ON CLASSIFICATION OF AGRICULTURAL SYSTEMS — AN ECOLOGICAL APPROACH

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A brief survey of criteria used in some classifications of agricultural systems reveals ecological aspects to be rarely emphasized. It is therefore proposed to base a future classificatory system on a combination of two main groups of criteria: one describing the limitations for cultivation set by the environment, and another the cultivative adaptation, mainly expressed by the intensity of land use.

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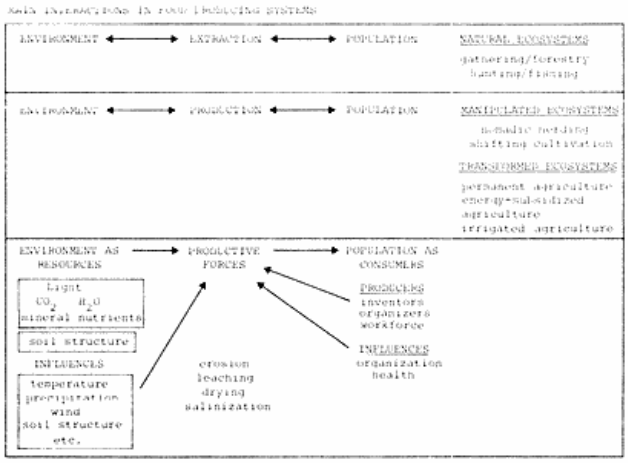

Fig. 1. Main interactions in food producing systems.
Fig. 1. Vigtigste sammenhænge i fødevareproducerende systemer.

The acquisition of biological production is one of man's most fundamental activities. Food and other biological materials are mainly produced by agriculture (including animal husbandry), but also by forestry, fishing, hunting and gathering. These industries — especially the land-based ones — have traditionally caught the interest of geographers because they stress the dependency of population on area-productivity. In spite of this, a coherent terminology describing man-utilized bioproductive systems has not yet been agreed upon — even a convenient term covering all such systems is still missing (»cultural ecosystems« might be a useful term).

Because cultural ecosystems are such multi-faceted phenomena (agriculture is no exception!), quite many approaches on typology are possible. Thus, emphasis may be put on the environment for production, the character of the productive process, the socio-economic aspects, or the forms and utilization of output. Almost every textbook on agricultural geography has a list specifying the determining elements for an agricultural production. In fig. 1 the various elements in biological extraction and production are arranged around the central extractive/productive process.

The most fundamental distinction to make is probably between extraction and production. Extraction encompasses such processes as gathering, hunting, fishing, and forestry, by which natural, »wild« ecosystems are utilized. In contrast »production« may be understood as utilization of ecosystems changed by man such as by »manipulated ecosystems« (where only wild plants or animals have been exchanged for domestic ones), or »transformed ecosystems«, where also the physical environment as soil and water has been encroached on. All agricultural systems are, naturally, classed within »production«.

Main criteria for earlier typologies were often chosen as to stress the importance of one single or combinations of the elements depicted in fig. 1. A few of the major lines of approaches shall be briefly mentioned below.

Relatively few authors try to classify agriculture via the physical environment it necessarily must be adapted to. Most often climate is used for a basis. Distribution of crops in their widest extension has been proposed by M. Vahl (1922) in his climatic classification based on major types of natural vegetation. Promising attempts to assess the Earth's potential crop production in its climatic dependency have been published by S. S. Visher (1955), Jen-hu Chang (1968), and H. Lieth (1968). Further investigations in climatic crop potentials assessed from computer-simulated maximum net productions of given crops and specifying the climatic elements considered (often only actual radiation and temperature, excluding water balance) may yield results of practical value. It is more difficult to calculate the effects of soil conditions on

Fig. 2. Types and distribution of growth seasons (gr.s.).

