ECOLOGICAL HUMAN GEOGRAPHY
some considerations of concepts and methods

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The field of interest for ecological human geograhy is defined as the study of utilization systems. The application of different ecological concepts in human geography is shown, and the fertility of using different types of systems approaches in the analysis is demonstrated on a simplied, closed agricultural system.

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Although terms such as »human ecology« and »cultural ecology« are frequently mentioned in current geographical literature, few attempts have been made to specify where in the extremely wide field of human ecology an ecological human geography might be placed, what concepts and methodologies should be considered important to it, and what relations it might have to other geographical disciplines. In the present paper we shall make an attempt to treat some of these questions, but without going into details; emphasis will be laid upon presentation and examplification rather than upon a deepgoing discussion of concepts and methodologies. Neither will the presentation be related to other geographical perceptions of human ecology; the history of ecology and of human ecology in geography is an interesting and complex topic which deserves a separate treatment.

THE UTILIZATION SYSTEM CONCEPT

Ecological human geopgraphy is concerned with utilization systems that can be described as consisting of those elements of the social and the physical/biological »systems« which interact most intimately in the process of material production. The two systems, the social and the natural, operate on the basis of laws, which are, at the level of abstraction relevant here, fundamentally different, and they should therefore in this connection be perceived as two separate systems, fig. 1. However, elements from both of them will be necessary in the ecological analysis of the material production.

Although the level of technological development influences the availability of resources and the environmental limitation for a certain material production, there are still some basic physical and biological characteristics that must be included in the analysis. The social conditions however, also influence the material production and must therefore be included in an analysis of the utilization system. This means that - according to our definition - the ecological human geography is a materialistic science as it is focusing upon flows of energy and matter directed by man, and the explanation is rooted in the natural as well as in the social sciences. A central theme is the manipulation of these flows of matter and energy and an understanding of how changes in manipulations will influence the system.

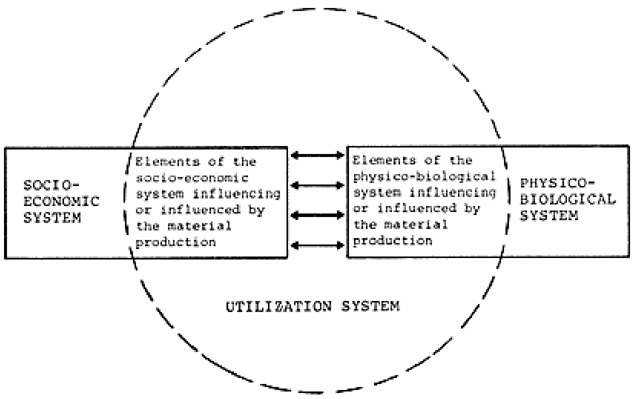


Fig. 1. A diagrammatic illustration of the utilization system concept. Utilization systems are defined in relation to a material production and consist of those elements from a socio-economic as well as from a physical-biological system that are most intimately related through the production process.
Fig. 1. Skitsen illustrerer udnyttelsessystem-begrebet. Et udnyttelsessystem defineres i relation til en materiel produktion; det består af de relevante elementer fra såvel det socio-økonomiske som det fysisk-biologiske system samt af de vekselvirkninger mellem systemerne, som denne produktion indebærer.

It is convenient to apply terms and concepts from the biological ecology in the analysis even though their meaning will naturally undergo changes when applied in ecological human geography. Likewise, experiences and laws from biological ecology cannot be directly transferred to ecological human geography due to the unique human ability to operate the material production process and adapting it to the physical/biological environment. It will therefore not be possible to transfer conclusions on systems behaviour directly from biological ecology to utilization systems. The biological-physical analysis of a utilization systems will seldom result in a complete understanding of the material production as the socio-economic influence will often be of equal or even greater importance. When much of the ecological, human-geographical and anthropological literature so far published may leave the reader with the opposite impression, it may stem from the fact that the main stress has been laid on analysing systems where the biological influence dominates such as in low-technological, isolated systems. This does not indicate, however, that the ecological, human-geographical approach is not yielding on systems with a significant socio-economic directing of the production.

When intending to advocate relevance and usefulness of a specific approach, the question naturally arises what it can yield compared with other and maybe more well established approaches. The relevance of an economic human geography will undoubtedly be met with approval by the majority of human geographers - and also by the present authors, who moreover believe that many problems in human geography can only be satisfactorily elucidated if economic and ecological approaches are supplementing each other, f.e. concerning the understanding of the material production process and its physical/biological and social implications.

One reason for this is that economic theory does not suffice to describe systems strongly linked with environmental factors because it does not incorporate basic physical and ecological laws. It will therefore be less fertile to use an economic approach when analysing systems with a limited exchange with the surroundings and with slow technological change, and this partly explains why there is such a strong tradition for ecological studies of this kind of systems (Rappaport (1971), S. Christiansen (1975)).

Likewise, a physical-ecological analysis can also be required where the production system is determined by socio-economic factors rather than by environmental limitations. In this case especially problems connected with the dependence on limited resources and limited capacity for waste disposal call for an ecological approach (Roos, 1978).

Thus, ecological analyses in human geography are not restricted to the traditional resort, i.e. studies of isolated, low-technological societies, but is a socially relevant discipline yielding conclusions important for the understanding of the material basis of a modern society.

