. Subsequently, a joint meeting of the two groups - land utilization types and land qualities - will be necessary. Such is strongly recommended.

iii. Soil Degradation Hazards

It is recommended that one delegate from each country,1/ interested in assessment of soil degradation hazard, forwards national material on soil and wind erosion, salinization and alkalinization, waterlogging and other forms of soil degradation, to Prof. I. Szabolcz. Close collaboration with the ISSS and the FAO/UNEP/Unesco project for a world assessment of soil degradation will be maintained by Prof. Szabolcz to ensure a common approach in this work.

iv. Moisture Availability

Continued research on this subject is strongly recommended. Specifically, the meeting recognized that for adequate ratings of the land quality 'moisture availability' (for different soils and land units in Europe under the prevailing climatic regimes), two main sets of data are required.

a. Moisture availability (in mm water) in the rooting zone. For soils not influenced by groundwater, moisture availability can be calculated from such soil characteristics as rooting depth, texture, humus content and depth of the A horizon, bulk density (as an expression of structure) etc. The data available from the 1:1 000 000 Soil Map of Europe are considered to be sufficient for this purpose for the level of generalization required.

   For soils influenced by groundwater, additional data is needed on the minimum and maximum level of groundwater and capillary rise. Models are available to calculate the effect of these factors on moisture availability.

b. Climatic data. Detailed information is required on the amount and distribution of rainfall, and evapotranspiration. If such data is available for each station, figures can be calculated giving the probability of water deficiencies during certain periods (days) over a number of years. Maps based on a rating of these probabilities for the representative meteorological stations are necessary.

In the opinion of the meeting, such data is not available in sufficient level of detail in many countries. To meet this need, it is recommended that countries having sufficient data, construct the required probability maps and present them at a future meeting as a basis for discussion and formulation of guidelines for subsequent compilation of similar maps of other European countries.

1/ Delegates already nominated during the meeting are: Messrs. Bardaji (Spain), Gerey (Hungary), Stefanovits (Hungary), and Szabolcz (Hungary). Further nominations from the remaining interested countries are anticipated.

CLOSING SESSION

On behalf of the Director-General of FAO, Dr. Pécrot thanked the Government of Czechoslovakia and particularly the Organizing Committee of the Consultation for the perfect organization of this successful meeting. He also thanked the participants and observers for their excellent contributions and the high level of technical discussions. He pointed out that this first meeting on Land Evaluation for Europe has been quite different from the previous sessions of the ECA Working Party on Soil Classification and Survey, as most subject matters of the agenda were new. The meeting was a first and important step toward standardization of land evaluation methodologies in Europe. It gave an opportunity to land evaluation specialists from various European countries to meet and inform their colleagues of their working methods and experience. The session was briefed on the FAO Framework for Land Evaluation which is being developed. It will be tried in the European countries and it is hoped that suggestions for improvement and adaptation to European conditions will be submitted to the FAO Secretariat and discussed in further meetings of the Working Group. Dr. Pécrot stressed that the adoption of a standard approach to land suitability evaluation by the European countries will take time and efforts and he reminded that it took more than 20 years to agree on a uniform soil nomenclature in Europe. He was however confident that ultimately, and with the coordinating assistance of FAO, a standard approach to land evaluation would be adopted in Europe.

On behalf of the participants in the Session, Prof. Tavernier warmly thanked the Organizing Committee and particularly Dr. Hrasko, for the excellent organization of the meeting and the facilities offered, and he expressed his hopes for a successful continuation of the work.

Speaking on behalf of the Romanian Society of Soil Science, the delegate of Romania, Prof. Florea, suggested that a small ad hoc Expert Consultation on Land Evaluation be organized next year in Romania in connection with the Symposium of the Romanian Society of Soil Science which is likely to take place in August/September 1976. This proposal was accepted with gratitude. It was agreed that the meeting would have a limited participation and would mainly be organized for the benefit of the Romanian soil scientists, since the preliminary results of the activities recommended at the present meeting would not be available for general discussion in one year's time.

STUDY TOUR

After the Session, two one-day field tours were organized in Czechoslovakia on 4 and 5 September. The location of the areas visited and the itinerary are shown on the accompanying sketch map. The first day was spent in the lowlands southwest of Nitra where the Gabcikovo State Farm was visited; the second day in the mountainous area on the Poniky Cooperative Farm.

The classification of the soils both in the FAO Legend and in the US Soil Taxonomy and their agricultural potential were discussed and in most cases an agreement was easily reached at the second level of generalization of the FAO Legend.

1. Some divergency still exists in the nomenclature at the third level of the soil units. This seems to be due to differences of opinions on the priority to be given to soil characteristics in the subdivision of soil units at the third level (e.g. Vermic or Calcaric - in Calcic Chernozems - See profile 1, Komjatice).

2. Calcaric Fluvisols may be subdivided into Gleyo-calcaric Fluvisols to indicate the presence of hydromorphic properties at less than 50 cm from the surface (see profile No 2 - Gabcikovo Farm).

3. Separation between Mollic Gleysols and Gleyic Phaeozems was discussed (profile 3 Gabcikovo Farm). This profile provided a good example of the effect of long term artificial drainage on soil characteristics. Originally a Mollic Gleysol in a backswamp area with high water table and poor drainage, the soil is now close to a Gleyic Phaeozem (Chiernicza) after artificial drainage during the last century.

4. In spite of the objective criteria used in the definition of the argillic B horizon, the presence or absence of this horizon in borderline cases is still subject to divergent interpretation in the field in the absence of thin sections. Profile 4 (Sladkovicovo) is a good example. Although the mechanical analysis showed a clear increase of clay in the B and the forest association was reportedly indicative of a leaching process, no clayskins were visible and the structure was not typical of a Bt. After some discussion, it was suggested to classify the profile in the Haplic Phaeozems.

5. The profiles studied during the excursions were classified as follows in the FAO Legend and the US Soil Taxonomy:

1st day	FAO Legend	Soil Taxonomy
Profile 1	Calcaro-calcic Chernozems	Typic Vermustoll
Profile 2	Gleyo-calcaric Fluvisol	Typic Fluvaquent
Profile 3	Calcaro-mollic Gleysol	Typic Haplaquoll
Profile 4	Haplic Phaeozem	Udic Haplustoll
Profile 5	Luvic Chernozem	Typic Argiustoll
2nd day		
Profile 1	Orthic Luvisol	Dystric Eutroboralf
Profile 2	Stagno-gleyic Luvisol	Aquic Eutroboralf
Profile 3	Eutric Cambisol	Dystric Eutrochrept

Excursion Programme

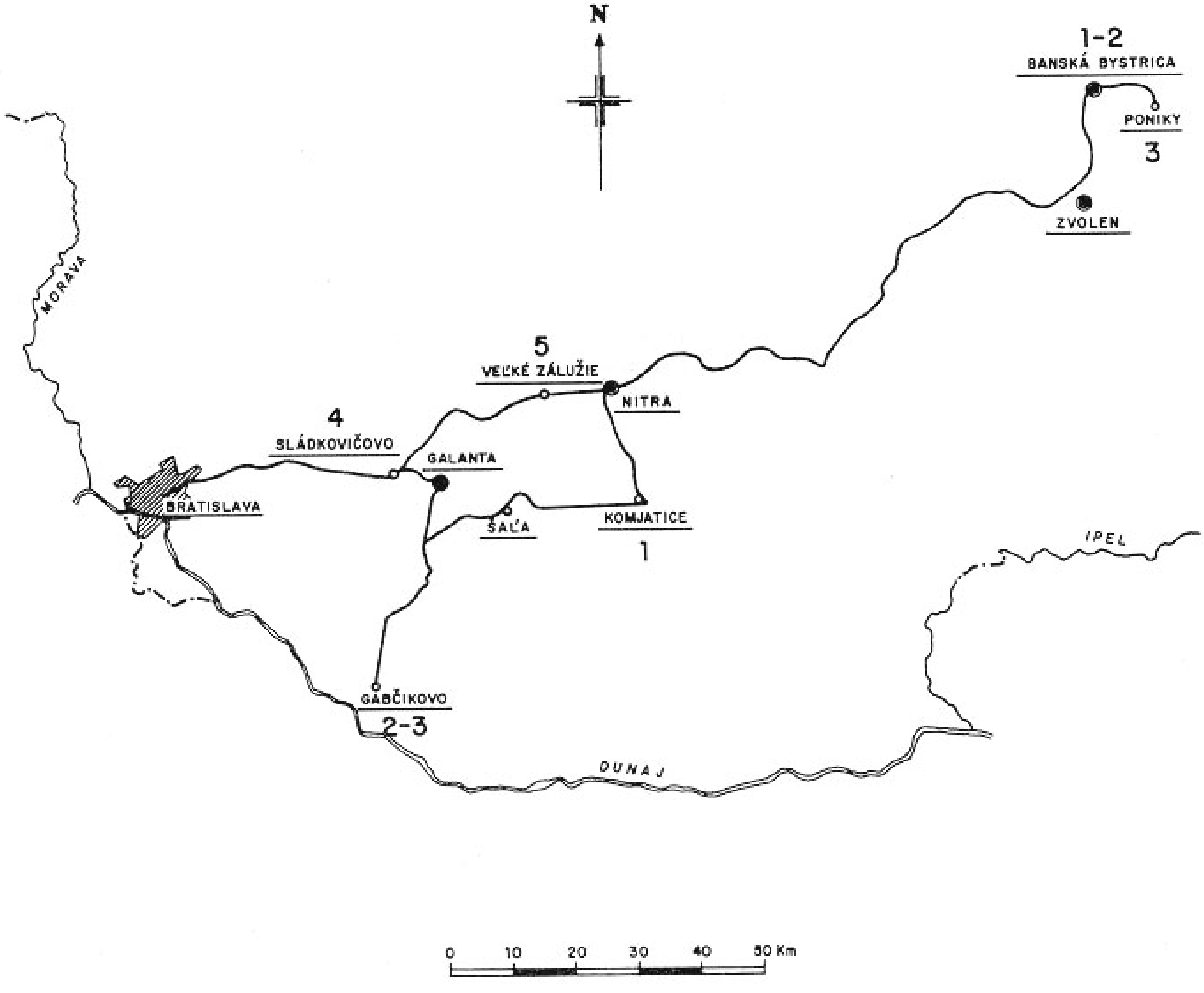
4 September 1975

07.30 Nitra to: Komjatice (profile No 1), Sala, Gabcikovo (profiles No 2 and No 3), (lunch), Sladkovicovo (profile No 4), Velke Zaluzie (profile No 5), and return to Nitra 19.00.

5 September 1975

07.30 Nitra to: Banska Bystrica, Poniky, (profiles No 1 and No 2), (lunch), (profile No 3), farewell dinner and return to Nitra 24.00.

ITINERARY OF STUDY TOUR AND LOCATION OF PROFILES



BASIC ANALYTICAL CHARACTERISTICS OF THE PROFILE No 1 (Komjatice)

Calcaro-calcic Chernozem, developed from loess (Nitrianska Hilly Land)

Depth in cm	Particles size distribution (μ in %)					Humus %	CEC meq 100 g	pH		Carbo-nates	Available nutrients in mg/100 g	
	> 250	250–50	50–10	10–1	< 1			H_2O	KCl		P_2O_5	K_2O
5–10	0.8	11.3	49.6	20.6	17.7	2.36	23.0	7.7	7.3	2.0	13.5	21.0
30–40	0.5	12.0	48.5	18.8	20.2	2.00	23.0	7.6	7.3	2.0	6.9	14.0
55–65	0.2	10.1	48.0	18.5	23.2	1.71	24.0	7.8	7.4	4.0	6.9	12.0
100.110	0.2	11.9	47.6	24.4	15.9	–	11.0	7.9	7.5	18.0	–	7.0

Total Analysis of the Mineral Portion (in %)

Depth in cm	Loss on ignition	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	P_2O_5	SO_3	MnO	TiO
5–10	7.01	69.32	11.13	4.49	1.94	1.48	2.28	1.10	0.15	–	0.10	0.72
30–40	6.37	68.50	12.16	4.62	1.60	1.44	2.45	1.04	0.14	–	0.09	0.74
55–65	7.98	66.20	11.30	4.49	3.79	1.60	2.14	0.97	0.10	–	0.10	0.80
100–110	17.42	48.12	8.70	3.32	16.32	3.12	1.69	0.75	0.11	–	0.07	0.56

BASIC ANALYTICAL CHARACTERISTICS OF THE PROFILE No 2 (Gabcikovo)

Calcaric Fluvisol (Alluvial Soil), developed from carbonaceous alluvial deposits (Danubian Plain)

Depth in cm	Particles size distribution (μ in %)					Humus %	CEC meq 100 g	pH		Carbo-nates	Available nutrients in mg/100 g	
	> 250	250–50	50–10	10–1	< 1			H_2O	KCl		P_2O_5	K_2O
10–20	6.5	28.8	37.5	20.4	6.8	1.7	22.3	7.4	7.3	25.2	8.4	17.2
35–45	3.6	31.0	39.6	18.7	7.1	0.9	18.6	7.5	7.4	27.4	3.2	9.3
50–60	4.5	47.9	33.5	10.5	3.6	0.33	7.0	7.6	7.5	28.6	1.6	5.0
75–85	7.8	65.4	14.6	9.3	2.9	0.37	6.2	7.5	7.4	32.7	–	–

Total Analysis of the Mineral Portion (in %)

Depth in cm	Loss on ignition	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	P_2O_5	MnO	TiO_2
10–20	16.32	44.40	4.68	11.22	11.28	5.58	2.16	0.94	0.16	0.16	0.52
35–45	15.26	42.58	4.54	10.94	13.18	5.73	2.03	0.93	0.13	0.09	0.55
50–60	15.78	50.11	3.47	8.90	12.06	5.27	1.65	1.25	0.13	0.03	0.52
75–85	13.60	46.28	3.84	9.92	12.67	5.87	1.92	1.17	0.11	0.08	0.55

BASIC ANALYTICAL CHARACTERISTICS OF THE PROFILE No 3 (Gabcikovo)

Calcaro-gleyic Phaoezem (Chiernicza), developed from carbonaceous alluvial deposits (Danubian Plain)

Depth in cm	Particles size distribution (μ in %)					Humus %	CEC meq 100 g	pH		Carbo-nates %	Available nutrients in mg/100 g	
	250	250–50	50–10	10–1	1			H_2O	KCl		P_2O_5	K_2O
10–20	2.1	26.9	28.7	31.3	11.0	2.6	24.2	7.6	7.3	12	7.5	17.0
35–45	0.9	24.0	31.7	30.4	13.0	2.7	20.3	7.6	7.4	13	4.9	6.0
55–65	4.1	36.6	22.8	21.4	15.1	0.9	15.4	7.8	7.4	19	3.2	5.4
80–90	8.2	40.4	23.7	19.8	7.9	0.6	12.0	7.8	7.5	23	1.7	4.7
130–140	3.3	27.6	46.1	17.5	5.5	0.41	7.0	7.9	7.5	27	–	–

Total Analysis of the Mineral Portion (in %)

Depth in cm	Loss on ignition	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	P_2O_5	MnO	TiO_2
10–20	15.77	50.70	5.10	12.70	2.61	1.69	1.38	0.44	0.12	0.06	0.57
35–45	11.61	52.94	5.41	13.51	2.38	1.96	1.70	0.61	0.12	0.07	0.60
55–65	16.22	66.43	4.11	11.16	3.63	1.63	1.76	0.93	0.09	0.06	0.45
80–90	23.12	67.47	3.75	7.93	5.35	3.28	2.00	1.04	0.08	0.05	0.42
130–140	16.27	78.64	3.46	3.28	2.00	1.04	1.26	0.78	0.05	0.03	0.21

BASIC ANALYTICAL CHARACTERISTICS OF THE PROFILE No 4 (Sladkovicovo)

Luvic Phaeozem (Brown Chiernicza), developed from carbonaceous alluvial deposits (Danubian Plain)

Forest association: Fraxino-angustifoliae - Ulmetum carpinetosum

Depth in cm	Particles size distribution (μ in %)					Humus %	C/N	Base satur. %
	250	250–50	50–10	10–1	1			
5–13	2.8	25.0	25.4	31.3	15.5	5.17	8.6	85.7
20–30	2.7	18.1	24.6	28.7	25.9	2.10	8.1	89.5
50–60	2.9	17.0	26.2	26.7	27.2	1.57	-	94.2
85–95	2.1	22.7	30.4	22.5	22.3	1.03	-	100.0
105–125	1.4	18.5	40.2	21.0	18.9	0.76	-	100.0

Depth in cm	pH KCl	Fe %	Total analysis in %				
			SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO
5–13	6.3	0.23	62.32	4.65	12.55	1.65	1.76
20–20	6.4	0.26	65.62	4.65	13.11	1.30	1.76
50–60	6.3	0.29	67.01	4.68	13.41	1.25	1.76
85–95	6.7	0.28	66.83	4.47	13.47	1.30	1.82
105–115	7.3	0.11	63.78	3.96	11.21	4.55	3.50

ANNEX

PRESENTED PAPERS

INTRODUCTION TO THE APPROACHES TO LAND SUITABILITY IN EUROPE

by

L.J. Pons

During the ECA Working Party on Soil Classification and Survey in Ghent in September 1973, it was decided that after the completion of the soil map 1:1 000 000 the joint activities would continue with land suitability classifications, based on the new soil map. In modern soil science it is more and more accepted that the value of soil maps may considerably increase if interpretation work such as suitability classification for certain kinds of land use are added.

The ECA Working Group on Soil Classification and Survey has provided much experience in cooperation and correlation in classification of soils and the preparation of small scale soil maps in the different European countries. A similar task, but more difficult, is lying before us and will be discussed during this technical consultation on land evaluation for Europe. Like the start of the work for the Soil Classification and Survey, the first step to be taken for the establishment of a common system for land classification is the collection of data on present land evaluation systems in use in the different countries. For this purpose, each country delegation will be invited to present a short review about the current activities on land evaluation and especially about the methods and approaches to land evaluation for land use planning in his country. We hope that this inventorization will provide useful information for the realization of the task ahead.

The inventorization will:

1. give a better idea to the participants about activities in relation to land classification in other countries for land use planning;

2. undoubtedly show a wide range of different approaches to land evaluation, partly due to specific land conditions or specific land use but also to specific preferences for the methodology of the land evaluation;

3. provide a basis for the development of a common approach and, once a certain basis has been accepted, will clearly show the gaps in information that have to be filled to meet the requirements for this common approach.

The organizers of this technical consultation have invited me to introduce this part of the programme. I accept this invitation with pleasure amongst others because in the last few years we have made short studies of European systems of land evaluation with our students. Among the papers for this meeting you will find two reports dealing with a comparative study of some West European systems of interpretations of soil surveys and a comparision of these systems with recent FAO proposals (Albers, Hielkema, Krul and van Lanen, 1975).