RAINFALL REGIMES	TEMPERATURE REGIMES			
	Hot (tropical)	Hot-temperate (subtropical)	Temperate-cold (temperate)	Cold
wet	continuous gr.s. (rainforest type)	wet-hot + wet-temperate gr.s.	temperate gr.s.(summer) + 'winter fallow'	low temperatures
wet-dry	2 wet + 2 dry gr.s. (savannah type)	wet-hot + dry-temperate gr.s. (summer-rain type = Chinese type) dry-hot + wet-temperate gr.s. (winter-rain type = mediterranean type)	wet-temperate gr.s. (West European type) dry-temperate gr.s.	desert
dry	possibly 1 or 2 dry gr.s.	possibly 1 dry gr.s.	possibly 1 dry gr.s.	desert
	no cropping possible: except by irrigation (desert)			

Fig. 2. Types and distribution of growing seasons (gr.s.). The main types of agricultural climates have been arranged according to temperature levels in growing seasons (horizontally) and to levels of humidity (vertically).
Fig. 2. Typer og fordeling af vækstsæsoner. Hovedtyper af landbrugsklimater ordnet efter temperaturniveau (vandret) og fugtighedsniveau (lodret).

potential yields, unless quite rough estimates are aimed at such as shown by W. Hollstein (1937). Nowadays soil characteristics are more liable to be changed by cultivation than before, regarding both mechanical and chemical properties.

Though of great interest, neither assessment on possibilities to cultivate specific plants, nor the theoretically acquirable yields of a specific plant are of direct usefulness for an agricultural classification. The first approach points at too many possibilities, and the last one does not single out well-defined types, but describes rather a continuum of yield levels.

Hollstein's work (op cit.) points at another possible basis for classification, namely at the temporal characteristics of growth seasons. The climatic types of annual growth possibilities are distinguished primarily by occurrence of growth-inhibiting temperatures, secondly on drought. His ideas are very similar to those of the Danish botanist Raunkjær on the growth forms of wild plants (C.C. Raunkjær 1907). Slightly modernized, it can be said that growth seasons of different duration and annual numbers must be met with different cultivative »strategies«. As low temperatures also mean low accessibility to water for plants, it is no wonder that cold spells and dry ones may have similar effects on vegetation. If seasonal variations in temperature are combined with similar ones in rainfall, som characteristic patterns emerge as shown in fig. 2. The similarity between the agricultural types proposed here and those based upon climatic classification are not surprising, since different types of climate must be met with different agricultural strategies. One of the arguments against a classification of growth seasons is that it involves both climatic and botanical characteristics. Delimitations of classes depend on properties of the plants chosen as indicators, and such properties change in time. In spite of this weakness, a growth season classification seems worthwhile striving at because it touches upon an important aspect of any agricultural system.

Characteristics of the productive process are of natural interest for at typology. Early classifications concentrated often on technology, especially the tools used. E. Hahn (1892) distinguished his »Wirtschaftsformen« — gatherers, hunters, hoe or plough agriculturists — mainly by their tools. Also later classificators used these criteria, but changed the emphasis somewhat. G. Hatt (1922) focused attention on the distribution of work between sexes, and added a new subdivision, semi-agriculturists, where women were the cultivators.

R. Thurnwald (1932) applied for his classification also the type of society involved, whether it was homogeneous or stratified. H. Bobek (1959) advanced further along this path and proposed a classification with five stadia based on »Lebensformen« (related to the physical world), »Produktionsverhältnisse« (related to the distribution of work, property etc. in society), demographic valeur (dynamics of population), and pattern of settlement. Other authors have added the criterion of orientation of production to distinguish subsistence from market-orientated agriculture. Some of these ideas referred resemble those of Marxist writers where the connection between nature, development of »productive forces« (technical and scientific level etc.), and »mode of production« are central items.

This brief survey of possible ways to establish an agricultural classification would perhaps be too incomplete if classifications based on consumptional patterns remained unmentioned. H. Kariel (1966) made such an attempt; detailed material for further improvements of dietary regionalization seems to be available with the increased interest in the subject from FAO and WHO.