THE APPLICATION OF ECOLOGICAL CONCEPTS IN HUMAN GEOGRAPHY

In the following presentation of the use of central concepts in the study of exploitation systems, we shall apply examples of a traditional subsistence agricultural systems as well as a modern industrialized system to illustrate the fertility of ecological analyses. Fig. 2 is a simplified sketch of the flows of energy and nutrient ions in a traditional agricultural system commonly practised in river valleys in western Jutland about 1800. Briefly summarized, the material production is related to three main types of land utilization: meadows, heaths, and fields. Livestock is grazing the meadow and provides manure for the fields. The grain products from the fields are mainly used for human consumption, while the heath is providing sheep-grazing, heather for fuel, moor for fertilizing the field, etc. (for a comprehensive description, see Jensen & Jensen, 1979).

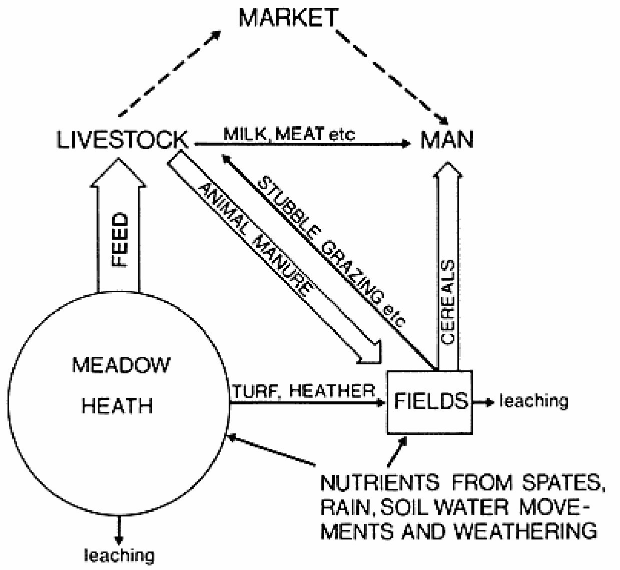


Fig. 2. The main circulation of matter in a traditional, closed river-valley system. Circles indicate uncultivated areas, squares cultivated fields, and arrows flows of matter; their size indicate relative order of magnitude only. The sun provides the sole essential input of free energy.

Fig. 2. Skitse over de væsentligste stofstrømme i det traditionelle lukkede ådalsystem. Cirkler symboliserer vild vegetation, kvadrater kultiverede arealer og pilene stofstrømme. Cirklers og kvadraters størrelser samt pilenes bredde antyder deres relative betydning og skal ikke tolkes kvantitativt. Solen udgør det eneste væsentlige tilskud af fri energi til udnyttelsessystemet.

In this system the main flows of matter and energy are: nutrient ions in the soil are absorbed by vegetation and will from there either recirculate via decomposition of plant materials, or, be transmitted to the livestock via their feed (grass, heather, stubbles, and small amounts of grain sometimes supplemented during winter), or, to human beings. Most of the nutrient ions are returned to the soil in the form of manure from livestock and man. The flow of nutrient ions forms, as indicated, an almost closed system with exception of the ions added by weathering and spates or removed by leaching and a very limited export of agricultural products.

Energy in the form of photosynthetically active radiation is required for the assimilation of nutrient ions and the production of plant tissues. A small fraction of the incoming energy will be stored in the vegetation and constitutes the source of free energy available to animals and man. In a number of steps, the free energy is used, i.e. the energy is degradated and converted into heat which is radiated to the universe. Thus, energetically, the system is in a steady state, depending only upon the solar source of free energy. For a discussion of energy, degradation of energy, free energy etc., see P. V. Christiansen et al. (1975).

The human behaviour concerned with modification of natural processes in the physical-biological system, - that is manipulating the above mentioned flows of matter and energy - in order to assure a sustained production of food and other necessities may be termed the ecological strategy.

In the exploitation system in question, the strategy consists of f.e. choosing certain plants, favour their growth, and regulating the amount and location of livestock in order to make optimal use of the plant production in meadow and heath. A very essential part of the strategy is in this case the use of livestock as »nutrient-ion pumps« which transfer the ions originating from the meadow to the field, the size of which is determined partly by the available amount of manure (i.e. the size of the meadow) and partly by the available work-power and technology.

Thus the traditional river-valley system has a very limited exchange of matter with the surroundings (a »matter-closed« system), and such systems are today found in agricultural areas of underdeveloped countries.

These matter-closed systems can be subjected to an ecological optimization, where the goal is to find the best possible relationship between production and input of human labour, given for example area-constraints. In our example, the optimization problem could be to determine the field acreage yielding the biggest possible production of food crops with a reasonable input of labour, this point is discussed later. In each case, realization of an optimal strategy will depend on an appropriate social organization.

Evolution in technology has made agriculture less dependent on local resources, and the present structure of the river-valley system is reflecting economic rather than ecological considerations. A possible version of the present river-valley system is shown in fig. 3. The system is highly »matter-open«; most of the manure is imported into the system as mineral fertilizers, leaching is much greater than before, and almost all products of the system are exported.