However, during the preparation of my introduction I was confronted with two main difficulties. The first difficulty was the risk to give wrong representations and judgements resulting from lack of information. Land classification and land suitability evaluation are very rapidly developing parts of soil science in present times. Consequently, the methods used in the different countries are being revised or not yet published and it is extremely difficult to get full information of the most recent approaches. For that reason, I would regret it very much if some country delegates are disappointed about my assessment of the quality of their national systems of land suitability classification in comparison with other systems in the reports of our students as well as in my own review.

The second difficulty was related with the timing of my introduction. Even for a general description of the land evaluation systems, I feel the need for a basis for comparison and for definitions of the terms used. In fact, this basis has already been worked out recently during the preparation of the FAO framework where the definitions are given. However, I am not yet supposed to speak about this Framework. I hope to overcome this difficulty by giving only a few general definitions. In my introduction I will compare the current European systems very broadly with some definitions used in the FAO framework. At a later stage of this meeting, once the Framework has been explained by several specialists, I would like to go into more detail in comparing some important aspects of the European systems with the FAO framework.

During the last ten years in Europe an increasing number of countries have tried to develop new approaches to what is called by Vink in Brinkman and Smyth, 1973: "Economic Land Classification" for planning and recommendation of rural land use. Economic land classification is a synthesis of technical land suitability classification and social and economic variables.

Soil or land specialists are normally not equipped to penetrate into these very complex and also partly political social and economic aspects of land use planning. However, governments dealing with land use planning need a number of alternative solutions to be able to take proper decisions. In this respect the above mentioned technical land suitability classifications for a defined purpose are needed (Beek and Bennema, 1974). Therefore, in this review we will restrict ourselves to this "(technical) land suitability classification".

In this land suitability classification "fixed socio-economic and physical assumptions" will be used (Vink in Brinkman and Smyth, 1973; Arnoldus and Vink 1975 in World Soil Resources Report No. 45). In the literature a number of synonymous terms for (technical) land suitability classification are in use, e.g. technical feasibility classifications, ecological land evaluation, etc.

Land suitability classification can be described as the expression of the fitness of a given tract of "land" for a defined "type of land use" in a certain "classification system" under fixed "socio-economic and physical assumptions". In our present introduction we will restrict the comparison of European Land Suitability Approaches to an evaluation of some aspects of the above mentioned topics of the FAO framework for land evaluation. Once the Framework has been explained in more detail, we will compare some European systems with the requirements of the Framework.

In describing the kinds of, and the differences between the European Land Suitability Approaches we are using two tables. Table 1 describes in general terms the purpose of the land suitability classification in each country and the several aspects of a selected number of European Land Suitability Approaches as compared with four main topics of the FAO framework. In Table 2 we have tried to classify these aspects in order to get a better basis for comparison.

Table 1 begins with the name of the suitability classification and the publication from which it is derived. A general description is following about the purpose of the land suitability in the overall land use planning of the respective countries if the data were available. Table 1 is continuing with remarks on the national classification in the context of four main topics. In Table 2 these remarks are more or less evaluated.

Topic 1 - The socio-economic assumptions

Every land suitability classification needs a set of assumptions concerning the nature of the land use types and the general conditions under which these types are relevant (Vink, 1975; Arnoldus and Vink, 1975). Under different socio-economic conditions the suitability for a certain land use will be different, e.g. the ratio of relative suitability of a certain tract of land for grassland or arable land in many European countries is related with the fixed prices for the respective products in that country.

The assumptions can be divided into assumptions of a social and/or economic character and assumptions of physical character (Arnoldus and Vink 1975). For our present review, we distinguish between:

1. socio-economic and physical assumptions;
2. socio-economic assumptions only;
3. physical assumptions only;
4. none or very limited number of assumptions.

In Table 2 a rough classification is made according to this aspect of the assumptions. In many descriptions of land suitability approaches these assumptions are incomplete, although I am sure that they have been kept in mind and used in the procedure. This may probably be the reason why the classification of this topic is rather unsatisfactory.

<u>Topic 2 - Types of land use</u>

The land suitability systems in Europe show a remarkable uniform description of the kinds of land use for which the suitability is established. In most cases they include a small number of major types of land use that are relevant in the current environmental socio-economic and natural conditions. Nearly all European approaches are using the following major types for rural land use:

- arable land with a number, a group or a rotation of crops;
- horticulture or orchards (not in every system);
- grassland;
- forestry;
- some types of non-agricultural utilization such as nature vegetation and nature reserves, construction of sporting fields, recreation purposes or amenity uses.

According to the character of the agriculture of each country, related to typical soils and to special climates, and especially for more detailed maps, specific land use types are described, e.g. vineyards, vegetables, tobacco, etc. In a number of countries sometimes a major type of land use is split up in somewhat more restricted types of land use, e.g. grassland into grassland and rough grassland or into intensive permanent grassland and extensive grassland; arable land in irrigated arable land and dry arable land; forestry in intensive and extensive forestry, etc. These subdivisions are mainly used in larger scale maps.

For this reason in Table 2 we distinguish only three subdivisions in the descriptions of land use types:

1. major types of land use;
2. subdivisions of the major types of land use in some more detailed types;
3. land use for specific crops.

If in the approaches suitabilities for irrigation are provided, the letters A or B are used for land use types, without and with irrigation, respectively.

Other aspects of land use types such as mechanization level, knowledge of the farmer, internal structure of the farm and size of plots, soil pattern, major and minor land improvements are in the majority of the classifications broadly described in the assumptions (see Topic 1). One of the main purposes of a good description of a land use type is to note the requirements of the crops with respect to the soil and to the land. Cultivation of crops not only require certain soil or land qualities for its growth but also the possibilities for the application of machinery, etc. Thus, a type of land use has not only requirements for the growth of its crops but also for a certain management. Based on the way in which land use types describe the specific requirements with respect to land, the approaches to land suitability are divided into:

a. approaches with a clear description of the requirements;
b. approaches with only general remarks in that respect.

Topic 3 - Soil or land characteristics or qualities

Land is a wider concept than soil, as it includes also the atmosphere, the biosphere, the geology and hydrology and the results of human activity both above and below the surface (Brinkman and Smyth, 1973). The FAO Framework, however, is not clear in defining land and soil and in tracing the boundary between the meanings of the two words. Sometimes soil is including all the physical factors influencing crop growth, hence also hydrology and climate. In the following we are using the FAO definition of Brinkman and Smyth (1973) on page 63 in which soil is more restricted. The physical aspects of the natural environment, i.e. macro topography, climate, surface- and groundwater hydrology and certain man-made features are excluded from soil, but included in land. We distinguish three groups of approaches of suitability classification with relation to the aspect of soil or land:

1. use of characteristics only;
2. use of soil characteristics with some land characteristics;
3. use of land characteristics.

The question if land, or only soil characteristics are used in suitability procedures in the different countries, partly depends on the internal organization of the survey institutes in each country. If only soil characteristics are used, other features will probably be added by other institutes and considered for the land use alternatives in another way. In some countries some aspects of land are not mentioned, but are nevertheless used, e.g. the climate in the Netherlands. The reason is that in the Netherlands only one climate is considered.

A second aspect of this topic is the combination of the characteristics into qualities, and their contribution to the rating of these qualities in order to specify comparisons with crop and management requirements. With relation to the use of these qualities and whether they can be compared with FAO standards, we distinguish three goups of approaches:

a. approaches in which the land characteristics almost only or only in themselves are taken into account;

b. approaches in which they are totally, or to a large extent, combined to some kind of quality;

c. approaches in which they are combined to clearly described qualities, comparable with the land qualities in the FAO framework.

In some approaches it depends on the level of suitability classification and on the scale of the maps if soil or land characteristics are used and whether qualities are used or not.

Topic 4 - System of classification

The system of classification is the way to express the land value or the land suitability in an easy and practical understandable way. Two main systems are used, viz: the categoric system with two or three levels of generalization, based on potentials, limitations and gradings of land qualities for certain land uses and the numerical system based on soil or land indexes in which the land value for a certain land use is expressed in calculated figures or in calculated percentages of the quality of the best known land. Systems with calculated indexes have the general disadvantage that a limiting factor is not sufficiently standing out if there are no other limiting factors. In categoric systems the severity of one limiting factor is already determining the suitability in the correct place (see Albers, etc. 1975). Another disadvantage of the numerical system is that the final figure gives no information about the nature and severity of the limitations. Sometimes the classification systems used are not purely categoric or numeric but some kind of mixture of these two systems. In some countries a numerical system is used in which the categoric classes are formed by grouping soil or land indexes. It is also possible that the system used may be characterized as a categoric system in which a grouping of the indexes acts as the criterion for the classes.

In Table 2 we distinguish four kinds of classification systems for the land suitability:

1. the numerical system;
2. the categoric system;
3. the numerical system with certain groups of indexes;
4. the categoric system based on groups of indexes.

Besides this, judgement is given about the way in which the indexes are calculated, e.g. a) by way of multiplication applying correction factors or b) by adding and subtracting. Both kinds of calculations have their advantages and disadvantages.

In the categoric system, the classification units are distinguished on basis of qualitatively or quantitatively expressed criteria. It is very difficult to determine the boundary between quantitative and qualitative approaches. We consider a land suitability as a quantitative one if all aspects of the land suitability, especially the production capacity and the cost benefit ratios, are expressed in quantitative terms under quantitatively described assumptions. In this respect, none of the known land suitability systems are fully quantitative.

In the numerical land suitability systems the indexes are calculated by adding and subtracting fixed values for the different ecological factors or by myltiplying such values and correcting them by correction factors. Also in this kind of classification system it is very difficult to distinguish between qualitative and quantitative ones.

According to the definition given above, also the descriptive numerical classifications are not meeting the requirements of quantitativeness. The indexes are established with help of parametric approaches in which it is tried to estimate influences of soil and land properties and characteristics, as well as on yields, and to simulate interactions between different properties both in relation with yields and with agricultural management practices. Because the interactions are very complicated, some factors and their weights are yet unknown or not well-known and the calculated indexes are given without possible variations. In our opinion, indexes are equally valuable as compared to classes of the categoric system. For this reason I would prefer to distinguish between a) qualitative or b) semi-quantitative systems of classifications. Included in this topic we also give the number of principle classes (3-7) and the number of generalization levels (II-IV).

REFERENCES

Albers, H.T.M.P., Hielkema, J.V., Krul, H.A. and van Lanen, H.A.J. A comparative study of
1975 some West European land classification systems. Publ. No. 559, Dept. of Soil Sci. and Geology, Wageningen, The Netherlands.

Albers, H.T.M.P., Krul, H.A., and van Lanen, H.A.J. Some Existing West European land classi-
1975 fication systems compared with recent FAO standards. Publ. 600, Dept. of Soil Sci. and Geology, Agricultural University, Wageningen, The Netherlands.

Arnoldus, H.M.J. and Vink, A.P.A. Assumptions used in land evaluation. In World Soil
1975 Resources Report 45. FAO, Rome. p. 150-152.

Beek, K.J. The concept of land utilization types. In Approaches to Land Classification.
1974 Soils Bull. 22. FAO, Rome. p. 103-120.

Beek, K.J. and Bennema, J. Land evaluation for agricultural land use planning - An ecological
1974 method. In Approaches to Land Classification. Soils Bull. 22. FAO, Rome. p. 54-70.

Bibby, J.S. and Mackney, D. Land use capability classification. The Soil Survey, Technical
1969 Monograph 1.

Bulgarian Working Group on Land Evaluation. Land productivity evaluation in Bulgaria. In
1974 Approaches to Land Classification. Soils Bull. 22. FAO, Rome. p. 83-95.

Carvalho Cardoso, J. Soil survey and land use planning in Portugal. Transac. 9th Int.
1968 Congr. Soil Sci. Australia. IV: 261-269.

Edelman, C.H. Applications of soil survey in land development in Europe. I.I.L.C.
1963 Publ. 12, Wageningen.

FAO. Report on the Ad Hoc Expert Consultation on Land Evaluation. Rome, Italy, 6-8 Jan.
1975 1975. World Soil Resources Report 45. FAO, Rome.

Gardiner, M.J. Land evaluation studies in Ireland in Approaches to Land Classification.
1974 Soil Bull. 22 FAO, Rome. p. 96-102.

Gibbous, F.R. and Haans, J.C.F.M. Dutch Victorian approaches to land appraisal
1974 Transac. 10th Int. Congr. Soil Sci. Moscow. V:19-26.

Gordon Steele, J. Soil survey interpretation and its use. Soil Bull. 8 FAO, Rome.

Lee, J. and Diamond, S. The potential of Irish land for livestock production.
1972 Soil Survey Bull. 26. Agric. Institute, Dublin.

Reichel, H. Überprüfung der Ergebnissen des Reichsbodenschätzung auf ihren ökonomischen
1973 Aussagewert unter heutigen Produktionsbedingungen. Hohenheim.

Rothkegel, W. Landwirtschaftliche Schätzungslehre. Stuttgart.
1952

Stefanovits, P. and Fórisz, M. Elaboration of a new method of soil appraisal in Hungary.
1974 Transac. 10th Int. Congr. Soil. Sci. Moscow. V. 26-34. (Russian with English summary.)

Stremski, M. Division of productive agricultural areas into categories based on natural
1965 principles of effective land utilization. Roezniki Gleboznowcze.

Vink, A.P.A. Land use in advancing agriculture. Springer Verlag, Berlin, Heidelberg,
1975 New York.

Table 1. Short description of the aspects of European Land Suitability Approaches as compared with 4 topics of the FAO Framework.

NATIONAL APPROACHES OF LAND SUITABILITY CLASS. (Name, year, author) and their PURPOSE / Topics	1. SOCIO-ECONOMIC AND PHYSICAL ASSUMPTIONS	2. TYPES OF LAND USE	3. SOIL OR LAND CHARACTERISTICS OR QUALITIES	4. SYSTEM OF CLASSIFICATION
1 Provisional Land Use Capability Classification of England and Wales and Scotland BIBBY and MACKNEY, 1969	For agricultural use Moderate high level of management (if not specified in other ways). Improvements at acceptable costs are included. Limitations are physical. Major economic structure is fixed. Different infrastructural farms are not considered. Not for single crops.	- Arable land with a number of crops - Grassland - Rough grassland - Forestry - Recreation Changes of characteristics and resulting changing in suitability classes after major reclamation projects (e.g. pumping schemes) are considered in different land use types	LAND CHARACTERISTICS (physical soil characteristics, hydrology, climate, etc.) are combined to graded groups of land characteristics (limitations) forming kinds of LAND QUALITIES (w : wetness; s : soil limitations; g : gradient and soil pattern (6); e : susceptibility to erosion; c : climate (3)	CATEGORIC SYSTEM of qualitative character with partly quantitative description of qualities - 7 LAND CLASS. CLASSES based on potentiality and severity of limitations for decreasing number of landuses. - L.C. Subclasses based on kinds and grades of limitations (5) - L.C. UNITS (for scale 1 : 25.000 and larger)
2 Land evaluation in Ireland GARDINER, 1974 Physical contribution to national Land Use Planning and suitability studies for single types of land use	High level of management. Full use of fertilizers. Present national socio-economic conditions	- Arable land with broad groups of crops - Mechanized pasture farms - Horticulture - Forestry - Amenity uses Major soil improvements and improvements of drainage are considered in different land use types	SOIL CHARACTERISTICS (only physical ones)+ HYDROLOGICAL characteristics(no climatic characties, related with crop growth as well as with management. Rating of the characteristics are established by yield ratings related with soil types	CATEGORIC SYSTEM of qualitative character - 6 CLASSES based on potentiality and limitations for decreasing number of land uses

3 Soil suitability Classification in the Netherlands (Bodemgeschiktheidsklassifikatie) Mimeographed report Jan. 1975 Stiboka, Netherlands. Physical Contribution to the regional and national Land Use Planning and for use in Agricultural Extension Services.	Under Dutch economic conditions. For modern mechanized agricultural and other rural industries of acceptable size. Whole farm is supposed to be occupied by one mapping unit. Under prevailing Dutch climate	- Arable land - Grassland - Horticulture - Forestry - Nature reserve - Construction of sporting fields - Low-story housing development - Tertiairy road construction with well defined requirements. Major land improvements and their consequences for change of qualities are considered	SOIL CHARACTERISTICS (not to be changed in a simple way) including HYDROLOGICAL CHARACTERISTICS , combined with external factors e.g., climate to semi-quantitatively expressed SOIL QUALITIES	CATEGORIC SYSTEM Of qualitative character with some quantitatively described qualities - 3 MAIN CLASSES based on potentials and levels of soil qualities for each considered land use type } small scale maps - INTERMEDIATE CLASSES based on soil qualities - SUBCLASSES based on specification and grading of soil qualities } large scale maps
4 Land Capability of Portugal (Capacidade de uso do solo) CARVALHO CARDOSO, 1968 Physical contribution for preparation of the Map of Ecological Stations and the Ideal Land Use Map.	Necessity to use the soil in the most economic way. Without danger for deterioration (erosion,salinity). Moderate modern farm management. Fixed socio-economic conditions	-Arable land with crops with and without irrigation -permanent extensive grassland -Intensive and extensive forestry -Natural vegetation and nature reserve	LAND CHARACTERISTICS combined to 5 semi quantitative groups of land characteristics (qualities): Nature of soil - effective soil depth-erosion-water in and on the soil-stoniness-rock outcrops and toxic salts (climate is in water) Each of 5 qualities is graded 0-100	CATEGORIC SYSTEM of semi quantitative character. - 5 CLASSES based on potentials, general limitations and increasing risks of soil damages leading to decreasing possibilities for land use; formed by grouping of indexes. The latter are formed by multiplication. - SUBCLASSES based on three kinds of general limitations: risk of erosion, wetness and rootzone limitations.