The approaches mentioned so far are all of the »logical division« type using one or more criteria to distinguish types of agriculture. Another recent approach is interesting by using the »agglomerative« principle: That of J. Kostrowicki (a range of earlier works summarized 1978) and his cooperators of the IGU Commission on agricultural typology. After an early agreement on the most

appropriate properties for description of agriculture, a large material was collected covering a wide range of the world's agricultural variation. The different descriptions were later grouped together by various similarity measures (e.g. by Aitchinson 1976). A final version of the resulting types appeared in several publications as in J. Bonnamour (1973, pp. 44-45). The typology reflects of course the criteria chosen for description as well as the weighting of them.

Though Kostrowicki's work has dealt with many aspects of agricultural geography and already has proven its value, it has not totally solved the question of terminology, especially regarding single-criteria terms. It must be added that this was not aimed at by the Commission either.

From a cultural-ecological viewpoint it seems highly appropriate to emphasize the role of energy and matter in the agricultural production, besides that of areas. A systematical arrangement of the various forms of agriculture in terms of flows of energy and matter will gain in acceptability the more it depicts phylogenetical development. Previously presented classifications, such as by D. Whittlesey (1936) and recently by H. Ruthenberg (1971), exhibit features of the kind suggested and encourage a follow-up. It is here proposed to develop a type of classification based on intensity in land-use; this is thought to hinge on the mode of managing maintenance of fertility understood as the soil-stores and supply of plant nutrient ions. A classification of this kind stresses the importance of the ecological aspects of agriculture: Flows of energy and matter combined with structure.

As previously mentioned, all cultural-ecological systems may be classed in one of the two main groups: the extractive and the productive. To the first one are counted all systems funtioning by direct extraction of biological material from natural ecosystems such as gatherers, fishers and hunters, i.e. »fertility« is maintained by the natural ecosystems itself. If terms are needed to distinguish between systems based on extraction of materials of vegetable or animal kind, the usual ones: collectors/gatherers and fishers/hunters are insufficient. Possibly new terms may be useful. Maybe terms of Nordic origin may serve the purpose such as sanking systems (Nordic: »sanke« = gather/collect regardless of origin) and veiding systems (Nordic: »vejde« = catching any kind of animals).

The productive systems all include some transformation of the natural elements. Two classes seem evident: one producing from manipulated ecosystems and another from transformed ecosystems. Manipulation of an ecosystem is here understood as the replacing of some of the original biological elements in the ecosystem structure by domesticated plants or animals instead of the original wild ones. As by natural ecosystems, fertility is maintained »automatically« by nature alone. Herding (nomadic) people and shifting cultivators belong to this group. The weakness of a rigid distinction is of course that shifting cultivators do make a certain impact on other elements of the ecosystems — soil, weeds — as well; however, this impact is comparatively slight if compared with that within transformed ecosystems.

When shifting cultivators intensify their land-use, the landscape reflects this clearly when fallow via bush-fallow is changed into grass-fallow. H. Ruthenberg recommends the R-coefficient.

$$R = \frac{\text{years cultivated}}{\text{years cultivated} + \text{fallow}} \cdot 100$$

as an expression of this intensification, and within the same area fixed R-values can usually be found to express the cultivation systems quite satisfactorily.

From the point of view adopted it is important to consider agricultural practices in the light of soil fertility. To achieve stable yields within any agricultural system, the removal of plant nutrient ions through harvest and leaching must be compensated for by weathering (and transport to surface layers) and perhaps artificial adduction. The minimal removal for instance by shifting cultivation is usually balanced by the outcome of long-time weathering and transport. Possibly the survival of shifting cultivation within the tropics must be seen in the light of its ability to accumulate and store ions over long successive periods of fallow; the value of such a property is important in the milieu of high ion-mobility caused by heavy rainfall and high chemical activity.

Transformed ecosystems are characterized by high inputs, of labour (or energy), but accidentally also of plant nutrient elements (including water).

Extra labour may compensate for low contents of plant nutrient by speeding up weathering, nitrogen-fixation etc. Intensive working of soil, as by ploughing, has the combined effects of improving soil structure, increasing weathering — thus producing more nutrient ions —and bring them into the top stratum of the soil.

Transformation of ecological systems is necessary when a faster compensation for harvest losses of nutrients is needed. If the increased weathering is inadequate, fertilization by import of plant nutrients is necessary. Agriculture based on »artificial« fertilization forms a rather distinct group of transformed ecosystems.