The flow of free energy from short-waved solar radiation is supplemented by the use of fossil energy either directly in agricultural machinery or indirectly in the production of mineral fertilizers, machinery, or other means of production. The use of mineral fertilizers can examplify an essential problem related to the increasing turnover of matter in the developing society (cf. Roos, op.cit.). A frequent implication of this is a transfer of ions from a high-concentrated occurence of minerals to one with low concentration of ions, for example through leaching to groundwater and to the sea. According to the second law of thermodynamics an essential amount of free energy will be needed for the recirculation, i.e. to close the circulation of matter. This energy for recirculation becomes a very important variable in the analysis of the most modern and highly matter-open systems when resources or waste-deposit possibilities are depleted.

A brief description of the ecological strategy in the mod-

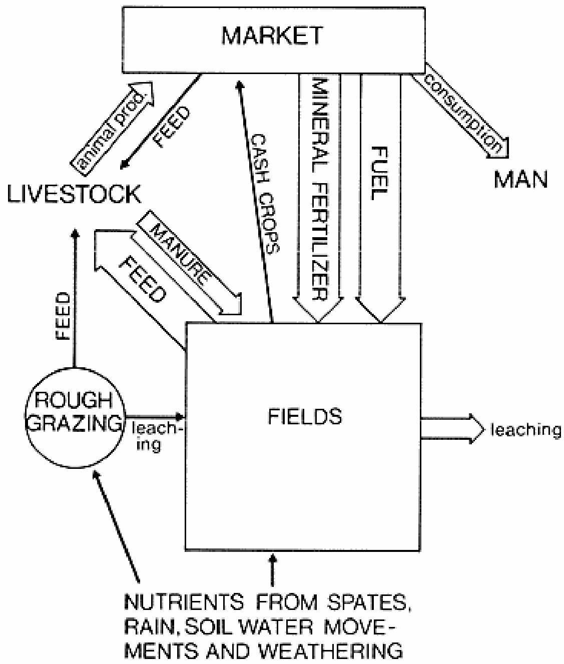


Fig. 3. The main circulation of matter in a modern agricultural system (cf. fig. 2). The plant production is now almost exclusively based on the fields and almost all matter circulates through the market (a matter-open system). Import of fuel and farm machinery constitutes an essential subsidy of free energy to the utilization system.

Fig. 3. Skitse over de væsentligste stofstrømme i et moderne landbrugssystem (sml. med fig. 2). Planteproduktion er nu næsten udelukkende baseret på ageren og stort set hele stofcirkulationen går via markedet (systemet er stof-åbent). Import af brændstof og maskiner betyder et væsentligt tilskud af fri energi til udnyttelsessystemet.

ern river-valley system is the following: The production-mix and production-level are optimized using notable amounts of free energy taken from limited resources outside the system; the optimizing is based primarily on economic criteria. In this way the structure of the agricultural system is not a result of the farmers' ecological optimizing. However, an ecological system-analysis can contribute greatly to the understanding of the system's dependence on local and global resources an of the long-term consequences of this dependence; an understanding of great importance for the planning of an optimal use of resources at national or global level. Many centrally planned and a few other societies (e.g. Norway, see NOU, 1974) do actually make use of such considerations in their general planning.

Through the presentation of the river-valley system, we have tried to point out subjects which can be analysed within the framework of ecological human geography. In the case of an environmentally limited system, the analysis may lead to an understanding of the adaptation of the exploitation system to the environmental conditions, given the level of technology. In order to describe the somewhat unquantifiable concept of adaptation a number of measures can be applied. Most important in this connection is perhaps the carrying-capacity under sustained yield conditions, and the »efficiency« understood as the ratio of actual productivity to potential productivity. A number of serious problems of definition concerning the terms mentioned shall not be discussed here, (cf. Sofus Christiansen, 1979).

Analyses of environmentally not strongly limited systems might lead to an understanding of ecological side effects and to an evaluation of efficiency in utilization of limited resources. This is certainly a principally more limited scope, but anyway of great practical importance to society.

THE SYSTEMIC APPROACH IN ECOLOGICAL HUMAN GEOGRAPHY

By using the word »utilization system« it is already indicated that a holistic, systemic approach will be suitable for problems in ecological human geography. Before we enter into a presentation of types of systems approaches, three essential points concerning our use of the system concept must be underlined. Firstly, the word »system« is used for a part of the universe, consisting of some elements and their mutual connections. The description of the system is not only a description of these elements and connections, it is very important too to focus attention upon the structural and functional totality.

Secondly, it must be stated that there is a significant difference between »systems approach« and »General System Theory« as defined by von Bertalanffy (1951). The latter is based on the idea that »... there exist general laws which apply to any system of a certain type, irrespective of the particular properties of the system or the elements involved«. Whether or not this is a correct and fertile point of view on some high level of abstraction is not to be discussed here. We exclusively intend to apply the far more pragmatic systemic approach as a methodology for dealing with the complex interactions of elements within a utilization system.

Thirdly, we concentrate our analysis on systems where elements can be quantified and connections can be expressed in a reasonable way by use of mathematical functions. It is possible to make a quantitative, functional analysis of these so-called »hard systems«, and the methods suitable for such analysis is the object of the following presentation.