5 Land Productivity Evaluation in Bulgaria (Bulgarian Working Group, 1974) Physical contribution to the solution of problems of land productivity and land use problems	Modern agriculture in large sized farms, highly mechanized. Full use of Fertilizers,	-Crops on dryland -Orchards on ,, -Vegetables on ,, -Vineyards on ,, -Tobacco on ,, -Pastures,, ,, -Meadows ,, ,, -Forests ,, ,, -At application of irrigation, correction factors are used	SOIL CHARACTERISTICS are forming one "stable" quality and are expressed as a soil mark (in relation with specific crop) OTHER LAND CHARACTERISTICS ("dynamic factors") are graded with correction factors giving soil index. CLIMATE is expressed separately as a correction factor.	NUMERIC (so called Parametric) SYSTEM Land suitability is expressed as an index calculated by correcting the soil index by a climatological correction factor
6 Land evaluation in Hungary (pers. comm. Dr. Mattē,1975) Only provisionally published: STEFANOWITCH, 1974 in Russian with short english summary Originally use as a base for land taxation. Physical contribution to the National Economic Land classification system, National Land Use Planning. Land Suitability map scale 1 : 500.000 NW Hungary. Item scale 1 : 200.000	?	-Arable land with 10 selected crops -Grassland -Vineyards -Forestry	SOIL CHARACTERISTICS are grouped to "qualities" and expressed in notes. Addition or subtraction produces soil indexes. On lower level also LAND CHARACTERISTICS are used as correction giving site indexes. Correction factors for each graded quality in relation with land use are available on tables	CATEGORIC SYSTEM in which lower levels are NUMERICAL characterized. Levels depend from map scale. - 10 CLASSES based on groups of soil indexes 1 : 100-90; II 90-80, etc. - SUBCLASSES based on correction factors of "land qualities" giving site indexes - LOCAL VARIANTS
7 A regional Landsuitability Classification (dept. Oise in France) developed by BEGON et REMY (not published)	-Modern mechanized farms of large size -French socio-economic conditions -Climate is considered as non-variable	-Arable land with 4 local crops: sugar beets mais, small grains, potatoes	LAND CHARACTERISTICS are grouped to LAND QUALITIES, each graded in notes and corrected by correction factors for their relative importance for each crop. Addition of the weighted quality notes gives a definite note, expressing the production capa city.	NUMERIC SYSTEM with figures
8 Landclassification in Western Germany (Bodenschätzung) ROTHKEGEL, 1952 REICHEL, 1973 Originally soil taxation for tax, now developing into land taxatationsystem used for tax, agricultural development, etc. The Arable Land Indexes (Ackerzahlen) are corrected per farm for some factors in relation with the economy of the farm (size, roads, etc.) giving the FARM index as a grading for the rentability of the farm.	All farms are compared with an "ideal" farm (modern, mechanized) on the best soil in Hildesheimer Börde.	-Arable land -Grassland -Horticulture -Vineyards -etc. For selected land use types corrections are made.	SOIL CHARACTERISTICS are grouped into three main groups ("qualities") (top. soil text, parent mat.;dev.of soil profile), each providing indexes that are shown in tables and added giving soil indexes (Bodenzahl). Corrections for climate and slope are giving by multiplication: arable land indexes (Ackerzahl) (Rate for production capacity)	NUMERIC SYSTEM with arable land indexes (Ackerzahl) in a range 0-100.

Table 2

COMPARISON OF VARIOUS EUROPEAN LAND SUITABILITY APPROACHES

TOPICS / COUNTRY	1. SOCIO-ECO-NOMIC AND PHYSICAL ASSUMPTIONS	2. KINDS OF LAND USE	3. SOIL OR LAND CHARACTERISTICS OR QUALITIES	4. SYSTEM OF CLASSIFI-CATION
1. England and Wales and Scotland	1	1+2-A-b	3-B	2-0-b-7-III
2. Ireland	1+4	1+3-A-b	2-A+B	2-0-a-6-I
3. Netherlands	1	1-A-a	2-C	2-0-b-3-III
4. Portugal	1+4	2-B-b	3-B	4-A-b-5-II
5. Bulgaria	1+4	2+3-B-a	3-B	1-A-b-0-0
6. Hungary	1+4	3-B-b	3-B	4-B-b-10-III
7. France (regional)	4	1+3-A-b	1+2-B	1-B-b-0-0
8. Federal Republic Germany	4	1+3-A-b	3-B	1-B-b-0-0
1. Socio-economic + physical assumptions 2. Socio-economic assumptions only 3. Physical assumptions 4. No or very few assumptions		1. Major types of land use 2. More detailed types of land use 3. Land use for a specific crop A. Non-irrigated agriculture only B. With application of irrigation a. with clear description of the requirements b. lacking clear description of the requirements	1. Soil characteristics only 2. Soil +some land characteristics 3. Landcharacteristics A. Characteristics not combined B. Characteristics combined to some kinds of landqualities C. Characteristics combined in landqualities. Following FAO Framework	1. Numerical system 2. Categoric system 3. Numerical system with certain groups of indexes 4. Categoric system based on groups of indexes A. multiplication correction factors B. addition + subtraction a. qualitative b. semi quantitative 3-7. number of principal main L.S. Class II-IV. Number of generalization levels

APPROACHES TO LAND EVALUATION IN EAST EUROPEAN (SOCIALIST) COUNTRIES

by

S. Krastanov, I. Kabakchiev
N. Poushkarov Institute of Soil Science, Sofia, Bulgaria

Introduction

When evaluating land in East European (socialist) countries, a status is considered which is common to all of them, i.e. the public property of land. Therefore, the products of the land must be distributed among all members of the society in accordance with both quantity and quality of labour applied. In such cases, the great differences which exist in productivity of land used in agriculture result in uneven distribution of farmers' incomes. The elimination of that disadvantage is only possible through an objective comparative assessment of ecologic conditions that will reveal all the differences between them and will serve as a basis for application of definite economic measures.

Principles

In connection with the above, 3 main concepts are differentiated in the methods used in almost all of East European countries: soil assessment, land productivity evaluation and economic evaluation of land.

The comparative evaluation of soils as regards their natural properties is known as soil assessment. The rating of the natural soil properties influencing yields is an essential subject of soil assessment. These factors determine both the potential and actual fertility.

According to the terminology of East European countries the concept of "land" is, to a considerable extent, covered by that of "ecologic conditions". In this connection, land productivity evaluation embraces a complex of physio-geographical and natural factors determining the objective (ecological) conditions when using land as means of production (soil, climate, geographic location, water status, etc.).

Economic evaluation of land is an approach used to make an economic evaluation of fertility as a specific economic form of appearance of the actual soil fertility or, in other words, evaluation of social and economic conditions such as: intensification, mechanization, profitability, etc. The latter defines the social profitability of physical parameters of land. Some physical indices are also used as a criterion of economic evaluation in a large number of methods (slope, length of plot, configuration, distance from a settlement, resistance of soil, etc.). These indices affect strongly the final economic results.

The economic indices used for the economic evaluation, such as total income, net income, etc., are not the actual ones but those calculated for a moderate degree of development of means of production at certain relations of production. That makes it possible to compare the results obtained from economic evaluation; otherwise it will not serve the purpose, namely to present the results from land productivity evaluation in comparable values. Thus, for instance, the incomparable evaluation of land for wheat (grain in kg) and alfalfa (in kg) can be transformed into comparable ones only through conversion of these values into either a total or net income expressed as a pecuniary value.

The three main concepts given above for land evaluation show that soil assessment is the first stage in evaluating land. The following stage is land productivity evaluation which is, in fact, a correction of soil assessment by means of the respective correction coefficients for climate, humidity, etc. At the end, the economic evaluation of land comes as a final, concluding stage of the complete evaluation of land as a means of production.

Soil assessment and land productivity evaluation are both characterized by a comparatively great stability as compared to the economic evaluation of land. Due to the fact that it is based upon economic indices the economic land evaluation can vary from year to year to a considerable extent; the economic land evaluation is also subjected to a considerable fluctuation.

Specificity of land evaluation is another feature of the methods used in East European countries for evaluation of land. The land is, in fact, evaluated specifically for each crop and not as regards suitability (for agriculture). This is necessary, as the final stage (economic evaluation) makes use of the yields calculated for the different crops and they are actually the basis of economic land evaluation. The use of calculated yields of crops is rather common for all the methods of land evaluation in East European countries. A common feature of the approach to land evaluation in all those countries is the combining of land evaluation and land budget. A general concept, known as "kadastar" gives expression to that relation which is, in fact, both qualitative and quantitative assessment of land used in agriculture.

The conventionality of the evaluation is also a common feature. Soil assessment and land productivity evaluation are actually valid only at a definite level of technology of crops. The change of crop rotations, system of fertilizer application, etc., results in a respective change in the evaluation values of soils and ecologic conditions; therefore, it is necessary to repeat evaluation of land or correct the existing one by suitable methods.

Irrespective of the large number of common features in the approaches to land evaluation in the different East European countries there is something specific characterizing each one of them. That is due to different reasons: degree of development of the problem, specificity of physico-geographic conditions, climatic factors, level of agriculture, etc.

U.S.S.R.

No common method has so far been accepted in the U.S.S.R. for land evaluation. Different methods are used in the different republics and the research work carried out on the problem varies to a really great extent, respectively. Only recently a draft project was made at the Institute of Soil Science for a common method to be valid for the cereal crop growing regions in the U.S.S.R. It covers the zones of chernozems and podzolic soils in the U.S.S.R., as well as the most widespread crops in those zones such as: rye, wheat and potatoes. The main principles in the project are in the division of the territory into homogeneous climatic-economic regions and the establishment of a correlation between productivity of the above three crops and soil properties. If we assume that the climatic conditions of a certain region are homogeneous, we could find productivity and, hence establish a correlation between the latter and soil properties. The evaluation scale is made with the aid of this correlation; soil properties serve as a basis in that procedure, and not the yields obtained. The so-called soil assessment yield is calculated in this way.

The participation of each soil factor in productivity is calculated by the following formula:

$$Y = A + B_1X + B_2X_2 + \dots B_nX_n$$

where Y is the calculated yield,
A is a free value,
B is a regression coefficient, and — linear, parabolic, multiple, regression?

The method for determination of fertilizer effect only and the increase in crop yield is also of interest in this project. It is in fact a calculation of the increase of yield obtained as a result of 1 kg fertilizer applied and Rouble 1 invested. There are also correction coefficients for complexity of soil cover, soil texture, erosion, salinization and stoniness.

These project methods are also used in the different republics for a qualitative assessment of land, which sometimes differ greatly from each other.

The latest method for a repeated assessment of soils and land productivity evaluation, used in Belorussia, embraces to a considerable extent the main principles of the above-mentioned common method. The qualitative criteria used when fixing the assessment scale are the major soil properties responsible for soil productivity as regards the main crops grown. Those are properties such as: genetic soil type, degree of soil forming process, soil drainage, soil texture, nature and strata of soil forming rock. Properties that are less constant such as: stoniness, erodability, acidity and content of available forms of P and K, that are normally changing in the process of agricultural production, are introduced through correction coefficients. Such coefficients are also used to effect the influence of plot configuration and climate and soil productivity.

The evaluation of one or other soil property accepted as a criterion (exercising a proved effect on yield of crops) is separately made for each crop by the following formula:

$$X = \frac{Y_a}{Y_b}$$

where X is the evaluation of soil property,

Ya is the productivity of soil characterized by a poor condition of the evaluated property, and

Yb is the productivity of soil characterized by an optimal condition of the evaluated property estimated at 100 marks.

Evaluation was made for the following crops: wheat, rye, barley and potatoes. On the basis of the evaluation made for each of the crops an average evaluation is made for each factor separately using the following formula:

$$X = \frac{Y_1 \cdot a_1 + Y_2 \cdot a_2 + Y_3 \cdot a_3 + Y_4 \cdot a_4}{100}$$

where X is the average evaluation

X_1, X_2, X_3 and X_4 are the evaluations of each factor for wheat, winter rye, barley and potatoes,

a_1, a_2, a_3 and a_4 are the relative area of the above crops from the total area on which the respective crop is grown (in %).

The correction coefficients are set up on the basis of long-term observations on yield obtained from a large number of plots of different soil types and under different climatic conditions (e.g. for erosion effects, the number of plots is 1348). According to the methods used in Belorussia, the optimal condition of soil for the above four crops is as follows: no erosion and stoniness, soil chemical properties are at their optimum (pH in KCl = 5.1-5-5; P_2O_5 = 10.1-15.0 and K_2O = 8-14 mg/100 g soil), size of plot is over 10 ha and is situated in the southern climatic region of the country. In this case, the soil assessment coincides with the average evaluation of the soil by the evaluation scale. In the locations where conditions differ from those quoted above, an appropriate correction is introduced in the evaluation. That correction varies from 29 to 55 percent for erosion, from 5 to 45 percent for stoniness. The correction coefficient for content of available P and K varies from 0.62 to 1.15. The correction of the evaluations made through the above correction coefficients can be used to recognize the actual from the potential soil fertility. Correction of evaluation is separately made as regards climatic conditions. For this purpose the whole territory of the country is divided into 4 climatic regions, each one being characterized by its own climatic coefficient.

Land evaluation in Azerbaydjan is based upon humus content in soils and its distribution down to a depth of 100 cm, as well as the content and distribution of N and P down to a depth of 60 cm. Besides the major evaluations related to normal non-eroded soils, the following correction coefficients are used:

Erosion from 1.0 to 0.5
Soil texture from 1.0 to 0.6
Depth of profile on a solid rock from 1.0 to 0.6
Degree of soil improvement from 1.3 to 1.0
Bogginess from 1.0 to 0.4
Salinization from 1.0 to 0.75
Alkalinity from 1.0 to 0.6
Size of plot and stoniness from 0.1 to 0.4

The methods are developed for cereals and cotton. Evaluation scale is set up separately for the major soil types under irrigation.

The methods used for evaluation of land in Moldavia are similar to those just described. The evaluation scale has been made on the basis of thickness of humus horizon, humus content and nitrogen content in the layer down to a depth of 50 and 100 cm, pH and degree of base saturation. The major evaluation is corrected with correction coefficients for the following indices:

Soil texture from 1.0 to 0.7
Thickness of soil profile from 1.0 to 0.9
Erosion from 1.0 to 0.4
Salinization from 1.0 to 0.4
Gleyization from 1.0 to 0.4
Hydromorphicity from 1.0 to 1.3

This method is applicable for wheat, maize, sunflower and sugar beets.

Romania

The methods accepted in Romania for soil assessment are based upon analysis of the separate elements of environment. Soil assessment is made on homogeneous areas, the so-called ecologic units. Each one of the fadors possesses invariable quantitative parameters in the boundaries of those units.

Four categories have been assumed for a conventional grouping of factors of ecologic environment as in a closed scale of 100 grades where each category can move inside certain boundaries (soil - 0-50 grades, climate - ±20 grades, relief - ±15 grades, and hydrology - ±15 grades). The main properties directly affecting natural fertility of certain ecologic units are used when setting up the evaluations. Thus, for instance, in order to set up "soil" as a category the following are taken into consideration: depth of profile, soil texture, nutrient content and availability of nutrients, pH, base saturation, degree of salinization and water and physical properties. As regards climate, an index of dryness (calculated on the basis of precipitation and temperature) is used. As for relief, degree of slope and runoff ability of terrain are considered, and for hydrology, the level of ground water is taken into consideration.

Graphs have been drawn on the basis of detailed survey on the effect of the different soil, climatic, relief, and hydrologic properties on yield of arable crops to make the quantitative assessment possible. The sum of evaluations of the four categories gives the idea of the total assessment of the ecologic units.

Soil assessment is made as regards 9 crops such as: wheat, maize, sunflower, potatoes, sugar beets, orchards, vineyards, pastures and meadows.

The final evaluation for certain agricultural enterprises is achieved by grouping of average soil assessments of ecologic units comprised in 10 classes of soil assessment at an interval of 10 grades.

Yields of arable crops are used as a criterion of soil assessment as regards ecologic conditions. If productivity is considered as a basis, determined by a definite management level, yield can be calculated corresponding to one grade of soil assessment. Therefore, for each farm there could be established a crop potential as regards the average soil assessment. That potential makes it possible to draw conclusions about the degree of potential fertility use of lands. Besides, evaluation is also made of economic conditions existing in the different agricultural enterprises. Correction is made of soil assessment as regards ecologic conditions depending on situation, configuration, roads, etc. The main criteria for economic evaluation are as follows: average yield of major crops, direct and total cost per hectare and ton of product and profitability index.

Bulgaria

The essence of the methods used for a relative evaluation of soils in Bulgaria is actually the evaluation of the factors determining soil fertility as regards certain crops. Fertility is determined by the rate at which transformation of nutrients takes place in forms available to plants, as well as the velocity of their transportation to plants. In the case of an extensive agriculture system, there should be most reliance on natural soil fertility, this being mainly estimated by nutrient supply in the soil. Under the conditions of an intensive agriculture system, when large amounts of fertilizers are used, the soil properties (that assure its most efficient use) are of primary importance. The method developed for a relative evaluation of land, is based on this. Indices considered as exercising the strongest effect on the development of arable crops under the conditions of a comparatively high intensification, are: a) soil texture of arable layer for field crops and subsoil for orchards, forest trees and vineyards; b) depth of humus horizon; c) depth of soil profile (for soils formed on solid rocks only); d) texture coefficient; e) pH of arable layer; f) humus content in arable layer; g) level of ground watertable.

When selecting soil indices, the availability of data for the respective indices has also been taken into consideration.

As regards the effect of the above soil properties on soil fertility, they are normally graded from 0 to 100. Each soil type is evaluated for the major crops grown in the country (or in some of the regions in the country being characterized by specific natural conditions), namely: wheat, maize, sunflower, alfalfa, sugar beets, cotton, tobacco, orchards (apples, pears and plums), vegetables (tomatoes and peppers), vineyards, natural meadows and pastures, Virginia variety of tobacco, fibre-yielding flax, rice, peaches, cherries.

The final evaluation values of soil, as regards a specific crop, are obtained as an arithmetic mean of the assessments given for soil properties and are expressed in grades from 0 to 100. When some of the indices are 0, the total grade is also 0. In such case the other soil indices cannot manifest properly. This is in agreement with the law of indispensability of soil fertility factors.

Besides soil conditions, climate also strongly affects plant development. It is evaluated separately. Requirements during vegetation periods have also been considered of primary importance when evaluating suitability of climatic conditions as regards growing different arable crops in the different climatic regions. According to the availability of those requirements, the country is divided into regions suitable to different extents for growing of certain crops.

With crops requiring high temperatures (cotton, vineyards, tobacco) when temperature deficiency is a limiting factor both as regards growth and quality of production, temperature is the most important factor for evaluation of climatic conditions. The total temperature for the whole vegetation period is used as an index of evaluation and characterization of temperature conditions.

With crops which have no special requirements as regards high temperature (wheat, maize, sugar beets, sunflower), for which the existing temperature conditions are good enough up to a high altitude above the sea level, conditions of humidity are considered to be the major factor in evaluating climatic conditions. Conditions of humidity are characterized by different indices with the different crops - hydrothermic coefficients, coefficient of moistening, water balance.

The evaluation of climate is expressed as a coefficient from 0 to 1. I is used to correct soil evaluation grade and to calculate the final evaluation of ecologic conditions called field assessment number.

The advantage of the method accepted for evaluation of ecologic conditions, lies in the fact that such an evaluation is relatively constant. The changes occurring in soil, as a result of major amelioration practices or any other changes such as erosion, salinization, etc., can be included by correction of the already established main grade using the respective correction coefficient.

Coefficients of irrigation, stoniness, erosion and salinization are also established.

The thus established evaluations of the indices accepted for the different crops can be expressed by the following equation:

$$Y = (S \times Z_1 \times Z_2 \times \dots Z_n) \quad (1)$$

where Y is the yield,
S is the soil, and
$Z_1 \dots Z_n$ are the other factors of productivity. In this case the following factors can be included under Z: climate, irrigation, erosion, salinization, stoniness. Additionally there can be set up an equation concerning soil factors:

$$S = \frac{Q_1X_1 + Q_2X_2 + Q_3X_3 + Q_4X_4 + Q_5X_5 + Q_6X_6}{n} \quad (2)$$

where S is the soil,
$X_1 \dots X_6$ are the soil factors,
$Q_1 \dots Q_6$ are the coefficients by which the factors are multiplied (they are all whole numbers from 1 to 4), and
n is the sum of the numerical values of the coefficients.

