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Human ecology and its applications

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Abstract

The term human ecology was first used in 1921 by sociologists at the Chicago School of Sociology. During the 20th century definitions and interpretations of human ecology have varied considerably, not only between the natural and human sciences, but also among academic disciplines in the social sciences including anthropology, geography, psychology and sociology. This paper presents some key concepts and principles that stem from a wide range of contributions. Then it shows how ecological concepts could be used to interpret human settlements.

Keywords: Human ecology; Social sciences; Natural sciences; Human settlements

1. Introduction

Ecology derives from the ancient Greek words "*oikos*" and "*logos*" and means "science of the habitat". It is generally agreed that this term was first used in 1866 by Ernst Haeckel (1834–1919) a German zoologist (Haeckel, 1866). Ecology designates a science that deals with the interrelationships between organisms and their surroundings. Since the late 19th century the term ecology has been interpreted in numerous ways. In the natural sciences, for example, botanists and zoologists often use the term general ecology to refer to the interrelations between animals, plants and their immediate surroundings.

Animal and plant ecologists maintain that the interaction between organisms and all the components of ecosystems follow principles that refer to their similarities and their differences (Begon et al., 1996). A community develops from simple to more complex forms through a sequence of developmental stages known as succession. Successive stages in this sequence are marked by the invasion of a new species, or the association of species, and the series culminates in a climax stage in which a dominant species appears. The dominant species is related to the environment in such a way that it is able to control and maintain the community indefinitely. By using an analogy, some contributions imply that human groups and communities are phenomena that developed according to biotic factors and processes.

In contrast to general ecology, human ecology generally refers to the study of the dynamic interrelationships between human populations and the physical, biotic, cultural and social characteristics of their environment and the biosphere (Lawrence, 2001). However, this is not the original meaning of this term which was first used in 1921 by Robert Park and Ernest Burgess. They defined human ecology as the study of the spatial and temporal organisation and relations of human beings with respect to the "selective, distributive and accommodative forces of the environment" (Park et al., 1925). This seminal contribution led to

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numerous studies of the spatial distribution of human populations especially in urban areas (Hawley, 1950; Sargent, 1983; Young, 1983). In addition, the application of concepts borrowed from plant and animal ecology for the study of human communities implied that human ecology was interpreted as the study of those biotic factors that influence the social organisation and spatial distribution of human groups and communities.

2. What is human ecology?

Human ecology is a term that has been and still is characterised by a lack of consensus about what it means. According to Bruhn (1974, p. 105) human ecology "has been proposed as a science, a separate discipline, a philosophy, a point of view, and an approach for studying a given problem". Bruhn has presented an overview of the applications of human ecology in disciplines including anthropology, geography, psychology and sociology. He argues that social scientists in these disciplines have frequently used a biological analogy by treating human habitats as metabolisms. This analogy means that these habitats are studied in terms of their abiotic and biological components as well as flows of energy and materials. Unfortunately, anthropological dimensions including human customs, knowledge and values, as well as communication and information, are usually not considered. Therefore, most of these contributions do not provide a framework that includes contributions from both the social and natural sciences.

2.1. Concepts and principles of a human ecology perspective

One basic principle of biological life is that all living organisms (irrespective of their species) impact on their surroundings. The interrelations between organisms and their surroundings influence the volume and quality of the available local resources, the discharge of waste products and the creation of new resources. In addition, organisms are components of ecological systems and, therefore, they influence the living conditions of other species. This systemic interpretation of people–environment relations is shown in Fig. 1. It was published in Lawrence (2001) in order to show the reciprocal relations between components of the social and natural sciences.

There are certain conditions and limits overriding the sustenance of human groups and societies that are defined by some fundamental principles (Boyden, 1992). First, the biosphere and the Earth are finite. Both natural and human ecosystems at all scales of the planet and its atmosphere are circumscribed by certain immutable limits, such as the surface of land, its bio-mass and bio-diversity, the water cycle, bio-chemical cycles and thermodynamic principles about the production and transformation of energy, including the accumulation and radiation of heat from the Earth. Although these principles are fundamental, their relative importance has been interpreted in various, sometimes contradictory ways even by scientists in the same discipline. They highlight the diversity and limitations of current knowledge which has not been well co-ordinated.

Second, human ecosystems are *not* closed, finite systems because they are open to external influences of an ecological kind (e.g. solar energy, water cycles) of a biological kind as well as an anthropological kind (e.g. disease and warfare) (Commoner, 1972). Unfortunately, recent contributions on this subject include misconceptions about the autonomy of human settlements and the ability of modern technology to overcome ecological constraints. These claims are hard to justify given that sedentary populations have been highly dependent on all kinds of imported goods from the hinterlands (Boyden, 1987).