Types of systems approach

On can roughly differentiate between system analyses where the final goal is either descriptive or analytic. The only purpose for the descriptive type is to provide a quantitative often diagrammic description of the system (elements, connection, transport of matter and energy etc.), while the aim of the analytic type is to provide a functional description of the system, which makes it possible to predict the evolution of the system and its reaction to external interventions and disturbances.

Analytical systems approaches often take the form of mathematical models. We shall not enter into details concerning the construction of that kind of models, only give a

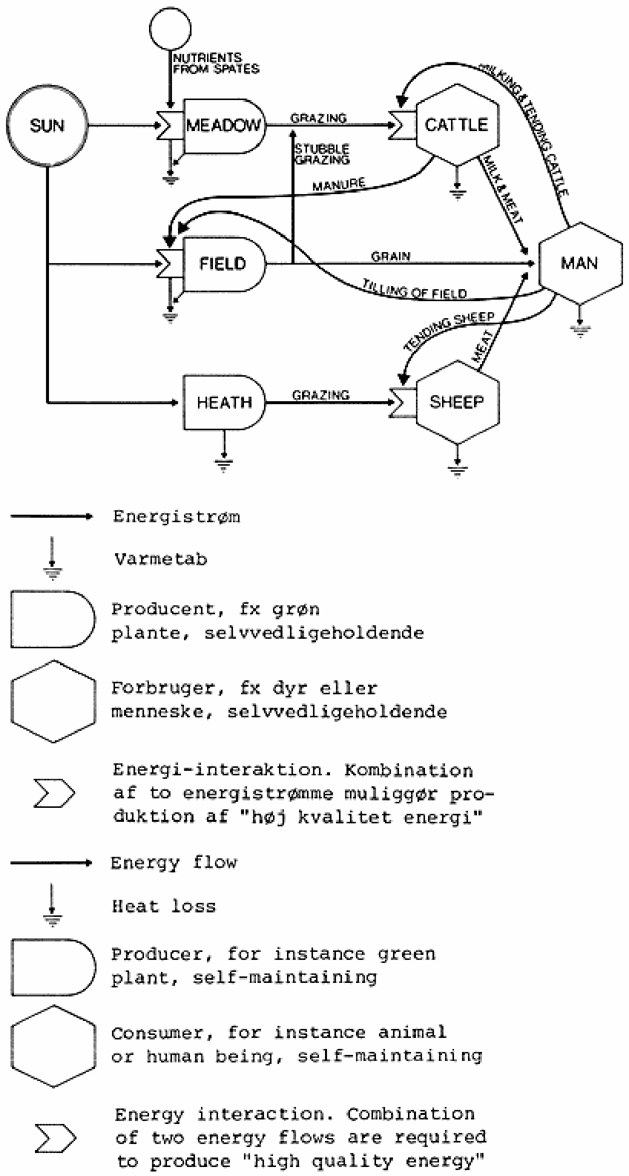


Fig. 4. Descriptive model of the traditional river-valley system in Odum's energy circuit language. Contrary to the normal praxis, flows and reservoirs are not quantified in this model. Some examples of symbols are shown; for a more detailed explanation of the symbols, see Odum and Odum (1976).

Fig. 4. Deskriptiv model af det traditionelle ådalssystem i Odum's energistrøms-sprog. Strømmene og reservoirerne er, i modsætning til hvad der oftest er tilfældet for denne type modeller, ikke kvantificerede. Nogle eksempler på symboler er angivet; for en mere udførlig beskrivelse af symbolernes betydning henvises til Odum og Odum (1976).

few essential characteristics. Mathematical models can be:

1. Dynamic or static. In dynamic models all variables are considered functions dependent on time, while static models mirror the system in a certain moment.
2. Normative or non-normative.Normative models, or optimization models, are used to identify the optimal functioning of the system in relation to a specified pre-con-

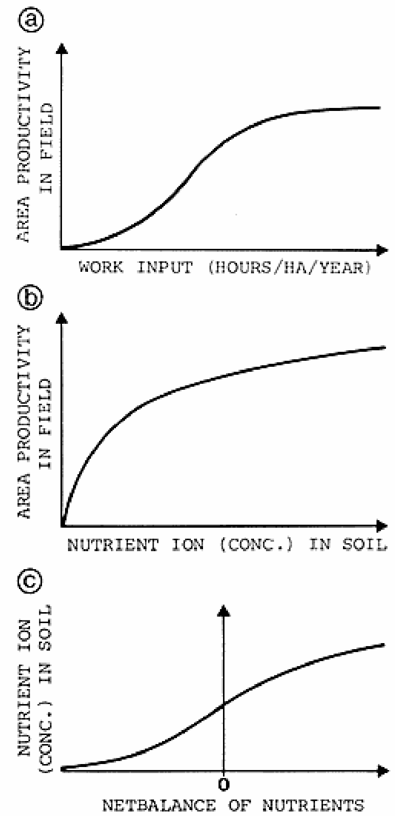


Fig. 5. Examples of possible functions describing the dependence of area productivity on work input (fig. 5a), area productivity on nutrient-ion concentration (fig. 5b) and nutrient-ion concentration on net balance of nutrients, defined as supply of nutrients from manure less removal of nutrients by cropping (fig. 5c).