The final version of the equation for evaluation of ecologic conditions is of the kind:

$$Y = \frac{(Q_1X_1 + \dots Q_nX_n) \times Z \times \dots Z_n}{n} \quad (3)$$

The land evaluations calculated from natural indices, are the basis on which economic evaluation is made. The main principles of economic land evaluation in Bulgaria are as follows:

a. systems of indices are used;

b. indices must give expression to both differences in natural conditions and differences in economic conditions in the same time;

c. indices must not consider elements of subjectivity;

d. indices must ensure the measuring of the effect of land quality on bulk of production primarily, as well as size of income and efficiency of labour and means.

The above principles being taken into consideration, the following indices of economic evaluation were approved in Bulgaria:

1. total production per 100 leva direct working expenses;

2. total production per hectare;

3. net income per hectare.

When evaluating land from economic point of view some natural indices are also used such as: slope of land, resistance of soil to tillage, length and configuration of plot.

The economic evaluation is made at a definite level of development and productive forces: tools and equipment, skill and ability of people engaged and form of organization of the agricultural enterprise. It is separately made in the present structure of crops and for the future structure, being calculated from land productivity evaluation.

The methods used for land evaluation in the other East European countries consist of elements from one or other of the methods used in the U.S.S.R., Bulgaria and Romania.

Conclusions

All the methods are considered to be just the initial stage of development of a more accurate method. The incompleteness of those methods and their inaccuracy is based upon different reasons, the most important one being explained by some features of interaction of factors. Productivity can be expressed generally by the equation:

$$Y = Y(Z, X, V, P)$$

where Y is the productivity,
Z is the soil,
X is the climate,
V is soil management, and
P is the crop.

The large number of factors and the interaction between them determine the complexity of the method for land productivity evaluation. Due to this, each trial for such an evaluation should be considered as an approximation only, i.e. just a step towards establishment of real productivity of land. Intensive work is being carried out at present on the use of methods for statistical evaluation that will make it possible to achieve a more objective expression of that interaction.

A FRAMEWORK FOR LAND EVALUATION

by

Working Group on Land Evaluation 1/

presented by G.M. Higgins

Introduction

Mankind has, since evolution, evaluated land for alternative uses. Particularly in the past 50 years there has been a proliferation of systems and formulae for land evaluation, many prepared in isolation. Several attempts have been made, specifically in the past seven years, to standardize methodology. Perhaps the most successful of these has been the October 1972 Wageningen consultation which resulted in the publication by FAO of "A Framework for Land Evaluation". The purpose of the present paper is to describe the development of this Framework and its concepts.

Development of the Framework

By 1970, most countries of the world had developed their own particular systems of land evaluation. This made interchange of information difficult and there was clearly a need for international discussion to achieve some form of standardization. The idea for such a consultation was conceived in 1970, to develop a Framework of Land Evaluation that would be widely acceptable to survey and evaluation organizations and which would meet the needs of the widest range of possible users. Preparatory work for the consultation was undertaken, in the subsequent 24 months, by two multi-disciplinary committees, one in the Netherlands and one within FAO. These activities resulted in the joint preparation of a background document (FAO, 1972) which formed the basis for further discussions. The consultation was held at the International Agricultural Centre, Wageningen, 6-12 October 1972 and was attended by 44 internationally recognized resource appraisal experts from 22 countries. Papers describing various land classification systems, used throughout the world, formed part of the background document and were published by FAO (1974). A summary of the discussions of the consultation and the recommendations agreed upon, was published by ILRI (1973). General agreement was reached on most of the questions discussed and a major step forward was effected by devising a Framework for Land Evaluation, into which national systems could fit. Subsequently this Framework was published by FAO (1973) and given wide distribution, with a request for comment.

Comments were received from 14 countries and were considered at a small 'ad hoc' expert consultation in Rome, 6-8 January 1975. Participation consisted mainly of representatives from the two original multi-disciplinary committees. The objectives of this most recent consultation were to review comments and experience on the use of the Framework, identify gaps in the present document and suggest improvements. Ten major subject areas for improvement were identified and an account of the proceedings is to be published in 1975. A revised Framework is to be produced later the same year, incorporating

1/ The presentation is based on the work of the committees, working groups and consultations described in the second section of the paper.

changes agreed upon at the consultation, which are also taken account of in the present paper.

Concepts of the Framework

The Framework defines land evaluation as "the process of collating and interpreting basic inventories of soil, vegetation, climate and other aspects of land in order to identify and make a comparison of promising land use alternatives, in terms applicable to the objectives of the evaluation".

At first sight the concepts proposed do not seem unprecedented, but in practice they call for considerable change in traditional resource interpretation thinking. A multi-disciplinary approach is required which uses a physical basis, in a social and economic context, for comparing land suitability. Basic is the concept that land evaluation is only meaningful in relation to a clearly defined use.

In essence the Framework recommends qualitative or quantitative classification of land for well defined utilization types, under unimproved conditions, by suitability orders, classes, subclasses and units. A single stage (physical and socio-economic studies together) approach or a two stage (physical studies followed by socio-economic studies) approach is allowed for, as appropriate to the requirements of a particular evaluation. This latter point is the essence of the Framework which, as its name implies, is intended to provide merely an outline of principles and terminology within which local systems of land evaluation may be formulated.

Definitions

A number of definitions are basic to the understanding of the Framework. These are:

Land - a tract of land is defined geographically as a specific area of the earth's surface: its characteristics embrace all reasonably stable, or predictably cyclic, attributes of the biosphere vertically above and below this area, including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal population and the results of past and present human activity and their interactions, to the extent that these attributes and their interactions exert a significant influence on present and future uses of land by man.

Land Suitability - the fitness of a given tract of land for a defined land use. Differences in the degree of suitability are determined by the relationship, actual or anticipated, between benefits and required inputs associated with the use of the tract in question.

Land Use Alternative - a form of land use that appears to be relevant for consideration under the general social, economic and physical conditions prevailing in the survey area. To serve as the subject of land evaluation, the use alternative must be defined as precisely as the intensity of survey permits.

Land Utilization Type - a term reserved for the low categorical level in a systematic typology of forms of land use.

Land Quality - a complex attribute of land which acts in a manner clearly distinct from the actions of most other land qualities in its influence on the suitability of land for a specific kind of land use. The expression of each land quality is determined by a set of interacting single land characteristics having different weight in different environments.

Land Characteristic - an attribute of land that can be measured or estimated.

Land Suitability Classification - an appraisal and grouping of specific tracts of land in terms of their land suitability for a defined use. Two kinds of land suitability classifications are recognized (each may be expressed in qualitative or quantitative terms), namely current land suitability classification and potential land suitability classification.

The further description of these conceptual terms is roughly in chronological order of use in a land evaluation study.

Land Utilization Types

Preliminary discussions with planning/development authorities is an essential first step in land evaluation, to identify the purpose and scope of the study and make a preliminary assessment of the relevant uses of land which are envisaged. This assessment is contingent on the overall socio-economic and physical condition of the area. Knowing the relevant uses of land envisaged, it is then possible to determine the scope of the study (in physical and socio-economic terms) and commence definition of the land use alternatives to be compared. Distinguishing factors which must be specified, for each use alternative being considered, include:

- produce (in a wide sense - the most important factor);
- financial investment intensity (recurrent and non-recurrent);
- labour (distribution and intensity, man days/ha);
- power requirements (source of power and energy equivalents/ha);
- know-how and required attitude of land user;
- required size and shape of land holdings;
- land tenure requirements.

These factors determine the character of the use envisaged and indeed govern its selection as relevant.

Land Qualities

Having defined the land use alternatives to be considered, it is necessary to establish the land qualities which require to be investigated, and so determine the actual physical data to be collected (socio-economic data is collected at the same time in a one stage approach). At the highest level of generalization, an example of a comprehensive land quality would be 'gross productivity'. This is the result of less complex land qualities such as 'moisture availability' and 'nutrient availability'. The land qualities can be analyzed in terms of land characteristics, as exemplified by the fact that moisture availability can be analysed in terms of rainfall distribution, potential evapotranspiration, soil depth and water holding capacity. The relative suitability (or non-suitability) for use, is determined by such factors. A few examples of major land qualities for various uses are presented below:

for Plant Growth

- radiation energy and photoperiod
- nutrient availability
- adequacy of foothold for roots
- pests and diseases

for Domestic Animal Production

- hardship due to climate
- endemic pests and diseases
- nutritive value of vegetation
- availability of drinking water

for Natural Product Extraction

- presence of valuable tree and shrub species
- presence of fruits
- game productivity for meat and hides
- accessibility of the terrain

for Rural Land Use

- resistance against erosion
- local trafficability
- vegetative cover
- possibility for mechanization

In general, recognition of a limited number of well chosen land qualities will provide an adequate basis for the evaluation of a reasonable number of possible kinds of use.

Classification

The Framework recognizes four kinds of interpretative classification, namely:

1. classification of current suitability in qualitative terms
2. classification of current suitability in quantitative terms
3. classification of potential suitability in qualitative terms
4. classification of potential suitability in quantitative terms

Any one or more of the classifications may be used by the evaluator.

Classifications of current suitability are appraisals of the suitability of land areas for a specific use, in their present condition or with modest modifications thereto (usually within the payment capacity of the farmer). The potential suitability classifications appraise the suitability of land areas for a specific use, when major land improvements have been effected. In all four classifications the suitability is assessed in terms of expected benefits of service and goods in relation to required inputs. Only when the distinctions between suitability groupings are expressed in numerical economic terms, may the classification be called quantitative. In quantitative classifications, the method of calculating non-recurrent inputs (including amortization or non-amortization of capital) is called for.

The Framework recognizes the same categories of interpretative groupings in all of the interpretative classifications. Each category retains its basic meaning within the context of the different classifications and in relation to different alternatives.

Four categories of decreasing generalization are recognized:

- Land Suitability Orders: reflecting kinds of suitability;
- Land Suitability Classes: reflecting degrees of suitability within Orders;
- Land Suitability Subclasses: reflecting kinds of limitations, or main kinds of improvement measures required, within Classes;
- Land Suitability Units: reflecting minor differences in required management

[redacted]

Order 'S' - Suitable Land: land on which sustained use for the defined purpose, in the defined manner, is expected to yield benefits that will justify required recurrent inputs without unacceptable risk to land resources on the site or in adjacent areas.

Order 'N' - Not Suitable Land: land having characteristics which appear to preclude its sustained use for the defined manner or which would create production, upkeep and/or conservation problems requiring a level of recurrent inputs unacceptable at the time of the interpretation.

Complete freedom is permitted in determining the number of Classes, Subclasses and Units to be used within local systems and, consequently, no standard definitions for these more precise categories are proposed. (This flexibility creates a risk of confusing the basic significance of classes - suitable or unsuitable - in different systems, a risk which is minimized, however, by systematic use of the Order category.) Some guidelines for the definition of classes, however, may be considered useful. If, for example, three classes are recognized in Order 'S' (as can often be recommended), the following names and qualitative definitions may be appropriate:

Class S1-Highly suitable: land having no significant limitations to sustained application of the defined use, or only minor limitations that will not significantly reduce productivity and/or benefits, and will not raise recurrent and minor capital inputs for production and conservation above an acceptable level.

Class S2-Moderately suitable: land having limitations which in aggregate are moderately severe for sustained application of the defined use: the limitations will reduce productivity and/or benefits and increase required recurrent and minor capital inputs for production and conservation to the extent that the overall advantage to be gained from the use, although still attractive, will be appreciably inferior to that expected on Class S1 land.

Class S3-Marginally (or barely) suitable: land having limitations which in aggregate are severe for sustained application of the defined use and which will so reduce productivity or benefits, and/or increase required inputs for production and conservation, that this expenditure will be only marginally justified.

Quantitative definitions must be in economic, measurable terms. In different circumstances, different variables may express most clearly the degree of suitability, e.g. the range of expected net income per unit area or standard management unit, or the net return per unit of irrigation water applied to different classes of land for a specified use.

Further subdivisions of classes into subclasses and units are foreseen on the basis of the nature of limitations (subclasses) and management requirements (units).

If, as seems appropriate in some cases, two classes are recognized in Order N, the following names and qualitative definitions could be used:

Class N1- Currently not suitable: land having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at currently acceptable cost: the limitations are so severe as to preclude successful sustained use of the land in the defined manner.

Class N2 - Permanently not suitable: land having limitations which appear so severe as to preclude any possibility of successful sustained use of the land in the defined manner.

Quantitative definition of these classes is normally unnecessary since, by definition, they are both uneconomic for the defined use. The upper limit of Class N2 is already defined by the lower limit of the least suitable class in Order S.

To assist in solving practical problems related to clearly recognized but very localized circumstances, the use of a conditionally suitable phase of the suitability classes is envisaged, where the land (or part of it) is suitable for the use in question only if certin known conditions are met. This phase is not intended for use where the interpretation of land is uncertain or dependent on further knowledge. Land of undetermined suitability, for a defined use, has no place in the classification (until its suitability is determined) and should be shown by the letters NC (Not Classified).

better U unclassified or NR not relevant.

Presentation

Since uniformity in presentation makes an important contribution to mutual understanding, the Framework recommends the following symbolization for the interpretative categories described above:

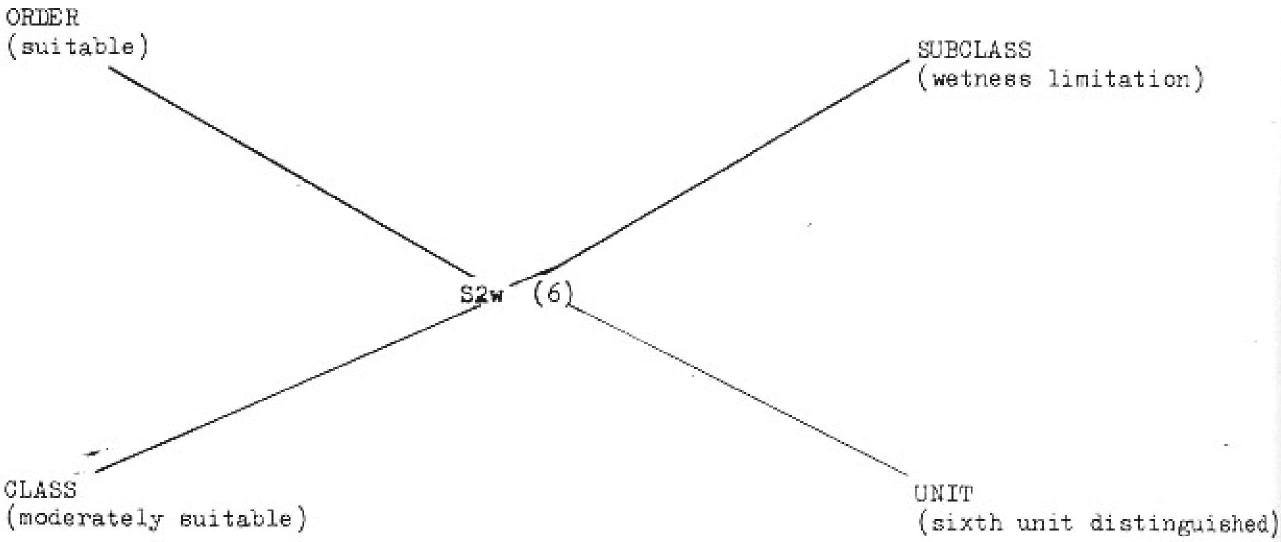
First Symbol - Land Suitability Order - Capital letters, i.e. either S or N.

Second Symbol - Land Suitability Class - Arabic number in sequence of decreasing suitability within the Order (1, 2, 3, etc., with conditionally suitable - Sc in the last position of the listing).

Third Symbol - Land Suitability Subclass - Lower case letters with mnemonic significance (e.g. c, t, ct, etc.)

Fourth Symbol - Land Suitability Unit - Arabic numbers in sequence (as convenient) enclosed in brackets.

A typical land suitability symbol developed in the Framework, might be:



There is no doubt that the cartographic method of presentation of evaluations is the most appreciated. However, presentation of all evaluation symbols on a single map, results in such a complex product that it defeats its own ends. Alternatively, formulation of single maps, for each individual evaluation, is a time consuming and costly process. While data may be presented in tabular, non cartographic, form for certain studies (e.g. national or international statistical studies), users do more usually, require information on the geographical location of the areas classified. Maps therefore are considered an essential product of most evaluations.

The need for both multiple use and single use evaluation maps is foreseen in the Framework and a distinction drawn between the two.

Multiple use evaluation maps, usually based on inventories of large areas at low intensities, are intended for broad planning purposes and depict the varying land potentials by contrasting the suitability of different areas for alternatives of use. In this instance map symbols may be presented as simple numbers, identifying each area in one or more tabular legends showing the suitability of each area for the various use alternatives being considered, e.g.:

Land Use Alternative / Land Area (Mapping Unit)	Land Suitability / Land Utilisation Types: A	B	C	D	etc.
1	S2	S3	NC	S1	
2	S1	S2	NC	S1	
3	S3	N1	S3	S3	
4	S3	N2	N1	N1	
etc.					

Separate tabular legends may be used to present current suitability classes and potential suitability classes, or alternatively both classifications can be combined in a single legend by diagonally subdividing each land use alternative and land area cell.

To summarize, the methodology proposed allows for investigation and comparison of promising alternative uses of land. It is hoped that the present account of the Framework will contribute towards its acceptance and use by resource surveyors and planners alike.

REFERENCES

FAO, 1972, 'Expert Consultation on Land Evaluation for Rural Purposes - Background Document'. Document AGL: LERP 72/1, FAO, Via delle Terme di Caracalla, Rome 00100, Italy.

FAO, 1973, 'A Framework for Land Evaluation' Document AGL/MISC/73/14, FAO, Via delle Terme di Caracalla, Rome 00100, Italy.

FAO 1974, 'Approaches to Land Classification', Soils Bulletin No. 22, FAO Via delle Terme di Caracalla, Rome 00100, Italy.

Hall, Peter. 1974. 'Urban and Regional Planning'. Penguin Books Ltd., Harmondsworth, Middlesex, England.

IILRI, 1973. 'Land Evaluation for Rural Purposes', Publication No. 17, International Institute for Land Reclamation and Improvement, P.O.Box 45, Wageningen, The Netherlands.

LAND UTILIZATION TYPES IN LAND EVALUATION

by

Klaas Jan Beek

Introduction

Under the title "Soil Survey Interpretation and Its Use" (Steele, G.J. 1967), FAO published in 1967 the different methods of soil survey interpretation developed in countries that have active programmes of making and using soil surveys.

The report is written mainly for soil scientists engaged in soil survey and its interpretation. This report consolidates the experience from a period during which the interpretation of a soil survey for practical purposes was mainly the responsibility and concern of the soil specialist.