Third, humans must create and transform energy by using materials, energy and acquired knowledge to ensure their livelihood (Odum, 1983). The increasing disparity between ecological and biological processes and products can be related to the rapid growth of urban populations, the creation of many synthetic products that cannot be recycled into natural processes, plus increases in energy consumption based on the use of non-renewable and renewable resources at a greater rate than their replacement (Hardin, 1993). The negative consequences of these trends include the depletion of the ozone layer, a reduction in bio-diversity, the accumulation of wastes, the "green house effect" and the incidence of environmental catastrophes including floods, landslides and famine.

Fourth, human beings can be distinguished from other biological organisms by the kinds of *regulators*

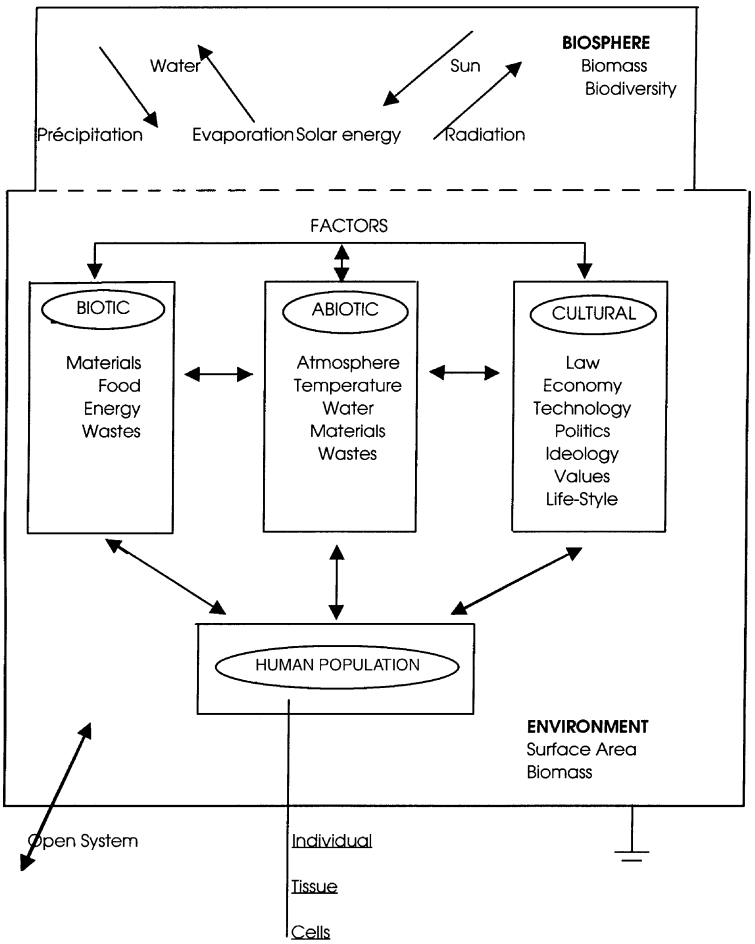

Fig. 1. The holistic framework of a human ecology perspective showing the interelations between biotic factors (genetic biospace), abiotic factors (ecospace) and cultural, social and individual human factors and artefacts.

they commonly use to define, modify and control their living conditions (Lawrence, 2001). Humans have several mechanisms that enable them to adjust to specific environmental conditions. These mechanisms include thermo-regulation and circadian rhythms, which are used to ensure and maintain vital needs, such as nutrition. This fundamental need is not only guaranteed by biological and physiological mechanisms, because cultural rules and practices (that vary between ethnic groups, across cultures and within societies) are also used. Adaptation is a set of interrelated processes that sustain human ecosystems in the context of a continual change. The outcome of adaptation depends on a complex set of biological, ecological, cultural, societal and individual human mechanisms (Laughlin and Brady, 1978). Cultural and social regulatory mechanisms are transmitted by the tacit know-how of populations, including social rules and customs that are shared and respected in order to ensure sustenance. For example, the construction of cities is meant to guarantee the long-term production of resources, provide secure living conditions and enable the reproduction of society. On the one hand, human groups may relocate or adapt their settlements in order to survive local environmental perturbations. The construction of dykes in The Netherlands is one example of this kind. On the other hand, since the earliest foundations of cities, human groups and societies have primarily adapted to their

environmental surroundings by modifying some constituents of their culture rather than by genetic adaptations.

The following set of principles are part of a human ecology perspective that explicitly accounts for cultural, societal and individual human factors.

The interrelations between humans and their surroundings are manifested through a wide range of physiological, psychological and cultural processes. Such processes include not only sensations and perceptions (which animals also share) but also beliefs, doctrines, ideas, and values, which are unique characteristics of the human intellect (Hardesty, 1977). In principle, the interrelations between people and the environment are not just spatial but also biological and cultural. Moreover, these interrelations are not static but subject to change over relatively short and long time periods.