Fig. 5. Eksempler på mulige funktionelle sammenhænge mellem arealproduktivitet og arbejdsindsats (fig. 5a), arealproduktivitet og næringsionkoncentration (fig. 5b) samt næringsion-koncentration og netto næringsionbalance, defineret som tilførslen af næringsioner ved gødning minus fraførsel ved afhøstning (fig. 5c).

dition. Non-normative models are used for analysing the actual functioning of a system regardless of it being optimal or sub-optimal.

To examplify the different types of systems approaches, we shall demonstrate how a descriptive, a static, normative and a dynamic, non-normative systems approach can be used in the analysis of the simplified river-valley system.

Descriptive models

Odum's energy-circuit diagrams provide an example of a descriptive systems approach which have been used as well in the study of natural ecosystems as of utilization systems (see f.e. Odum, 1971, Jansson, 1978, Bayliss-Smith, 1977). Energy reservoirs and flows of energy are described by means of symbols; some of them are shown in fig. 4, which is a model of the simplified river-valley system expressed in Odum's notation.

The main energy flows in fig. 4 are the heat losses and the flow from the sun to the vegetation and further on to animals and man. Not only pure energy flows but also flows of matter and information are included in the diagram. The energetic representation of essential flows of matter and of the human manipulation of the system is not very satisfying, especially when the numeric values of this representation are not based on very consistent considerations. This one-sided focussing on the energy aspect only is even more untenable when Odum is using his energy-circuit language on systems lacking really quantifiable energy flows, but a discussion hereof is without interest in this connection.

Descriptive systems approaches in general make only a limited contribution to analyses of utilization systems. They provide a comprehensive view of the system which can be very useful when formulating problems, but they rarely contribute to a deeper understanding of functional relations and thereby of how changes in human manipulations of flows of matter and energy will influence the system.

Ecological optimization models

In order to evaluate a certain ecological strategy in relation to a utilization system it is necessary to know which management of the system will be optimal for a given set of environmental and technological constraints. Such an optimal structuring of the system can be determined by help of ecological optimization models, static or dynamic, dependent on the problem in question.

Static models are the easiest to handle, and we shall here present a very simple example of a static model applied on the river-valley system. Let us presume that we wish to find the field-acreage that gives maximal production for a fixed amount of human work, assuming that the meadow acreage and thereby the amount of livestock and manure are constant. In other words, we are assuming a fixed boundary between field and meadow and a flexible one between fields and heathland, an assumption close to the actual conditions in the traditional river-valley system (Jensen & Jensen, 1979).

In order to find a solution to this problem, one must know the functional relations between productivity, nutrient-ion concentration, nutrient-ion supply, and work input. Examples of such relations are shown in fig. 5a, b and c.

If the relations are quantified, it is possible to calculate the optimal field size. The mathematical formulation and the implementation of the model by use of a digital computer will not be treated here, but it can be done without serious difficulties (see f.e. Rasmussen, 1979). The expected result of the implementation for the described system will be a relationship between total production and the field acreage as sketched in fig. 6.

Being normative, ecological optimization models are appropriate tools when analysing two different aspects concerning utilization systems: they can be used for testing hypotheses concerning ecological optimality of an existing sys-

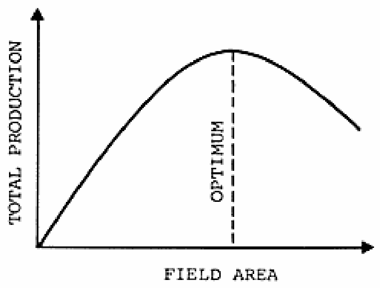


Fig. 6. Expected dependence of total production on field areas, resulting from the ecological optimization analysis.
Fig. 6. Principskitse af den sammenhæng mellem agerareal og total produktion, som vil være resultatet af den økologiske optimeringsanalyse.

tem and they can be used when planning a rational management of the ecological functioning of utilization systems.

Simulation Models

Simulation models are used to demonstrate the evolution of a system over time and the relation between this evolution and the system structure. The final goal for the simulation modelbuilder is to create a system structure which can simulate known or hypothesized time series for one or more of the central system variables. If the model succeeds in predicting these time series reasonably well, it is supposed to be a good representation of the actual structure of the real system.

Forrester (1968) has developed a special, diagrammatic representaion of systems - called System Dynamics, and a related programming language, DYNAMO, which is a very handy tool when constructing simulation models of systems in general, and it is therefore not surprising that it has been used on utilization systems at several occasions (see e.g. Picardi, 1974, and Shantzis, 1973). In System Dynamics, diagrams are constructed by help of a set of standard symbols, of which some are presented in fig. 8. A more detailed treatment of System Dynamics is given in Forrester (1968), Goodman (1974), and Petersen (1975).