Meanwhile soil survey interpretation has become increasingly an integral part of a more comprehensive kind of resource assessment: land evaluation, with land use planning and the solution of complex land use problems as its major purposes. Indicative for this trend is the publication by FAO in 1974 of Soils Bulletin 22 "Approaches to Land Classification". This bulletin comprises a number of documents presented at the FAO Expert Consultation on Land Evaluation for Rural Purposes, Wageningen, The Netherlands (Brinkman, R. and Smyth, A.J. ed. 1973) In this bulletin Olson, G.W., when discussing interpretative land classification in English speaking countries, quotes Jacks who in 1946 reviewed land classification as it "relates the grouping of lands according to their suitability for producing plants of economic importance". Olson then observes that land classification, as now generally used, includes practically all aspects of uses of areas of land. New techniques in the inventory of land components are referred to (Stewart, 1968). The computer is mentioned by Olson as being a promising tool for increased quantification of description of land class units, and in putting together, collating and correlating large amounts of data on soils, land use, slope, elevation, vegetation, climate, geology, drainage and other natural resources and social attributes. He also observes an increase in the formation of multi-disciplinary task forces to solve land use problems. Olson expects that in the future, land evaluation will probably become more comprehensive as well as more quantitative, and will be increasingly used as a basis for making both high level planning and low level implementation management decisions.

Vink, in his introductory remarks to the FAO meeting in Wageningen, emphasizes that "land" is a broader concept than "soil" and that soil surveyors need to be complemented by a new kind of specialist, e.g. "land evaluation specialists" or "land evaluation correlators", who are capable of accounting also for variables other than soil, which affect land evaluation. The meeting furthermore stressed the need for a multidisciplinary approach to land evaluation. Examples were given of small teams comprising of a soil specialist, an agronomist and an irrigation engineer or hydrologist for the early stages, and a large team also including economists and sociologists for the later stages.

Acknowledgements

This report comprises material from a more detailed study on the same subject in preparation under the supervision of Prof. Dr. J. Bennema, Tropical Soil Department, State University of Agriculture, Wageningen. The cooperation of Ir. R. Brinkman, Regional Soil Department, Wageningen University, in the preparation of figures 3 and 4; Dr. H. Luning, Development Economics Department, Wageningen University; and Dr. C.A. Robertsen, Land Resources Division, United Kingdom, on socio-economic analysis in land evaluation, is gratefully acknowledged.

The Wageningen Panel distinguishes between a purely physical land classification and an economic land classification, the latter being considered beyond the scope of the meeting. This consultation which was attended mainly by soil scientists purposely limited its discussion to methods of "physical land classification with economic considerations": the study of physical variables with economic constants. The principal means of introducing different economic constants in such methods should be by making separate land evaluations for different purposes during such meeting given the name "land utilization types" (Beek, K.J. and Bennema, J., 1972; Beek, K.J., FAO 1973). Often land utilization types represent alternative development/use options. The presentation of land use alternatives increases the value of land evaluation for land use planning.

Each land utilization type should be explicitly defined in terms of the assumed socio-economic and other relevant constants, e.g. produce, capital intensity, labour intensity, and other aspects of the envisaged land use. The assumption of different values for one or more of these constants would be possible by entering more land utilization types in the land evaluation procedure.

1. The Concept Land Utilization Type

Definition

A land utilization type is a specific subdivision of a major kind of land use serving as the subject of land evaluation and defined as precisely as is practical in produce terms, level of management, farm size, etc. It is a technical organizational unit in a specific socio-economic and institutional setting.

At the centre of every land utilization type is man with his decisive power to make the land suit his requirements. In a rural context he may do this by merely collecting the land's natural produce like fruits or wood, by employing animals to graze the natural vegetation, or by cultivating the land. Land utilization may range from traditional collecting, fishing and hunting systems of native Indians to highly sophisticated multiple systems of recreation with forestry.

A land utilization type comes to existence as soon as man decides to make land one of the factors by which to reach his objectives, e.g. agriculture, animal husbandry, forestry, recreation.

Because of the enormous variation in the ecological, socio-economic and cultural conditions, land utilization can be of many different types. Fundamentally each type represents a unique combination of the production factors land, labour, capital and management capacity in conjunction with a specific produce, just like any other industry designed by man to satisfy his needs. According to Duckham and Masefield (1970): "Land utilization represents a judicious balance between the ecological potential, the operational potential, the input potential and level and the demand for its produce".

Most existing land evaluation procedures somehow take into consideration broad types of land use, specific management practices, or even specific crops or species: land classification for irrigated agriculture, for arable crops, tree crops, pastures, horticulture, pine plantations, coffee, etc. It is rare however in land evaluation reports to find systematic listings of all the assumptions made concerning the technical, economic and social aspects of the envisaged types of land use. The non-inclusion of land utilization assumptions may result in considerable confusion and difficulties with re-interpretation when assumptions change through time or lose their validity.

Key attributes of land utilization types

Characterization of land utilization types may include a variety of factors according to the detail and purpose of the land evaluation study. This section deals only with the most fundamental diagnostic criteria which have a marked influence on the performance of the land and which for their significant role have been named "key attributes". Leading questions when selecting key attributes for the composition of relevant land utilization types are:

- Are the key attributes relevant and sufficiently mutually exclusive in their influence on land productivity?

- Can each key attribute be graded in a practical way, distinguishing relevant groups/levels/threshold values which are meaningful for the purpose of land appraisal?

- Can economic analysis quantify their influence on land performance (production functions) either for individual or combinations of key attributes?

- Can the key attributes be combined into realistic land utilization types (optimization) for highest benefit combination?

Examples of major key attributes are: type of produce, legal status (land tenure), size of farms, labour intensity, capital intensity, farmers' attitudes, farm-power (source and accompanying implements, operative capacity), know-how level of farmers. In broad reconnaissance studies it is not necessary that the pure influence of each key attribute (also named "diagnostic characteristic") on land productivity be known. It is often the combination of key attributes that is relevant. In detailed quantitative studies, production functions, multi-factorial regression analysis and multiple correlation would permit the assessment of the role of separate or groups of key attributes in the production process.

Often land evaluation serves a specific purpose, this having been broadly defined by the interested party who requested the study. Examples are land evaluation studies for the establishment of family farms in new areas, land appraisal for milk production or for the establishment of quick growing tree species for pulp production. It will depend on who specifies the requirements of the land evaluation study, as to which key attributes are stressed, which key attributes receive only casual mention and those which are not mentioned at all. The future land user is more interested in the economic results, the government more in political results, than how these results are obtained. The key attribute "produce" is named: pulp wood, or milk, but not which trees, which animals or which pasture grasses.

Not all relevant key attributes need specific mention in the final definition of the land utilization type. After systematic examination of each key attribute, the conclusions may also become part of the management specifications: the primary production (grasses, legumes) in grazing utilization types, systems of irrigation and crop rotations in agricultural types, the kind of trees in forestry types, etc. The management specifications are complementary to the definition of the land utilization type, and no definite rules for distinction between them can be given here.

2. Land Utilization Types and Land Evaluation Procedure

The selection and formulation of land utilization types is an integral part of the land evaluation procedure. Two rather distinct situations may be distinguished:

a. The land utilization type(s) is (are) defined at the beginning of the land evaluation procedure (figure 1).

b. The land utilization type(s) is (are) broadly defined at the beginning and subject to modification and adjustment in accordance with the findings of the land evaluation procedure (figure 2).

In situation a. the land utilization type may be considered as input for the land evaluation, whilst in situation b. this concept serves both as input and as output. In practice this distinction will be less sharp, as some adjustment or reconsideration of the land utilization type definition during the first stage of the two-stage procedure is likely to take place.

How the identification of land utilization types may take place can best be discussed against the background of two different land evaluation procedures (Beek in FAO, 1975):

<u>no. 1</u> <u>A two-stage land evaluation procedure</u>, in which the first stage is mainly concerned with physical land evaluation, later (but not necessarily) followed by a second stage consisting of some kind of socio-economic analysis: economic land evaluation.

<u>no. 2</u> <u>A parallel land evaluation procedure</u>, in which the physical analysis of the land proceeds concurrently with the socio-economic analysis.

The two-stage procedure is often favoured for small scale resource inventories for broad planning purposes, and at larger scales for the assessment of biological production potential. Suitability classifications will be mostly based on physical production potential of the land resources for broadly defined land utilization types, which are selected at the beginning of the procedure, e.g. arable cropping, dairy farming, wheat, tomatoes.

Even though the identification of the land utilization type may not be strictly defined to the beginning of the first stage, there is hardly any participation of the non-technical disciplines during this first stage. Their contribution is limited to a relevancy check of the selected land utilization type. Socio-economic analysis is postponed until the second stage.

In a parallel procedure the socio-economic analysis of key attributes of land utilization types and their combination proceeds simultaneously with the analysis and grading of physical factors (land qualities). This includes the identification of key attributes (for example crop selection), the analytical description of key attributes (such as the selection of suitable farm sizes or capital/labour input ratios) and the combination of key attributes into suitable land utilization types. This is the true inter-disciplinary approach to land evaluation.

This procedure will mostly be favoured for specific problems and proposals in connection with development projects.

At reconnaissance level, the socio-economic analysis of land utilization alternatives will be limited to the qualitative definition of development constraints and possibilities, e.g. comparative disadvantages of certain areas for certain kinds of produce, seasonal labour shortages or adverse land tenure conditions. At more detailed scales socio-economic analysis is often related to pre-feasibility and feasibility studies and will be based on data concerning the availability and allocation of production factors, input-output ratios, prices and costs, credit, marketing, labour/capital substitution, etc.

Because of the close inter-relationships between the concepts land utilization type, land evaluation and land use planning, two figures (figure 3 and figure 4) have been prepared for the FAO manual on land evaluation for comparison of the two-stage and the parallel procedure at three levels of land evaluation intensity: reconnaissance, semi-detailed and detailed.

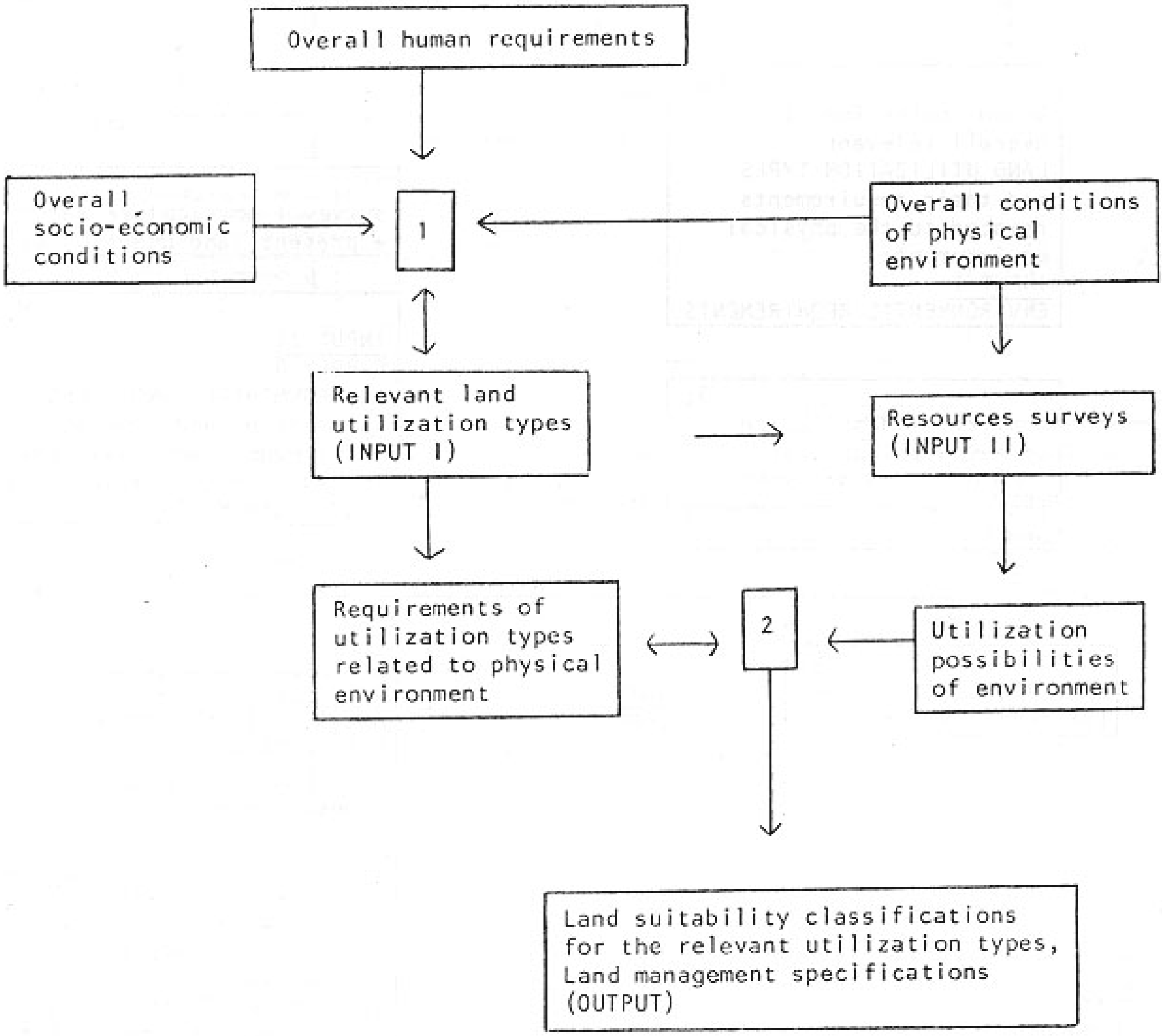


Fig. 1. Land evaluation procedure with land utilization type as input

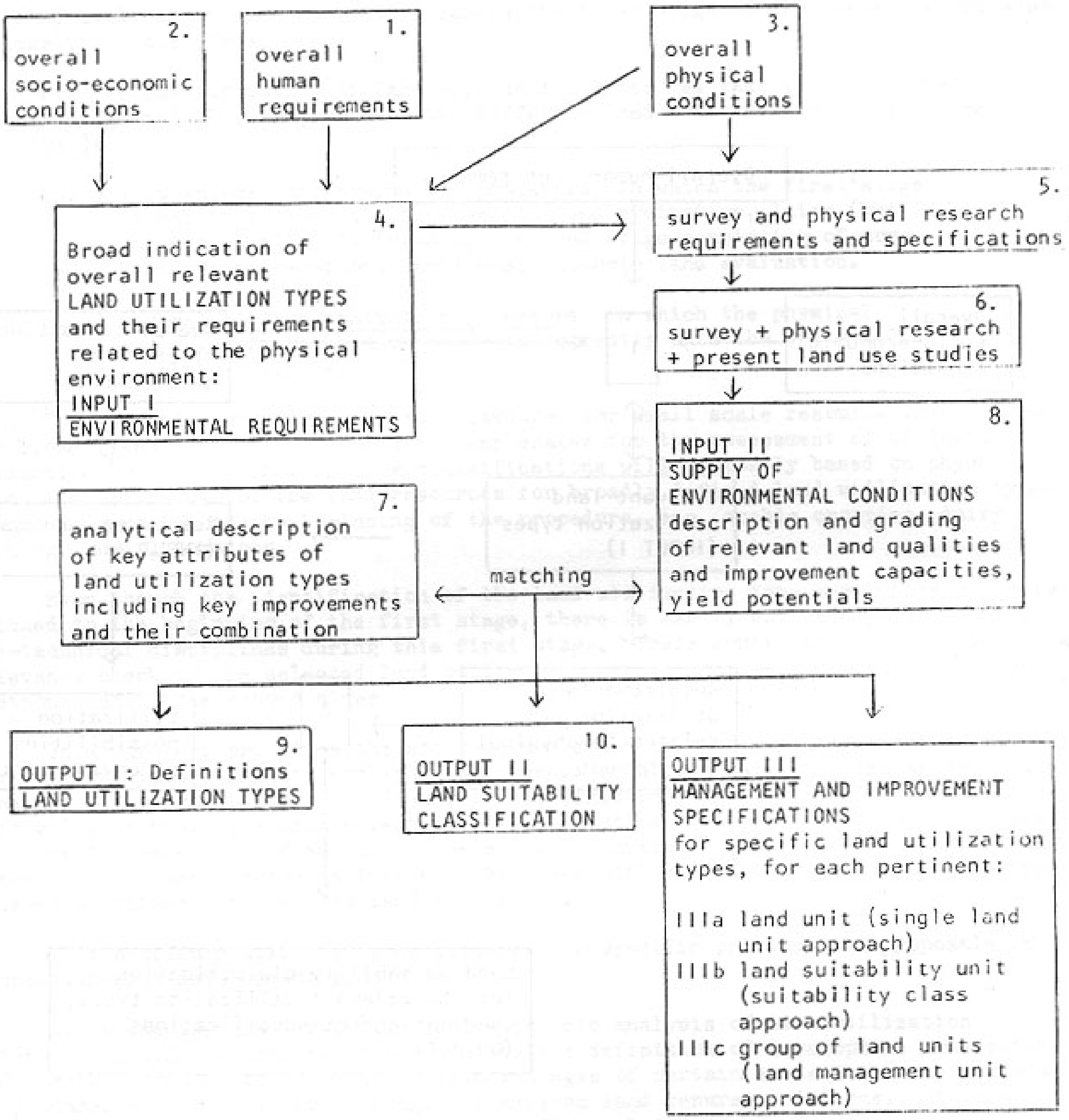


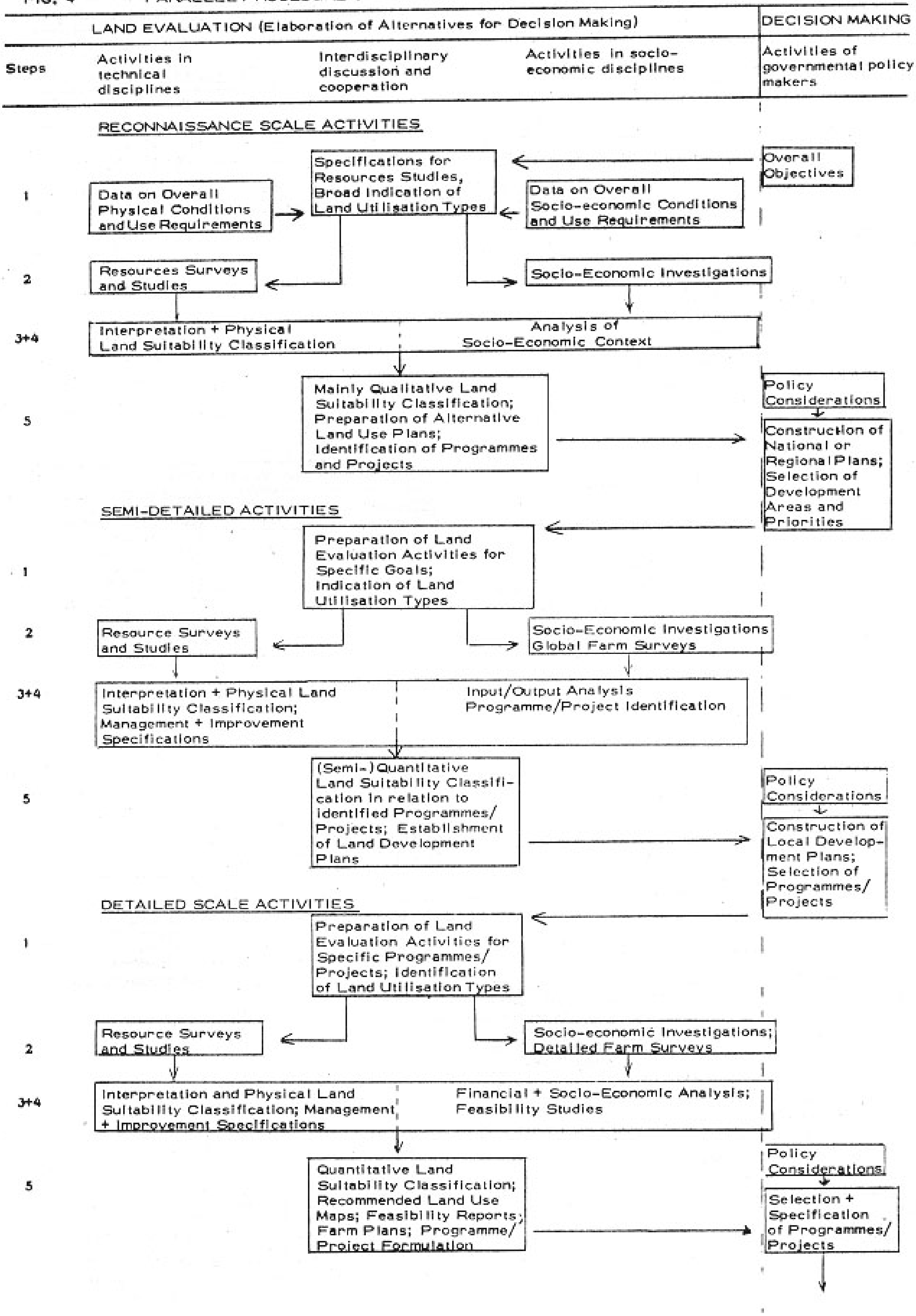
Fig. 2. Iterative land evaluation procedure with land utilization type as input and as output