It seems sustainable to class irrigated systems more or less separately; other transformed systems can possibly be arranged in a neat series beginning with 2 course rotations (alternating cropping and fallow years), 3-4 course rotations (with 2-3 years of alternating crops, then fallow) — successive rotation (no fallow, but crops changing in a fixed succession), and free rotation. Naturally, a coupling of animal husbandry with agriculture leads to some additional classes: most of them are in reality infield-outfield systems because of a difference

in intensity of exploitation (caused by fertilization) of the different elements of land in the system. By convertible husbandry (Danish: »kobbelbrug«), the fertilizing effects of animals is integrated into a system with homogeneous intensity.

In recent times — since about the 1870'es — it has been increasingly common to replace handwork by mechanical equipment. Possibly, this class of transformed ecosystem deserves a name of its own, the energy-subsidized ecosystem. This depends more and more heavily on fossil energy resources (see Pimental et al. 1974).

This rough outline of a classificatory system may need further elaboration to be serviceable. It may also be asked whether it fulfills the requirements set from the outset. Even though it may be said to be sufficiently simple and logical, it may be questioned whether it touches on features essential enough for a main classification. This question can hardly be briefly answered. May it suffice here to point out a few interesting parallels between the »intensity scale« and other features of classifications. Firstly, the intensity often correlates with labour inputs, farm population density, farm size and similar things. This is certainly no surprise, since it has been noticed long by authors, foremost by E. Boserup (1965). Secondly, the intensity scale roughly correlates with the kind of equipment used. This is not surprising either, as for instance the physical state of a fallow precludes the use of some types of equipment and favours others.

Finally, it may be underscored again that the main virtue of the intensity scaling is that it uses features that are objectively measurable in the landscape and hence of concern for the geographer; especially when used in combination with some appropriate environmental description, the classification sketched may prove to be useful.

From this short presentation some conclusions may be drawn about the criteria to be used in an ecological classification of agricultural systems on a world scale. There are two useful groups of criteria: »indirect« ones concerning the environment, and »direct« ones related to the agricultural practices. Also it is evident that several criteria must be used simultaneously to make a classification based on type and number of annual growth seasons and intensity of land use as main criteria.

RESUME

Et udvalg af klassifikationer af landbrugssystemer viser, at disse er baseret på anvendelse af meget forskellige kriterier. Kun få af dem berører essentielle økologiske forhold, som f.eks. det miljø, systemet er tilpasset til, den ydeevne og den produktionsmæssige indsats, systemet karakteriseres ved.

Da de klimamæssige rammer kun vil kunne brydes ved produktiv indsats, og derfor altid direkte eller indirekte præger dyrkningssystemet, foreslås en agro-klimatisk karakteristik som et hovedelement ved ethvert landbrugssystems beskrivelse (se fig. 2). Karakteristikken bør især omfatte den årlige fordeling af vækstsæsoner og deres termiske forhold. Dertil bør antagelig fremtidig benyttes en bestemmelse af potentiel produktion.

Når et landbrugssystem er karakteriseret ved sin miljøtilpasning bør det naturligvis fremhæves, at det andet vigtige tilpasningsaspekt — til socioøkonomiske forhold — er af nøjagtig samme vigtighed. Et væsentligt træk ved sidstnævnte tilpasning udtrykkes især ved landbrugets ydelser, der må ses i forhold til den produktive indsats. På grund af den generelle sammenhæng mellem ydelse og indsats kan man antagelig nøjes med en angivelse af intensitet, som den er udtrykt i arealbenyttelse og ved eventuelle tilførsler af mineralsk gødning, vand etc. Som hovedklasser foreslås naturlige økosystemer (ikke behandlet): manipulerede økosystemer, transformerede økosystemer, og — som underklasse under sidstnævnte — energisubsidierede systemer samt kunstvandede systemer (se fig. 1). Det vil af fig. 1 ses, at systemer som flyttemarksbrug (karakteriseret ved arealintensitet) let finder plads i de nævnte grupper.

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