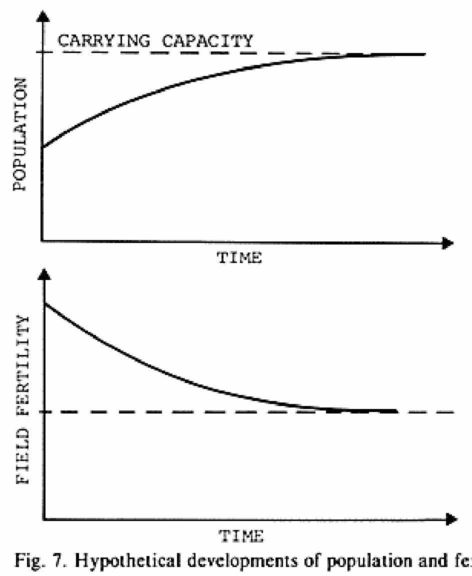


Fig. 7. Hypothetical developments of population and fertility of fields in the traditional river-valley system. These developments constitute the »reference modes« of the S.D.-model.
Fig. 7. Hypotetisk udvikling for befolkning og for agerens fertilitet i det traditionelle ådalsystem. Disse udviklinger udgør S.D.-modellens »reference modes«.

In order to demonstrate the use of a System Dynamics model for studying the dynamics of a utilization system, we shall again use the river-valley system.

The problem in question concerns the development of population size and of fertility of the cropland from an initial situation with a small population and a relatively high fertility towards a situation where the population has reached the carrying capacity and the fertility is stabilized at some lower level.

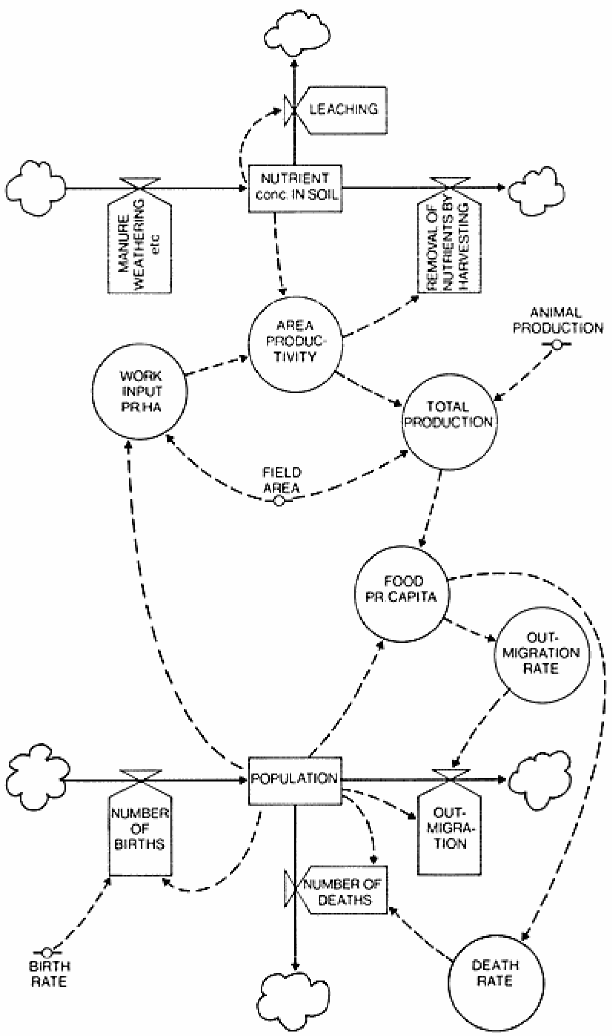
The growth rate of the population is assumed to be governed by a death rate and an outmigration rate influenced by the amount of food available per capita. The fertility of the cropland is determined by the relative magnitude of ion-flows. The amount removed by harvesting is determined by the productivity and thus by the work-input. Hypothetical time-series of fertility of cropland and of population size are shown in fig. 7. In S.D.-terminology these are termed reference modes. Fig. 8 shows the S.D.-diagram of those elements and connections which are supposed to be essential for simulating the development of the system.

A S.D.-diagram can directly be translated into a set of difference equations which make it possible to calculate the value of a system variable at a given point in time knowing the value a time-step earlier. The dashed lines in the diagram indicate impacts, given as functional relations, f.e. the intensity of outmigrations could be a function of the available food per capita as indicated in fig. 9.

In this extremely simplified example, all influences from one variable on another are taken as instantaneous. This is of course not realistic and delays in for example the influence of food shortage on out-migration or death rates will lead to less regular system behaviour, characterized by overshots or oscillations. Such delays are easy to include in the model.

A few among several problems connected with the use of simulation models in general and S.D.-models in particular should be mentioned. The necessary data basis for constructing and testing a S.D.-model is comprehensive and rarely available, a fact that demands a great number of estimates and fittings both in connection with numerical values of variables and with the functional relationships in the model. Thus it is often difficult to find test data, since all available data have been used when constructing the model. The difficulties increase when the system variables are not directly suitable for quantitative measurement.