FIG. 3 TWO-STAGE PROCEDURE OF LAND EVALUATION IN LAND USE PLANNING

	LAND EVALUATION (Elaboration of Alternatives for Decision Making)			DECISION MAKING
Steps	Activities in technical disciplines	Interdisciplinary discussion and cooperation	Activities in socio-economic disciplines	Activities of governmental policy makers
	RECONNAISSANCE SCALE ACTIVITIES			

[redacted]

FIG. 4 PARALLEL PROCEDURE OF LAND EVALUATION IN LAND USE PLANNING



(iii) Overall "on-farm" land suitability classification with farm economic variables

The land utilization types are broadly indicated at the beginning of the land evaluation procedure, but the "on-farm" key characteristics, e.g. farm size, labour input, capital input, produce, may be handled as variables. Some other "on-farm" key characteristics such as farmers' attitudes, beliefs, religion, may enter as constants as do all "off-farm" conditions which are not contemplated as being changed by the project for which the land evaluation is implemented. Such a procedure results in a land suitability classification, management and improvement specifications, and optimized definitions of relevant land utilization types, e.g. farm types depending on the detail and the aspects of land utilization taken into account. Examples are land evaluation for purposes of land settlement, large scale projects of irrigation, drainage or re-allotment, land reclamation, land reform, watershed management.

In the on-farm land suitability classification the off-farm conditions, or in the case of large scale projects the off-project conditions are considered as constants or constraints of a permanent nature: e.g. rural infrastructure: health services, roads, transport, distribution; rural institutions: education, extension, research; cooperatives, credit, marketing; legislation; sociological structures: land tenure, farmers' health and attitudes, demography; price structures; government objectives and policies, eventually international policies and structures.

The results of this procedure may be used as inputs of the next procedure (iv). Sometimes the results of the procedure (iv) provide an important feedback for procedure (iii), for instance for sensitivity analysis on the long term effects of land utilization types proposed by procedure (iii).

(iv) Overall land suitability classification with "off-farm" variables

Here the evaluation may include a variety of "off-farm" variables, including some macro-economic factors, which were listed as permanent socio-economic constraints in the previous approach. Application will be mainly at the level of macro and medium to long term development planning and the execution of perspective studies for development. Simulation of national and international policies as done in several econometric models produced for the Club of Rome also belong to this category (F.U.A., 1975). Aggregation and generalization of results obtained by approaches (i), (ii) and (iii) may provide an important input for this approach. This may include some active participation of the physical disciplines (parallel land evaluation procedure) or only their indirect participation (comparable with activities during second stage of two-stage land evaluation procedure).

Figure 5 summarizes this section.

LAND EVALUATION PROCEDURE	FIRST STAGE OF TWO-STAGE PROCEDURE (gradual transformation to) ---->			PARALLEL AND PROCEDURE	SECOND STAGE OF TWO-STAGE PROCEDURE
MAJOR KINDS OF LAND EVALUATION	I. EVALUATION OF BIOLOGICAL PRODUCTION POTENTIAL	II. PHYSICAL LAND SUITABILITY CLASSIFICATION FOR PRE-DETERMINED LAND UTILIZATION TYPES	III. OVERALL "ON-FARM" LAND SUITABILITY CLASSIFICATION	IV. OVERALL LAND CLASSIFICATION WITH OFF-FARM VARIABLES a) direct participation land resource specialist	b) indirect participation land resource specialist
FUNCTION OF LAND UTILIZATION TYPE	<u>input:</u> pre-selected crops/ produce <u>output:</u> --	<u>input:</u> pre-selected combinations of key attributes in defined socio-economic context <u>output:</u> --	<u>input:</u> broad indication <u>output:</u> optimal combinations of on-farm key attributes, with assumed macro-economic context	<u>input:</u> broad indication <u>output:</u> optimal combinations of key attributes in optimal macro-economic context	
PARTICIPATION OF TECHNICAL DISCIPLINES	+++	++	+	(+)	-
PARTICIPATION OF SOCIO-ECONOMIC DISCIPLINES	-	(+)	+	++	+++
IMPORTANCE ENVIRONMENTAL VARIABLES	+++	+++	+++	++	+
IMPORTANCE MICRO-ECONOMIC VARIABLES	-	-	+++	+	+++/+
IMPORTANCE MACRO-ECONOMIC VARIABLES	-	-	-	+++	+++/+
INCLUSION OF SOCIO-ECONOMIC ASSUMPTIONS	(+)	+	++	+++	+++

Fig. 5. Major kinds of land evaluation : role of disciplines involved

4. Matching of Land Utilization Types and Land Qualities (Figure 2)

As a first step in land evaluation a broad indication is given of land utilization types which should be relevant in view of the overall physical and socio-economic conditions. But once systematic surveys and studies have accumulated further data, the broad indications of the land utilization types and their land requirements may need to be reconciled with the more precise information on the land conditions. This process of adaptation and adjustment of the broad definitions of the land utilization types in the light of increasingly known land qualities has been named matching.

Matching represents the essence of the interpretative step following the resources surveys in a land evaluation procedure, and is based on the functional relationships that exist between the land qualities, the land improvement capacities and the key attributes of the land utilization types.

In its simplest form matching is the confrontation of physical requirements of specific crops with the land conditions to give a prediction of crop performance. Matching becomes more complex when the produce factor is complemented by other performance conditioning characteristics of the land utilization type, including non physical aspects like labour intensity and capital intensity.

Matching serves two major purposes:

- Relevancy check of the land utilization type. Systematic confrontation of land utilization types and land qualities permits an analytical review of the description of each key attribute and of the overall definition of the land utilization type.

- Systematic determination of management and improvement specifications: the land requirements of each land utilization type and its possibilities to manage and improve the land are systematically compared with the land qualities on the basis of fundamental cause-effect relationships between the qualities and the uses of the land. This can be done either qualitatively or quantitatively, when the parameters involved are translated into quantitative common denominating terms (mostly money, sometimes production volume). This analysis is probably the most difficult part of the land evaluation procedure. Systematically arranged information is scarce. A first attempt to improve this situation could be the preparation of systematic conversion tables/programmes/formulas, for specific land uses with the accent on individual crops, which indicate precisely defined levels of land qualities for different degrees of suitability, e.g. for high-medium-low-no suitability, only in physical terms. (Sys, C. 1975; Bennema, J. and van Goor, C.P., 1975).

Qualitative and quantitative matching

The procedure which for each land utilization type makes use of a conversion table relating pre-determined levels of land qualities to different classes of suitability is an example of qualitative matching. Sometimes such matching may give a quantitative impression, when the levels of land qualities or land properties have been given numerical values based on local research findings, which are then subjected to mathematical manipulation: parametric methods. But fundamentally such procedures should still be considered qualitative. Qualitative matching is often applied during the first stage of two-stage land evaluation procedures, particularly in small scale land evaluation when quantitative data are scarce. Quantitative matching is based on quantified expressions of the cause-effect relationships between the land qualities and the performance of the land utilization type.

When the land utilization type has been defined only in terms of "produce" quantification may be in units of produce or in monetary terms. In most cases, however, monetary terms will be preferred, especially when the produce and the corresponding yields have to be considered in a specific socio-economic context. Costs and benefits expressed in monetary terms will be the main elements for quantitative matching. At semi-detailed and detailed levels of land evaluation quantitative matching will make use of specific techniques of socio-economic analysis, e.g. linear programming and other mathematical optimization techniques.

This will also contribute to a more precise dimensioning of the key attributes of the land utilization types, to assure a proper prediction of their performance. The matching activities at this stage approximate those usually undertaken in land use planning and farm management, and land utilization types in this case become conceptually close to farming systems and farm types.

5. Single, Multiple and Compound Land Utilization Types, Farming Systems

Many land utilization types make demands on land that exclude other uses of the land at the same time: single land utilization types.

Exceptions are known, for instance in forestry and recreation: multiple land utilization types, which consist of more than one single use operating simultaneously on the same parcel of land each with its own inputs, requirements, produce and benefits, without being competitive beyond accepted limits (e.g. forestry plus recreation, flooded rice plus fish-culture). The single uses of a multiple land utilization type may interact or may be largely independent of each other, but for the purpose of land evaluation they remain two separate uses. A compound land utilization type also comprises more than one single use, but for the purpose or within the possibilities of a land evaluation, it constitutes one use, for example mixed cropping, multiple irrigated cropping. The composing single uses may be exclusive in their time or space requirements, occurring either on the same land in a rotation or on different parcels of land altogether. When a first selection of land utilization types is made the possibility of single-, multiple and compound uses should be considered according to the prevailing land/land use patterns in the area.

Interactions between land utilization types

It has been mentioned above that interactions may occur between the components of a compound or a multiple land utilization type. Interactions may also arise between land utilization types which do not belong to the same compound/multiple land utilization type and which may be located at greater or lesser distance from each other. In particular the latter kind of interactions may give rise to undesirable effects if not properly considered during the land evaluation, e.g. salinization or sedimentation in lower lying areas due to improper water and land use in the upstream area. There may also be positive interactions, for example the introduction of irrigated fodder production may increase the carrying capacity of nearby dry extensive grazing land.

Land utilization types for combinations of land units

Due to limitations of individual land units for certain uses, it may not always be possible to formulate relevant land utilization types for each single land unit. Sometimes the key to land utilization can be found by making several land units part of the same managerial unit, e.g. extensive grazing types which combine pasturing on uplands in the rainy season with the utilization of seasonally flooded lowlands in the dry season.

Compound land utilization types for combinations of land units

Especially in more detailed land evaluation it may be necessary to identify compound land utilization types and evaluate their performance for combinations of land units, when it is known that the managerial units will be located on more than one land unit, each with potential for a different single use.

Land utilization types and farming systems have several aspects in common regarding the management of the land and may thus appear to be closely related concepts. But fundamental differences exist: farming systems are carried out in holdings and their classifications are farm classifications according to farm characteristics, in particular cultivation practices, e.g. type of rotations, intensity of rotations, water supply, cropping patterns and animal activities, implements used for cultivation, degree of commercialization (Ruthenberg, H. 1971). Land utilization types are classified for the purpose of meaningfully indicating the potential of land units or combinations of land units, and their classifications are based on land management and improvement characteristics, which will generally not comprise the full range of farm management characteristics. At detailed levels of land evaluation precisely defined single/compound land utilization types may be readily extendable into farming systems by adding the necessary farm management characteristics.

6. Land Utilization Types and Present Land Use

Present land use is a valuable yardstick for assessing the feasibility and profitability of projected future land use. In most cases land evaluation in Europe will need to be carried out in areas with an established land use pattern. Here the selection of relevant land utilization types will very much depend on the interpretation of the present situation and past trends in land use.

A good classification of present land use is also important for easy correlation with the various types of land use occurring elsewhere. Considerable experience and some international agreement exist on the typology of present land use. Several of the key attributes used for national and world wide censuses (FAO 1965) or for world scale land use typology (International Geographical Union -IGU 1974) are also relevant for land use typing in land evaluation. These systems reflect the difficulty of establishing more than broad definitions of land use due to the enormous variation in environmental conditions, socio-economic conditions and management. The FAO Census provides a broad framework which can be expanded separately for each country. The IGU, after great effort, limited its land use typology to the combination of 22 key attributes each arbitrarily graded into five classes. Combination of the key attributes resulted in 18 world types of agriculture and 53 sub-types. These systems will be mostly too broad and unspecific to be of great use for land evaluation. But key attributes and nomenclature deserve attention and may provide some guidance in the diagnosis of land use types.

Land use typology has been, in the first place, the concern of geographers responsible for the study of the aerial variation of agriculture and the preparation of land use maps. Their emphasis varies according to specialization: physical geographers emphasize the importance of the ecological context as influents in their land use classification. Social and economic geographers stress the importance of population, markets, stage of socio-economic development and other related topics.

The task of the geographer is, in the first place, descriptive. But today there is an increasing concern to analyse the present land use systems on their development potential and to understand the complex combination of factors involved in the transformation of traditional land use (Vink, 1974; Kostrowicki, J. 1974; Kleinpenning, J.M.G. 1968; Gregor, H.F. 1970). Agronomists, when formulating land use recommendations, attempt to combine physical and socio-economic conditions to "satisfy market demand with the maximum profit or domestic or social satisfaction" (Duckham and Masefield, 1970).

The experience accumulated by border disciplines of land evaluation like geography, agronomy and farm economics should provide valuable support for the systematic analysis of functional relationships between land utilization and land conditions. These relationships are the backbone for an effective land utilization typology for land evaluation, and for land suitability classification.

Typologies of farming systems sometimes refer to land conditions for class distinction at a high level of generalization: e.g. "semi-permanent cultivation on fertile soils in the humid tropics", "unregulated ley in the drier savannahs", "unregulated ley in high altitude areas" (Ruthenberg, 1971) to suggest that land can be a main determinant in the formation of certain farming systems. Some of the literature on farming systems is quite explicit in its recognition that farming is a dynamic balance, in which land is a determining variable, subject to change, for better and for worse, depending on the functioning of the farming system. A farming system approach to land utilization typology should have the inherent capacity to make predictions of performance for different time periods. The geographer may give a precise description, with a great number of variables, of the land utilization, but this picture tends to become rather static and valid in the first place to describe the present situation. This produces important baseline information for the planning of land development, but is less informative than the farming system classifications regarding the existing equilibria between the land and the other production factors which will need to be influenced in order to reach the development goals.

The IGU agricultural typology

There is still no recognized international land use classification. The Commission on Agricultural Typology of the International Geographical Union (IGU) has prepared a provisional typology of agriculture based on the following 22 diagnostic variables:

A. Social and Ownership

1 - land ownership
2 - land operation.

B. Size of holdings

3 - number of actively employed people per holding
4 - total amount of arable land
5 - number of livestock
6 - gross agricultural output

C. Organizational and technical

7 - inputs of labour (per 100 ha and mandays/ha/year)
8 - inputs of animal power per 100 ha
9 - inputs of mechanical power HP/100 ha
10 - fertilizer NPK/ha
11 - irrigation (% of cultivated land irrigated)
12 - intensity of cropland use (harvested/total arable)
13 - perennial crops + semi-perennial (% of total cultivated)
14 - permanent grassland (% of total agricultural land)
15 - intensity of livestock breeding (units/100 ha)

D. Production

16 - land productivity/ha
17 - labour productivity
18 - degree of commercialization (% of total produce sold commercially)
19 - level of commercialization per hectare
20 - degree of specialization

E. Structural characteristics

21 - production orientation
22 - orientation of commercial production.

According to Kostrowicki (1974) the purpose of the IGU typology, like any classification, is to "organize our knowledge of the objects under study in such a way that their properties may be best remembered and their relationships more easily understood". The final goal of the typology is the preparation of a world map of agriculture. The question arises to which extent such a typology can be made instrumental in the explanation of relationships that exist between the type of agriculture and the land conditions. Kostrowicki (1974) recognizes the ad hoc value of the typology and informs that "the first studies of IGU on dynamics of spatial organization of agriculture, both for the past and for the future, including the progress and programmes of its future changes have been initiated". However, the IGU typology of world agriculture is in the first place a framework for the indication of differences and similarities in space, not in time. It is expected to have influence on the structuring of agricultural statistics and of more detailed agricultural typologies.

According to Kostrowicki a type of agriculture should be:

- "a more or less established form of crop growing and/or livestock breeding for production purposes characterised by a definite set or association of its internal characteristics, developed and shaped by specific historical processes in given external and other conditions;
- a supreme concept in agricultural classification embracing all other concepts used in systematic or partial typologies (such as crop rotation systems, cropping systems, systems of livestock breeding, farming systems, etc.);
- a hierarchical concept encompassing various orders, from types of world agriculture through several intermediate orders, down to the lowest order identified by grouping individual agricultural holdings;
- a dynamic notion changing in an evolutionary or revolutionary way along with a change of its basic characteristics."

It seems questionable if the four criteria can be met by the same typology. The characteristics defining an agricultural type have been limited to internal, inherent or endogenous characteristics. Exogenous variables such as natural conditions, location, transportation, market conditions, prices, supply and demand of agricultural products are considered both dangerous and unfruitful because their use should presuppose rather than prove their influence on the formation of agricultural types. Kostrowicki, nevertheless, recognizes the importance of the external conditions in the formation of agricultural types and the need to study them in combination with existing agriculture for planning more rational types of agriculture and their spatial organization, which are also the purpose of land evaluation and of this report.

The difference in objectives between the IGU agricultural typology and land utilization typing for land evaluation is clear now: the IGU typology limits itself to the description of endogenous characteristics of land use and if necessary an indication of the interactions between them; the land conditions are not considered to be endogenous characteristics; their influence on the formation of agricultural types has been purposely ignored.

Typology of land utilization for land evaluation has the explicit function of enhancing the possibilities for detection of functional relationships between the land utilization type and the land conditions, at present and in the future. For the description and classification of land utilization types, characteristics should be selected which are most expedient in making the land utilization type an operational tool in the land evaluation procedure.