Another important problem is that even when a model is able to simulate the development of one ore more variables



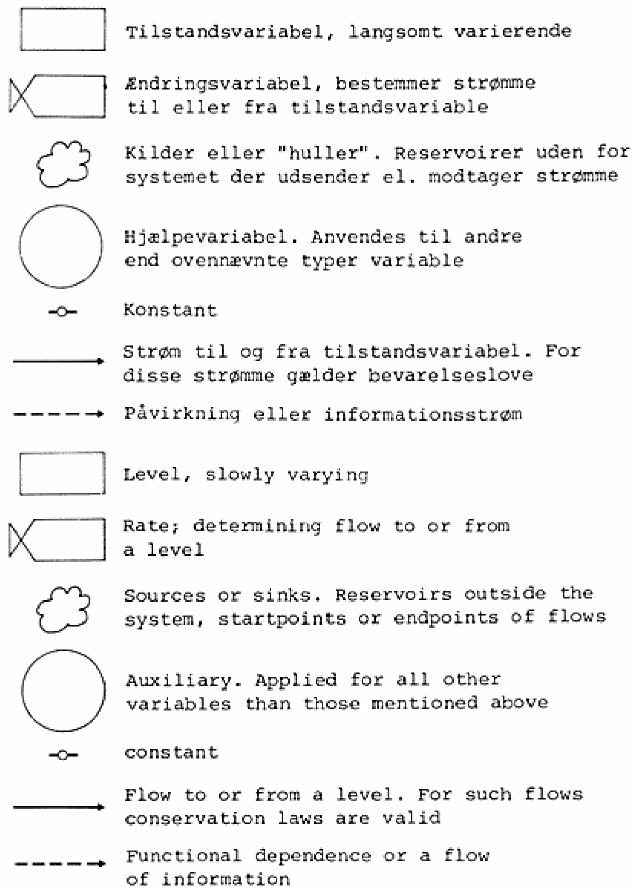


Fig. 8. System Dynamics diagram of the traditional river-valley system. Some examples of S.D.-symbols are shown.
Fig. 8. System Dynamics diagram af det traditionelle ådalssystem med eksempler på S.D.-symboler.

over time, it does not prove that the model is a good representation of the real world system.

Evaluation of systemic approaches

Quantitative system analyses, and especially mathematical models have some advantages compared with traditional methods of studying utilization systems. First of all the mere formulation of a model can forward the understanding of the logical structure of the system for the scientist and for the reader as well. In many cases systems with a complex structure and many interdependent elements can only be viewed generally and analysed quantitatively in a satisfactory way when using mathematical models. Lack of essential empirical data often makes the quantitative predictions of the model generally unreliable, but the very process of building a model of a system will often give strong indications of what sort of emperical data is necessary and thus serve as a valuable guidance for empirical work. The use of the terminology of the system's approach and of mathematical model formulations when studying utilization systems certainly involves a number of risks. Firstly, the mere use of the extensive vocabulary of systems analysis, often serves as a way to make common-sense statements sound more impressive. Secondly, the re-formulation of thoughts in mathematical language may force a simplification beyond what is reasonable,

Fig. 9. Table function showing the hypothetical functional dependence of rate of outmigration on the available amount of food per capita.
Fig. 9. En tabelfunktion visende den hypotetiske sammenhæng mellem den til rådighed værende føde pr. person og hyppigheden af udvandringer.

or lead to mathematical formulations so complex that the substance of the problem is effectively disguised.

Thirdly, the voluntaristic properties of the human management of utilization systems are difficult to incorporate into mathematical descriptions, which often tend to assume the presence of automatic self-regulating mechanisms. Thus the mathematical formulation sometimes implies a reductionistic, or even marginally authoritarian tendency. However, when aware of these risks, it is believed that a lot may be gained from future use of these tools in ecological human geography.

CONCLUDING REMARKS

This short presentation of an outline of an ecological human geography, its objects, concepts, and important analytical tools, is intended to illustrate that an ecological approach need not imply the direct use of biological analogues, or lead to environmental determinism. On the contrary, it may incorporate a treatment of the technology-dependent, complex interaction between socio-economic and physical-biological systems through the material production. Furthermore, it is not limited to studies of exotic, far-off, isolated systems, but may contribute substantially to quantitative analyses of environmental limitations and side effects in connection with the operation of production systems on a high technological level. Our own examplification of different types of systems approaches might contribute to the impression that subsistence systems are the only field where the ecological approach is fertile in human geography. As mentioned, we do not believe this although it might seem so when judged from the small examples we are forced to use in this presentation.

To sum up, under a wide range of conditions an ecological approach can advantageously be applied for analysing the material production, especially when long-term considerations of the necessity of a sustained basis of production are prefered compared to short-term economic considerations.

RESUME

Den økologiske kulturgeografi beskæftiger sig med udnyttelsessystemer, dvs. de dele af et socio-økonomisk og fysisk-biologisk system, som via den materielle produktion har en stærk vekselvirkning (fig. 1). Den er således en materialistisk videnskab, idet den fokuserer på menneskeformidlede stof- og energistrømme, samt på hvorledes manipulationen med disse vil indvirke på systemet. Forklaringsapparatet hører hjemme på grænsen mellem natur- og samfundsvidenskaberne. Såvel økologiske som økonomiske aspekter bør inddrages i en konkret kulturgeografisk analyse; med hvilken indbyrdes vægt, de kommer til at indgå, vil afhænge af det konkrete udnyttelsessystem (dets teknologiske udviklingsstade, dets udveksling med omgivelserne etc.). Det økologiske aspekt af analysen vil bidrage væsentligt til forståelsen af, hvorledes man kan forvalte stof- og energistrømmene på optimal måde, og derfor være relevant såvel i analysen af tilnærmelsesvis lukkede produktionssystemer, som vi finder i de mange u-lande i dag, som i analysen af ressource- og forureningsproblemer i teknologisk højt udviklede samfund. En række centrale økologiske begreber kan finde anvendelse i økologisk kulturgeografi. I relation til henholdsvis et traditionelt, lukket landbrugssystem (overvejende subsistens) som man fx kan finde i de jyske ådale omkring 1800, og et åbent, moderne landbrugssystem, demonstreres anvendelsen af termerne energi og fri energi, stofåbne/lukkede systemer, økologisk strategi, økologisk optimering, adaption, bæreevne og effektivitet.

Systembetragtninger er et vigtigt hjælpemiddel i den økologisk kulturgeografiske analyse. Man kan groft skelne mellem deskriptive og analytiske systemiske angrebsvinkler; deres fælles styrke er, at de kan skabe overblik over systemets strukturelle og funktionelle helhed. Det lukkede, jyske ådalssystem bruges i illustrationen af forskellige typer systembetragtninger. Odums energistrøm-sprog (fig. 4) anvendes i et eksempel på en deskriptiv model, hvor udbyttet primært er overblik over systemets struktur. Analytiske angrebsvinkler er demonstreret dels med en model som fokuserer på optimering af arealanvendelsen (fig. 5 og 6), og som bl.a. åbner mulighed for at vurdere systemets effektivitet, og dels med en System Dynamics-model (fig. 8), som fokuserer på udviklingstendenser.

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or lead to mathematical formulations so complex that the substance of the problem is effectively disguised.

Thirdly, the voluntaristic properties of the human management of utilization systems are difficult to incorporate into mathematical descriptions, which often tend to assume the presence of automatic self-regulating mechanisms. Thus the mathematical formulation sometimes implies a reductionistic, or even marginally authoritarian tendency. However, when aware of these risks, it is believed that a lot may be gained from future use of these tools in ecological human geography.

CONCLUDING REMARKS

This short presentation of an outline of an ecological human geography, its objects, concepts, and important analytical tools, is intended to illustrate that an ecological approach need not imply the direct use of biological analogues, or lead to environmental determinism. On the contrary, it may incorporate a treatment of the technology-dependent, complex interaction between socio-economic and physical-biological systems through the material production. Furthermore, it is not limited to studies of exotic, far-off, isolated systems, but may contribute substantially to quantitative analyses of environmental limitations and side effects in connection with the operation of production systems on a high technological level. Our own examplification of different types of systems approaches might contribute to the impression that subsistence systems are the only field where the ecological approach is fertile in human geography. As mentioned, we do not believe this although it might seem so when judged from the small examples we are forced to use in this presentation.

To sum up, under a wide range of conditions an ecological approach can advantageously be applied for analysing the material production, especially when long-term considerations of the necessity of a sustained basis of production are prefered compared to short-term economic considerations.

RESUME

Den økologiske kulturgeografi beskæftiger sig med udnyttelsessystemer, dvs. de dele af et socio-økonomisk og fysisk-biologisk system, som via den materielle produktion har en stærk vekselvirkning (fig. 1). Den er således en materialistisk videnskab, idet den fokuserer på menneskeformidlede stof- og energistrømme, samt på hvorledes manipulationen med disse vil indvirke på systemet. Forklaringsapparatet hører hjemme på grænsen mellem natur- og samfundsvidenskaberne. Såvel økologiske som økonomiske aspekter bør inddrages i en konkret kulturgeografisk analyse; med hvilken indbyrdes vægt, de kommer til at indgå, vil afhænge af det konkrete udnyttelsessystem (dets teknologiske udviklingsstade, dets udveksling med omgivelserne etc.). Det økologiske aspekt af analysen vil bidrage væsentligt til forståelsen af, hvorledes man kan forvalte stof- og energistrømmene på optimal måde, og derfor være relevant såvel i analysen af tilnærmelsesvis lukkede produktionssystemer, som vi finder i de mange u-lande i dag, som i analysen af ressource- og forureningsproblemer i teknologisk højt udviklede samfund. En række centrale økologiske begreber kan finde anvendelse i økologisk kulturgeografi. I relation til henholdsvis et traditionelt, lukket landbrugssystem (overvejende subsistens) som man fx kan finde i de jyske ådale omkring 1800, og et åbent, moderne landbrugssystem, demonstreres anvendelsen af termerne energi og fri energi, stofåbne/lukkede systemer, økologisk strategi, økologisk optimering, adaption, bæreevne og effektivitet.

Systembetragtninger er et vigtigt hjælpemiddel i den økologisk kulturgeografiske analyse. Man kan groft skelne mellem deskriptive og analytiske systemiske angrebsvinkler; deres fælles styrke er, at de kan skabe overblik over systemets strukturelle og funktionelle helhed. Det lukkede, jyske ådalssystem bruges i illustrationen af forskellige typer systembetragtninger. Odums energistrøm-sprog (fig. 4) anvendes i et eksempel på en deskriptiv model, hvor udbyttet primært er overblik over systemets struktur. Analytiske angrebsvinkler er demonstreret dels med en model som fokuserer på optimering af arealanvendelsen (fig. 5 og 6), og som bl.a. åbner mulighed for at vurdere systemets effektivitet, og dels med en System Dynamics-model (fig. 8), som fokuserer på udviklingstendenser.

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