Number Kostrowicki	Orientation of Production	Size of Farms	Produce	Region of Occurrence
	I. TRADITIONAL	SMALL SCALE	MIXED AGRICULTURE	
4.1	continuous or semi-continuous subsistence or semi-subsistence		mixed	IV
4.2	semi-commercial		mixed crops prevalent	III, IV
4.3	semi-commercial		mixed	I, III
4.4	semi-commercial		mixed livestock prevalent	I, II, IV
	II. TRADITIONAL	LARGE SCALE	AGRICULTURE	
6.1	traditional latifundia		livestock breeding prevalent	IV
6.2	traditional latifundia		crop growing prevalent	IV
	III. COMMERCIAL	SMALL SCALE	AGRICULTURE	
8.3	commercial	small scale	oriented toward fruit culture	I, II, III, IV
8.4	commercial	small scale	vegetable growing (market gardening)	I, II, III, IV
8.5	commercial	small scale	mixed, crop growing prevalent	I, IV
8.6	commercial	small scale	mixed	I
8.7	commercial	small scale	mixed, livestock breeding prevalent	I, II
	IV. COMMERCIAL	LARGE SCALE	AGRICULTURE	
9.1		large scale	horticulture, vegetables and/or fruits	I
9.3	irrigated	large scale	agriculture	IV
13.2	socialized		mixed agriculture	III
16.1	socialized intensive		mixed crop growing	III
16.2	socialized intensive		horticulture, fruits and/or vegetables	III
16.3	socialized intensive, collective		horticulture, fruits and/or vegetables	III
	V. COMMERCIAL, SPECIALIZED	LARGE SCALE	AGRICULTURE	
10.1	specialized		livestock breeding	I
10.3	specialized		grain crop	I
14.1	socialized specialized		grain or grain with livestock	III
	VI. HIGHLY INDUSTRIALIZED		AGRICULTURE	
12.1	highly industrialized	(small/medium scale)	livestock breeding	I, II, III, IV
18.2	socialized highly industrialized	(large scale)	livestock breeding	III
12.2	highly industrialized	(small scale)	crop growing	I, II, III, IV
18.1	socialized highly industrialized	(large scale)	crop growing	III

Fig. 6. Structured list of types of agriculture in Europe (adapted from Kostrowicki, J. 1974)

I = W. Europe; II = N. Europe; III = C.E. Europe; IV = S. Europe

7. Types of Agriculture and Land Evaluation in Europe

It should be possible to distinguish the most relevant types of agriculture occuring in Europe, complemented by a number of land utilization types which are expected to be relevant for the future, say the next 10-20 years. Each type should be carefully defined in terms of key attributes to serve as a starting point for systematic land evaluation at national, regional and possibly continental scale, according to major kind of land evaluation no.2 physical land suitability classification for pre-determined land utilization types. Socio-economic analysis could be considered as a follow-up activity for some sample areas at national level. An early international agreement on the definitions of the standard land utilization types and of the methodology in general, would permit the exchange of findings, in particular on suitability and management response of comparable land units. The basis for comparison of the land units themselves could be provided by the Soil map of Europe complemented by carefully correlated national soil and land resources maps. Also the IGU World Land Use Map will be a valuable tool. Figure 6 is a structured list of agricultural types reported by Kostrowicki to occur in Europe, and which should be the legend for the Europe sheet of the IGU World map.

The choice of relevant land utilization types for land utilization types for land evaluation in Europe will depend on the understanding of present land use and of the factors influencing the transformation of the present land use in more productive and more efficient types of agriculture, which according to de Wit (1975): "should remain sufficiently productive to function as a source of income for farmers and agriculturally based industries, both up-hill towards the farm and down-hill towards the consumer, but also guarantee a reasonable diet for the population in times of international stress. At the same time agriculture should remain a source of employment, contribute its share towards a more efficient energy use, function as a source of land for urban development and semi-natural conservancies rehabilitate valuable landscapes and in general lessen its effect on the environment". De Wit estimates that land productivity in The Netherlands could be at least 30% higher. He presents several growth patterns to realize increases in productivity based on variable fossil energy/labour input ratios. Buringh et al. (1974) when computing the absolute maximum food production of the world divided Europe into 49 broad soil regions. They report that 20.2 % of the land in Europe is cultivated and that almost 38% is potential agricultural land. In densely populated Europe increased productivity seems a more likely option than increase of the cultivated area. But due to changing cost relationships between traditional inputs, such as animal feed, fossil energy and labour, important changes in the present farming systems and land use patterns may be expected including the cultivation of new areas. An example is the revolutionary increase of maize cultivation on the poor pleistocene sands in The Netherlands, which were in the past considered of low suitability but are now increasing rapidly in value (personal communication Ir. K.J. Hoeksema, Wageningen).

Land use changes are difficult to predict, but observed recent trends deserve careful analysis. Improved technical knowledge to increase productivity seems a certainty. Systematic land evaluation and land use planning should be able to assist in the prediction of future land use needs, the modelling of alternative land utilization types and the orientation of agricultural research for the benefit of the population and its environment.

REFERENCES

Albers, H.T.P.M., Hielkema, J.V., Krul, H.A. and van Lanen, H.A.J. A comparative study of some
1975 West European land classification systems. Publ. 599, Dept. Soil Sci. and Geology, Agricultural University, Wageningen.

Albers, H.T.P.M., Krul, H.A. and van Lanen, H.A.J. Some existing West European land
1975 classification systems compared with recent FAO standards.

Beek, K.J. and Bennema, J. Land evaluation for agricultural land use planning - An ecological
1972 methodology. Dept. Soil Sci. and Geology, Agricultural University, Wageningen (mimeograph).

Beek, K.J. The concept of land utilization types. In Approaches to Land Classification.
1974 Soil Bull. 22 FAO, Rome. p. 103-120.

Beek, K.J. Identification of land utilization types. In Report on the Ad Hoc Expert
1975 Consultation on Land Evaluation. World Soil Resources Report 45. FAO, Rome. p. 89-102.

Bennema, J. and van Goor, C.P. Physical land evaluation for forestry. In Report on the
1975 Ad Hoc Expert Consultation on Land Evaluation. World Soil Resources Report 45. FAO, Rome. p. 103-117.

Brinkman, R. and Smyth, A.J. (Ed.) Land evaluation for rural purposes. Publication 17,
1973 Intern. Inst. Land Reclamation and Improvement (ILRI), Wageningen.

Buringh, P., van Heemst, H.D.J. and Staring, G.J. Computation of the absolute maximum food
1975 production of the world. Department of Tropical Soil Science, Agricultural University, Wageningen.

Duckham, A.N. and Masefield, G.B. Farming systems of the world. Chatto and Windus,
1970 London.

FAO. Programme for the 1970 World Census of Agriculture. Rome.
1965

Free University of Amsterdam. Food for a doubling world population. Preparatory paper, Club
1975 of Rome Conference, Alpbach, Tyrol. Institute for Economic and Social Research, Free University of Amsterdam (mimeograph).

Gregor, H.F. Geography in agriculture, themes in research. Englewood Cliffs N.Y. Prentice
1970 Hall.

Kleinpenning, J.M.G. Geografie van de landbouw, Utrecht, Antwerpen. Het Spectrum, Aula 375.
1968

Kostrowicki, J. The typology of world agriculture, principles, models and model types.
1974 International Geographical Union, Commission on Agricultural Typology, Warwaw.

Nix, H.A. The assessment of biological productivity in land evaluation. In Stewart, G.A.
1966 (Ed.) Land evaluation. MacMillan of Australia.

Olson, G.W. Interpretive land classification in English speaking countries. In Approaches
1974 to Land Classification. Soil Bull. 22. FAO. Rome. p.1-25.

Riquier, J. A summary of parametric methods of soil and land evaluation. In Approaches
1974 to Land Classification. Soils Bull. 22. FAO, Rome. p. 47-53.

Ruthenberg, H. Farming systems of the tropics.
1972

Steele, J. Gordon. Soil survey interpretation and its use. Soils Bull. 8. FAO, Rome.
1967

Stewart, G.A. (Ed.) Land evaluation. Papers of a CSIRO Symposium. MacMillan of
1968 Australia.

Sys, C. The pedology of rubber. In Report on the Ad Hoc Expert Consultation on Land
1975 Evaluation. World Soil Resources Report 45. FAO, Rome. p.59-79.

Vink, A.P.A. Physical geography for land use planning. Norma Wilkinson Memorial Lecture
1974 for Department of Geography, University of Reading.

Vink, A.P.A. Land use in advancing agriculture. Springer Verlag. Berlin, Heidelberg,
1975 New York.

Wit, C.T. de. Photosynthesis of leaf canopies. Agr. Res. Rep. 663, Wageningen.

Wit, C.T. de. Substitution of labour and energy in agriculture and options for growth.
1975 Neth. J. Agric. Sci. 23:145-162.

Teaci, D. and Burt, M. Land evaluation and classification in East European countries.
1974 In Approaches to Land Classification. Soils Bull. 22. FAO, Rome. p35-46.

GUIDELINES FOR THE INTERPRETATION
OF LAND PROPERTIES FOR SOME GENERAL
LAND UTILIZATION TYPES

by

C. Sys

Introduction

The general fundamental principles of land evaluation have now been discussed for about 2-3 years and a general agreement on the most important items of the reviewed "Framework for Land Evaluation" has been reached.

An important fact is that separate stages of both qualitative and quantitative land classification have been accepted. This distinction is especially useful in situations where there is neither practical experience nor data on yields and economics. Under these conditions reliable quantitative interpretation is impossible as long as the necessary experimental data are not available. In such cases one has to proceed to interpretative work without quantitative data, while the value of the qualitative interpretation depends largely on the experience of the expert.

Therefore it may be useful to prepare a basis for the discussion of guidelines that could help the expert in his qualitative interpretation of land properties for some very general land utilization types.

After discussion and agreement on these general guidelines, one could proceed to work out more detailed instructions for the determination of land capability classes for specific crops or crop rotations i.e. for precise land utilization types.

Suggestions are formulated about the type of land properties to be taken into account, while the degree in limitation of these characteristics should be estimated according to a qualitative procedure in order to achieve a relative scale of land evaluation.

Land use possibilities and management practices associated with these uses have to be considered. These will define the final land utilization types for which the land properties and the range in limitation of these properties are considered.

The present working document attempts to apply two main principles:

- the principle of prediction for relative appreciation of land properties
- the principle of recognition of permanent or changeable land properties

Prediction of the relative appreciation of land characteristics is related to the fact that the degree of limitation of land properties should express its qualitative influence on the capability of the land for the considered utilization type.

Therefore an agreement should be reached as to the land properties to be taken into consideration and on the number to be considered for the appraisal of the degree of limitation of land properties.

In this document suggestions are formulated for the interpretation of the following properties:

- climate
- slope
- flooding
- soil texture
- stoniness
- soil depth
- $CaCO_3$ status
- gypsum status
- sodium saturation
- salinity status
- weathering stage
- drainage
- permeability.

In so far as the number of degrees of limitations of land properties are considered, five levels are proposed:

S {
- no limitations
- slight limitations
- moderate limitations

N {
- severe limitations
- very severe limitations

This is retrograde - back to land capability.

It is further recommended that the definition of these levels in the degree of limitations should be parallel with the levels of improvement requirements necessary to correct changeable characteristics. 1/

The principle of recognition of permanent and changeable soil properties states that, for a specific land utilization type it is necessary to identify the characteristics that will remain without major change and those which will be significantly modified under influence of land improvement works.

The usual permanent factors include: climate, position, soil texture, soil depth, $CaCO_3$ content, gypsum content, weathering stage, subsurface stoniness, base saturation of subsoil, etc.

Changeable soil properties may include: drainage, surface pH, fertility status, surface stoniness, salinity, flooding, slope, etc.

1/ as defined in Publication 17, Land Evaluation for Rural Purposes, page 81, ILRI, Wageningen, 1973.

Rating of land properties

In this document suggestions are made for a review of the main land properties and for the rating of their degree of limitation for some general land utilization types. The studied land utilization types are chosen in function of the considered land characteristics.

Climate

Eco-climatological conditions are specific for each crop. It is suggested that a working party be established to define eco-climatological criteria for possible land utilization types and to suggest ratings for climatic characteristics.

Slope

Slope has to be considered for at least six broad land utilization types. For irrigated agriculture the degrees of limitation are much more severe than for rainfed farming. Among rainfed crops one should be more severe for annual crops than for perennials, while grassland and forest have to be considered separately.

Table 1 suggests the degrees of slope limitations for these broad land utilization types.

For most gravity irrigation systems it is accepted that landslopes are capable of being graded to less than 1 percent. Some exceptions permitting more slope are: graded contour furrows for row crops and fruit as well as contour ditches for hay and pasture. For sprinkler irrigation slopes of 20 to 35 percent become marginal.

Table 1 SLOPE LIMITATIONS FOR SOME BROAD LAND UTILIZATION TYPES (SLOPE CLASSES IN PERCENT)

Utilization type	Range in the degree of limitation				
	0	1	2	3	4
Gravity irrigation	S 0– 1	SC 1– 3	N 3– 8	N 8–16	N >16
Sprinkler irrigation	0– 3	3– 8	8–20	20–35	>35
Annual crops	0– 3	3– 8	8–15	15–25	>25
Perennial crops	0– 8	8–20	20–35	35–50	>50
Grassland	0– 5	5–12	12–25	25–50	>50
Forest	0–12	12–25	25–50	50–70	>70

Flooding

Flooding is considered a serious limitation. Although there is a difference in flood tolerance for most crops, the general flood limitations only are defined here. More precise information could be formulated when studying the capability for specific crops. From a general point of view the following are proposed:

0 - no flood limitation: the land surface is higher than the highest water level

1 - slight: the land surface is higher than the mean highest water level; however, occasional high floods may affect the land for a short period (not longer than 1-2 months)

2 - moderate: the land surface is at about the same level of the mean highest water level so that very often (more than 5 years out of 10) the land is flooded for a period of not longer than 2-3 months

3 - severe: the land surface is somewhat lower than the mean highest water level, so that almost every year very important floods occur during a period of 2-4 months

4 - very severe: the land surface is much below the mean highest water level, so that every year the land is flooded for more than 2 months and in most years for more than 4 months

Texture

Texture is considered as one of the most important soil characteristics for land 'capability' appraisal. It influences such important soil properties as infiltration rate, soil water availability, nutrient retention, drainage and tillage. The effect of texture on those properties may be modified by structure, nature of the clay minerals, organic matter content and the content of lime.

Texture is particularly important for irrigated farming. Soils of all textural classes - with the possible exception of very coarse sand - can be successfully irrigated if the proper irrigation method is chosen. Experience has shown that if the average infiltration rate exceed 12.5 cm per hour, gravity irrigation may not be practicable. For this reason two general land utilization types for irrigated farming are considered: gravity irrigation and sprinkler irrigation.

With regard to crop production, exacting crops (wheat, rice, barley, clover, alfalfa, sugarcane, sugarbeet, onions, bananas) give the best yields on heavy-textured soils; moderately exacting crops (cotton, maize, sorghum, millets) give better results on heavy-textured soils but are still satisfactory on lighter materials; still other crops such as groundnuts, carrots, potatoes, lettuce, tomatoes, some tobacco and watermelons do better on light-textured soils. Deep-rooting perennials(rubber, coffee, cocoa, citrus, dates, grapes, figs and olives) have still other textural requirements.

Table 2 suggests some guidelines for rating textural limitations for these general land utilization types.

Table 2

GUIDELINES FOR TEXTURAL LIMITATIONS FOR SOME BROAD LAND UTILIZATION TYPES

Land utilization type	Range in the degree of limitation				
	0	1	2	3	4
Gravity irrigation	CL, SiCL	SiC, SCL,L, SiL,Si	SL,SC, light C	LS, heavy C	S
Sprinkler irrigation	CL, SiCL	SiC, SCL,L SiL,Si	SL,SC, LS C	f S	c S
Exacting annual crops	Si,SiL SiCL, SiC,C	SC,SCL, CL,L	SL	LS	S
Moderately exacting annual crops	Si,SiL, SiCL, SiC, C,CL,L	SC,SCL	SL,LS	S	S
Crops with preference for light-textured soils	SL	LS,SCL, L,SiL	S	SC,CL,Si SiCL,SiC,C	
Deep rooting perennials	Si,SiL CL,L	SC,SCL, Si,SiL	SL,SiCL, SiC,C	LS	S

Stoniness

Four coarse fragment size classes could be considered:

- fine gravels; size between 2 mm and 2.5 cm
- coarse gravels; size between 2.5 and 7.5 cm
- stones; soze between 7.5 and 25 cm
- boulders; size more than 25 cm.

The stoniness of the top-soil could be rated with respect to the percentage of coarse fragments in the top 20 cm. When fragments of different sizes occur, the average size is taken into account.

An attempt to rate surface stoniness for arable land is given in Table 3.

Table 3 DEGREES OF SURFACE STONINESS LIMITATION

Volume percent	Fine gravel	Coarse gravel	Stones	Boulders
0 - 3	0	0	0	0 - 1
3 - 15	0	1	1	2
15 - 40	1	2	2	3
40 - 75	2	3	3	4
+ 75	3	4	4	4

It is believed that stoniness of the subsoil could also be estimated without making a distinction between gravel, stones and boulders.

As a base for discussion Table 4 suggests degrees of limitations for annual crops and pernnials.

Table 4 DEGREE OF SUBSOIL STONINESS LIMITATIONS

Percentage coarse fragments	Degree of limitation for annuals	perennials
3	0	0
3 -15	0	1
15 -40	1	2
40 -75	2	3
75	2	4

Soil depth

The depth of the soil that may be exploited by plant roots is an important criterion for land evaluation. A deep, well drained soil shows root penetration to below 150 cm for most crops.

For annual crops the dense root system is usually at a depth of less than 60 cm, while most tree-crops even have a dense to moderate root system to a depth of 150 cm.

Experience has shown that most crops will produce excellent yields with an effective root zone depth of 90 cm.

Table 5 suggests some guidelines for the interpretation of soil depth limitations for some general land utilization types.

Table 5 GUIDELINES FOR DEPTH LIMITATIONS

Land utilization type	Degree of depth limitations (cm)				
	0	1	2	3	4
Cereals and pasture (rainfed)	+ 90	40–90	20–40	10–20	0–10
Annual root crops (rainfed)	+ 90	60–90	40–60	0–40	0–40
Deep-rooting perennials	+150	90–150	50–90	20–50	0–20
Irrigated farming	+150	100–150	50–90	20–50	0–20

Calcium carbonate status

The presence of calcium carbonate affects both the physical and the chemical characteristics of a soil. High lime concentration may not severely restrict water movement but may prevent root penetration. Carbonate nodules are less active than concentrations in diffuse form. Especially important is the calcium carbonate present in particle sizes less than 20 microns. A high calcium carbonate concentration, particularly in the very fine fractions, brings risks of lime - induced chlorosis for many crops. As the sensitivity of the different crops to calcium carbonate differs, three groups of crops for evaluation of the $CaCO_3$ level (Table 6) are suggested. It is also accepted that the physical characteristic of calcareous soils change when they are irrigated. Therefore lime content affects suitability for irrigation, irrigated land becoming more coherent and resistant to root penetration when $CaCO_3$ content increases. Table 6 suggests some $CaCO_3$ limitations.

Table 6 GUIDELINES FOR $CaCO_3$ LIMITATION CLASSES

Utilization type	Degree of limitations ($CaCO_3$ percent)				
	0	1	2	3	4
Irrigated farming	3–25	0– 3 25–50	0 > 50	–	–
Crops that tolerate well $CaCO_3$ 1/	3–25	0– 3 25–50	50–75	> 75	
Moderately tolerant crops	0–15	15–30	30–50	> 50	
Sensitive crops	0– 3	3–10	10–25	25–50	> 50

1/ - Tolerant crops: wheat, alfalfa, figs, olives, dates.
- Moderately tolerant crops (these crops grow best in the pH ranges 6 - 7.5): barley, clover, cotton, maize, millets, rice, grapes, onions, sugarcane, sugarbeet, watermelons, lettuce, tomatoes, beans, artichokes, tobacco.
- Sensitive crops: citrus, bananas and potatoes.

Gypsum status

A small amount of gypsum is favourable for crop growth because it serves as a relatively soluble source of calcium to replace sodium in the exchange complex and thus acts to preserve soil structure. According to practical observations it may be concluded that plant growth is strictly limited when the gypsum content of the root zone is higher than 25 percent. Under irrigation, highly gypsiferous soils may develop dissolution depressions; for this reason those soils are not suitable for irrigation. For irrigated farming Table 7 suggests the degree of limitation of some gypsum classes.

Table 7 TENTATIVE GYPSUM LIMITATIONS FOR IRRIGATED FARMING

Gypsum status percent	Degree of limitations
0 - 3	1
3 - 10	0
10 - 25	2
25 - 50	3
>50	4

Sodium saturation

In arid areas, particularly under irrigated farming, sodium saturation has to be commented upon with regard to the utilization type. The exchangeable sodium percentage (ESP) tremendously influences the soil structure, the permeability and the water availability, i.e. for crops in an irrigated system, and thus this factor has a direct effect on the yield.

With regard to crop production, there are very few data on the influence of Na-saturation on yields. Some studies suggest the subdivision of crops into three groups, with regard to the influence of this factor. 1/

a. Tolerant crops: those that support rather well a certain sodium saturation; it is estimated that they have about 50 percent yield reduction at ESP 35. These are: dates, berseem clover, wheat, barley, alfalfa, sugarbeet, rice, carrots, onions, tomatoes.

b. Moderately tolerant crops: those having about 50 percent yield reduction at ESP of 15-25. These are: sugarcane, cotton, red clover, lemon, lettuce.

c. Sensitive crops: those having about 50 percent yield reduction at ESP below 15. Those are: maize, deciduous fruits, beans, avocadoes.

Table 8 suggests some guidelines for the evaluation of ESP for different land utilization types.

1/ Bower, C.A. et al., 1959. Chemical amendments for improving sodium soils. Agr. Inform. Bull. 195, USDA.
Lunt, O.R. 1963. Sensitivity of plants to exchangeable sodium percentage. Univ. of California, Report No. 5, Agric. Water Quality Research Conference.

Table 8 **GUIDELINES FOR THE EVALUATION OF ESP**

Utilization type	Degree of limitation (ESP)				
	0	1	2	3	4
Irrigated farming					
- on coarse and medium textures	<15	15-30	>30		
- on fine textures (C, SiC, SC)	< 8	8-15	15-30	> 30	> 30
Tolerant crops	<15	15-25	25-35	>35	> 35
Moderately tolerant crops	< 8	8-15	15-25	>25	> 25
Sensitive crops	< 5	5-8	8-15	15-25	>25

Salinity status

Salinity is probably the most common limiting factor in arid lands.

The different crops also have a variable sensitivity for soluble salts.

a. Very sensitive crops show yield reductions in the conductivity levels of 2-4 mmhos/cm and it is estimated that yield reductions of about 50 percent occur in the conductivity levels of 6-8 mmhos/cm. These crops are: beans, maize, soybeans (field crops); cabbage, potatoes, lettuce, peppers, onions, carrots and tomatoes (vegetables); clovers and alfalfa (forage crops); citrus and banana (fruit trees).

b. Sensitive crops show yield reductions in the conductivity levels of 4 to 8 mmhos/cm and it is further estimated that yield reductions of about 50 percent occur in conductivity levels of 12 to 16 mmhos/cm. These are: sorghum, wheat, rice, sunflower and sugarcane (field crops); spinach (vegetables); tall fescue, perennial rye and birdsfoot trefoil (forage crops); grapes, olives and figs (fruit trees).

c. Tolerant crops show yield reductions in the conductivity levels of 8 to 12 12 mmhos/cm, and about 50 percent yield reductions occur at conductivity levels of 16 to 18 mmhos/cm.

Salinity also affects the suitability for irrigation because the amount of water necessary for leaching will depend on the salt content of the soil. Table 9 suggests tentative salinity limitations for some general land utilization types.

Table 9 GUIDELINES FOR THE EVALUATION OF SALINITY

Utilization type	Degree of limitations (cond. mmhos/cm)				
	0	1	2	3	4
Irrigated farming					
- coarse and medium textures	< 8	8-16	16-30	> 30	> 30
- fine textures	< 4	4- 8	8-16	16-30	>30
Very sensitive crops	< 2	2- 4	4- 6	6- 8	> 8
Sensitive crops	< 4	4- 8	8-12	12-16	>16
Tolerant crops	<8	8-12	12-16	16-20	>20

Weathering stage

With the exception of soils with a positive charge, the weathering stage rarely makes a soil unsuitable for cultivation; however, it may influence the capability particularly in the humid tropics.

In arid and semi-arid areas, most soils are calcareous and the weathering stage is not taken into consideration.

In the humid and semi-humid tropical belt, the weathering stages could be looked upon as associated with the following degrees of limitation (at least for annual as well as for some exacting tree crops such as cocoa, bananas).

0 - no limitation: recent soil materials (mostly Entisols or Inceptisols) having a clay fraction with CEC of more than 24 meq/100 g of clay.

1 - slight limitation: soil materials with apparent CEC between 16 and 24 meq/100 g of clay (Oxic subgroups of Inceptisols, Alfisols and Ultisols).

2 - moderate limitation: soil materials with apparent CEC below 16 meq/100 g of clay but having a net negative charge (many Paleo-groups of Ultisols, Tropeptic and Typic sub-groups of Oxisols).

3 - severe limitation: soil materials with a net positive charge (Acric groups of Oxisols).

Drainage

Drainage is considered in almost every system of land 'capability' classification. It has also to be commented on in relation to the land utilization type.

The suitability for upland crops decreases when drainage conditions become impeded. In addition tree crops with a deep root system are more sensitive to poorly drained conditions than annual crops with a more superficial root system. Of course, crops like irrigated rice react quite differently to drainage conditions; in their case the suitability decreases when drainage conditions improve.

For irrigated agriculture, in addition to drainage, the depth of the groundwater in relation to its salinity status should be taken in consideration.

Table 10 illustrates tentative guidelines for the interpretation of drainage conditions for some general land utilization types.

Table 10 GUIDELINES FOR INTERPRETATION OF DRAINAGE

Utilization type	Drainage classes at different degree of limitation				
	0	1	2	3	4
Annuals	good	moderate	imperfect	poor	very poor
Perennial tree crops	good	good	moderate	imperfect	poor and very poor
Rice (irrigated)	←poor and very poor→		imperfect	moderate	good
Pasture	imperfect	moderate poor	good	very poor	
Irrigated agriculture					
- low to medium saline ground-water (EC <750)	good w.t.below 2 m	good w.t.betw. 1.2 - 2 m	moderate	imperfect	poor and very poor
- high saline groundwater (EC>750)	good w.t. below 3 m	good w.t.betw. 2 - 3 m	good w.t.betw. 1.2 - 2 m	moderate	imperfect poor and very poor

Permeability

In most cases permeability of the soil is related to texture and the presence of impermeable layers (depth). However, in many systems of land evaluation the permeability factor is considered particularly when irrigation is concerned.

Appreciation of permeability is based ypon the lowest permeability rate found between 20 and 120 cm, or between 20 cm and the depth of a limiting layer.

Tentatively the following subsoil permeability limitations could be suggested.

0 - no limitations:

- moderately permeable; the permeability is from 0.5 - 6 cm/h, mostly in medium to heavy-textured soils with good structure (loam, fine sandy loam, silt loam, silt).

1 - slight limitations:

- somewhat too rapid; permeability from 6-12 cm/h; mostly in light-textured soils (coarse sandy loam, loamy fine sand)
- somewhat too slow; permeability from 0.1 - 0.5 cm/h; in very heavy-testured soils with however a non massive structure (sandy clay, silty clay, clay).

2 - moderate limitations:

- too rapid; infiltration rate from 12 - 25 cm/h; in coarse-textured soils (loamy coarse sand, fine sand).
- too slow; permeability less than 0.1 cm/h; in very heavy soils with massive structure (sandy clay, silty clay, clay).

3 - severe limitations:

much too rapid infiltration rate; permeability is more than 25 cm/h; very coarse-textured materials (coarse sand and gravel).

Conclusions

The base of any system of land evaluation should be displayed in one separate table per land utilization type. This table should list the limiting factors as well as the range in degree of each of these limitations as follows:

Limiting factors	Range in degree of limitations				
	0	1	2	3	4
Climate					
Soil limitations					
- texture					
- depth					
-					
-					
Erosion limitations					
- slope					
-					
-					
Drainage limitations					
- drainage					
- flooding					
-					
-					

The next step should be the elaboration of such tables for the most important crops in order to arrive ultimately at better defined land utilization types. This will imply the detailed study of ecological and land conditions for the most important crops.

The present document having been critically commented upon, it is the intention to proceed with the suggested evaluation scheme for the various crops. The general principles of this work will be applied, but in addition the principle of the recognition of permanent and changeable land qualities will be taken into account.

REGIONAL CORRELATION AND EXCHANGE OF INFORMATION

by

A. Pécrot
Senior Officer, Soil Resources
Soil Resources, Development and Conservation Service

Introduction

Exchange of information and experience between areas having similar environmental conditions is a main objective of land evaluation. Experimental research programmes require heavy investments in terms of time and money and full use should be made of their results. Practical experience gained during project implementations is also valuable and should be fully exploited when starting new projects in comparable conditions.

Exchange of information has been so far seriously hampered by the diversity of methodologies and approaches utilized for land resources appraisal and interpretation of data. A reliable exchange of information and its utilization in specific conditions requires the use of a widely accepted land evaluation methodology and criteria which will be easily understood and used by all concerned.

In view of the variability of socio-economic data, both with time and local conditions, the exchange of information on land suitability will be primarily based on physical land factors such as soils, topography, climate and crop yields which have a definite influence on socio-economic results of specific land utilization types.

This information is then interpreted in terms of local conditions, taking into account minor variations in physical environment, specific aspects of the land utilization type, local socio-economic conditions and the unit costs of main agricultural inputs in relation to production benefits.

A uniform classification and interpretation of the physical factors of the environment, particularly soils and climate and the standardization of land use nomenclature, are therefore the first necessary steps for transfer of information.

Standardization of basic data for land evaluation

I. Soils

1. Soil Correlation and Classification

A uniform soil nomenclature and precise definitions of soil units, are basic requirements for soil correlation and transfer of information. Such classification is not suggested to replace the existing national classification schemes but to serve as a common denominator for soil correlation between countries belonging to a broad ecological region.

In both the USDA Taxonomy and the legend for the FAO/Unesco Soil Map of the World, the soil units are defined in terms of diagnostic horizons and properties which include key characteristics having prediction value for the use and productivity of the soil.

The level of generalization of the classification category on which the correlation is based should be consistent with the level of detail of the evaluation. For reconnaissance evaluation of large areas, the FAO/Unesco Soil Map of the World provides basic information on soil conditions. In addition to the soils present in each mapping unit, information on soil texture and general topography is provided. The phases shown on the map are particularly significant to the use and management of the land.

The World Food Conference (Rome, November 1974) recommended that FAO, in collaboration with other U.N. agencies and competent international organizations, prepare a global land capability assessment based on the information available on the Soil Map of the World. Such an assessment will be a basic tool for the exchange of information within broad ecological zones.

For more detailed evaluations, the soil correlation will be based on a lower level of generalization. The FAO legend of the 1:5 000 000 Soil Map of the World is a mono-categorical system of soil classification. Subdivisions of the soil units may be introduced as required and in fact sub-units were already established for the Soil Map of Europe at the 1:1 000 000 scale. Further sub-divisions may be made to meet the requirements of more detailed investigations. In order to keep sufficient uniformity in the system and the concept and definitions of soil units at lower levels of classification, it is strongly suggested that the establishment of sub-units should be decided in close consultation with the technical service concerned in FAO which, in consultation with the Correlation Centre for the Soil Map of Europe, will assume responsibility for regional and interregional soil correlation.

2. Standardized profile descriptions and laboratory procedures

Uniform profile descriptions and analytical methods provide essential background information for correlation and comparison of soils in different areas, for studies of soil crop relationships and for yield prediction purposes. The uniformization of profile descriptions made considerable progress during the last two decades. The "Guidelines for Soil Descriptions", published by FAO ten years ago and essentially based on the USDA Soil Survey Manual, was a basic contribution for this purpose. It is now being updated, taking into account the latest soil horizon designations and definitions recently accepted by the International Society of Soil Science and the USDA Soil Conservation Service.

The standardization of laboratory methods for soil analysis still requires further progress before analytical data produced in different laboratories and countries can be easily compared.

3. Uniformization of field experimental designs, processing and interpretation of experimental data on fertilizer use and soil management will allow comparison of soil productivity potential for a specific crop under a range of environmental conditions and the exchange of experience on soil management practices. Computerized processing of data is being actively developed in FAO and in many other institutions and the standardization of programmes should be pursued.

During the last two decades, FAO projects aiming at the promotion of efficient fertilizer use were carried out in a great number of developing countries. These projects include large experimental programmes conducted in accordance with standard designs elaborated by the technical service in FAO Headquarters. Experiments by thousands were and are still being carried out on major crops both in experimental stations and on farmers' fields. Relations between crop yields, fertilizer responses and soil data are investigated. Recommendations on fertilizer use and soil management are being improved and are disseminated through extension services with the necessary adjustments required by minor differences in local conditions.

Under the exploitive utilization, the land resources are used without any conservation practices or fertilizer input. As a result, the productivity decreases steadily within a few years time. In the conservative utilization, the nutrients and water removed from the soil are replaced and the management is just sufficient to maintain the productivity at a constant level. In the optimizing utilization, the various inputs including fertilizers are provided at their optimum and the productivity increases. Further subdivisions of the proposed system are based on the scale of operations (subsistence-commercial), the cropping pattern and the product.

This system is far from being finalized, but it provides an interesting approach to a classification of land utilization which takes into account the main factors of agricultural production and the hazard of soil degradation.

Using the Soil Map of Europe for Land Evaluation

The Soil Map of Europe at the 1:1 000 000 scale and related information on mapping units may be used as background information to make an assessment of available land resources, including the idle lands which can still be brought under cultivation. By definition, such an assessment should take into account the hazards of irreversible soil degradation. It would greatly facilitate regional exchange of information and experience on land characteristics and management practices.

i. Evaluation of Land Resources

For the compilation of the Soil Map of Europe, the continent was subdivided into 5 regions presenting relatively uniform ecological conditions. This subdivision may be provisionally kept for starting land evaluation on a regional basis.

As socio-economic conditions may be very different from country to country within a region, it is suggested to adopt the two-stage approach to land suitability evaluation as provided in the framework. The first stage is essentially an evaluation based on physical land characteristics. In the second stage, which can follow immediately the first stage or take place later, the economic aspects are analysed. The two successive stages are closely interdependent since the physical characteristics are selected insofar as they affect economical results.

As a first step to regional land evaluation in Europe, it may be suggested to limit the scope of the exercise to the first stage of the above-described approach.

The evaluation would be made by country and closely coordinated within the region by a regional land evaluation correlator. The major land utilization types for which the evaluation will be carried out will be selected on a regional basis and will reflect the main trends of agricultural planning in the countries. This work will be carried out in close liaison with the ongoing FAO activity on a world assessment of land resources which was recommended to FAO by the World Food Conference last year.

It is realized that in many European countries a large part of the territory has already been evaluated for town or agricultural planning, but until now an assessment of land resources at continent or regional level based on a uniform methodology has not been made.

ii. Assessment of Soil Degradation and Degradation Hazards

The problem of soil conservation in Europe has already been the subject of a study sponsored by the Council of Europe (1970). A map of Salt Affected Soils in Europe was published in 1968 by the Research Institute of Soil Science of Hungary. A number of other local studies were carried out, but so far no overall assessment of soil degradation based on a uniform methodology has been made in Europe.

Since, by definition, land suitability for a defined land use implies that no serious degradation of the environmental quality will result from the sustained land use, present soil degradation and degradation hazards are considered in land suitability evaluation.

FAO, in collaboration with Unesco, WMO and ISSS and with financial support from UNEP, will carry out a world assessment of soil degradation. The project will make an inventory of the main forms and intensity of present soil degradation and soil degradation hazards such as erosion by wind and water, salinity and alkalinity, waterlogging. This project is closely connected with the Global Assessment of Land Resources. A methodology and criteria for evaluation and classification of the various main forms of soil degradation will be developed and this group will be kept informed on the project progress. The applicability of the methodology to European conditions may be the object of a future activity of the group.

Proposed Outline of a Work Programme

On the basis of the above, an outline of a work programme to be initiated during the next two years may be suggested. It comprises the following main objectives:

1. Description and classification on a regional basis of main land uses - existing or actively contemplated by the planning authorities - including the required major land improvements and recurrent investments. This work should be conducted in collaboration with the International Geographical Union Working Group for Rural Planning and Development.

2. Characterization on a regional basis of ecological requirements of individual crops, through compilation of existing long term observations and experimental results and promotion of additional experimental programme where needed.

3. Selection and characterization of physical land characteristics or land qualities of long term validity which influence significantly the economic results derived from main land uses.

4. Evaluation of the suitability of individual soil units of the 1:1 000 000 Soil Map of Europe for main land uses with a view to making an evaluation of the soil associations (mapping units) of the soil map; a methodology will be established for this purpose, in close liaison with the world assessment of land resources which is being undertaken by FAO.

5. Study of the forms and intensity of existing soil degradation and soil degradation hazards inherent to main land uses; recommend and promote soil conservation measures and the establishment of facilities at country level for monitoring soil degradation.

6. Organization of regional correlation meetings for the coordination of work and establishment of criteria and parameters suited to regional conditions and relevant main land uses.

7. Preparation of preliminary country land suitability maps (1:1 000 000) scale and reports for review at an expert consultation which would be organized in 1977; in the light of the preliminary results a more detailed work programme would be proposed for the consecutive two year period.