Second, unlike other biological organisms, the interrelations between people and their surroundings are characterised by discursive and reflexive knowledge, including symbols and not just linguistic representations. This characteristic distinguishes anthropoid from human behaviour (Boyden, 1987).

Third, the "human environment" can be contrasted with the environment of other biological organisms by the instrumental functions and by the symbolic values that have been attributed to it. Human processes and products transform the constituents of the environment to meet prescribed aspirations, goals, and needs (Boyden, 1992). In addition, human activities can provoke unintended consequences on abiotic and biological constituents of ecosystems and in return, have an impact on human health and well-being. This is one reason why studies of the interrelations among the biological, ecological and cultural characteristics of human settlements are crucial if an integrated perspective is to be effectively applied.

3. Disciplinary applications of human ecology

Human ecology can be considered with respect to studies of people–environment relations which have a history in several scientific disciplines and professions including archaeology, anthropology, biology, demography, epidemiology, general ecology, geography, law, medicine, political science, psychology and sociology (Bruhn, 1974; Young, 1983; Steiner and Nauser, 1993).

Overviews of many contributions show that the majority of interpretations of people–environment relations, in general, and human ecology in particular, in several disciplines rarely adopt an integrated framework that includes the contributions from both the social and natural sciences (Lawrence, 2001). These interpretations reflect and reinforce long-standing customs of compartmentalised knowledge in these disciplines. These contributions usually separate people from their immediate environment or consider the environment as if it is unaffected by human activities. In general, the environment has been considered as a determinant of human behaviour by those social scientists who adopt causal explanations borrowed from the natural sciences.

Although this kind of interpretation is acceptable for many biologists, ethnologists and social scientists it is noteworthy that some natural scientists challenge this mechanistic approach to people–environment relations. Some authors, including Boyden (1992) argue that an organism should not be considered to be passive and subjected to impacts from the environment. Instead, an organism can be interpreted as an active agent that has a reciprocal relationship with other organisms and all the constituents of the environment. This mutual interaction enables the organism to be an active partner in co-evolutionary processes.

4. Interpreting human settlements using a human ecology perspective

Human settlements have been constructed by all sedentary societies, over several millenniums, in each continent of the world, in order to provide secure living conditions and guarantee sustenance (Lawrence, 2000). Human settlement processes impact on and are influenced by the natural cycles of the biosphere. They are dependent on the availability of natural resources and the exportation of waste products in order to sustain their populations. Human populations import energy, fuels, materials and water which are transformed into goods and services. The high concentrations of activities, objects and people in cities, and the flows between rural and urban areas,

mean that human settlements are major contributors to national economies and to environmental change at local, regional and global scales (Bairoch, 1988). They can also be a platform for social differentiation, segregation and exclusion. They may facilitate the communication of infections disease and social disorders, including criminality and violence which may contribute to stress and mental illness (McMichael, 1993). In addition, settlements of different size provide varying numbers and kinds of community services including education, health care, leisure and welfare services.

Human settlements, and all their ecological processes and products, do not conform to administrative, geographical or political boundaries. Towns and cities are open to external influences of an ecological kind (e.g. transboundary pollution of diverse kinds) of a biological kind, and also an anthropological kind (e.g. migration flows). The interrelations between human groups, their habitat and the global environment are complex and difficult to understand. However, it should be remembered that 100 years ago not less than 80% of the total population of the world lived in rural areas. Today about a half of the world's population live in cities and towns. During the 20th century cities have grown in number, in population size and in total surface area on a scale previously unknown. In 1840, London was the first city in the world to accommodate one million residents. Today, 240 cities have more than one million residents and 32 cities have more than 5 million residents. Some have suggested that these outcomes are the result of "the urban revolution" (Bairoch, 1988).

This paper argues that common interpretations of human settlements need to be reconsidered in order to make architecture, urban planning and policy decision-making more sensitive to environmental, economic and other social characteristics of human settlements that are intimately related to the living conditions not only within cities but also the whole biosphere. The following section of this paper presents some basic principles that social and natural scientists, architects and urban planners can apply at the beginning of the 21st century in order to improve living conditions then sustain human settlement for current and future generations. As this will not be an exhaustive list of principles, they should be considered as exemplars that can be complemented by others.

4.1. Compact human settlements

The first set of principle concerns "compactness" and the energy efficiency of buildings, services and infrastructure. The historic centres of many European cities are good examples of the compact city that can be contrasted with suburban development during the last century. The concentration of activities, the built environment and the resident population has many ecological and economic advantages compared with a more dispersed form of human settlement (Lawrence, 2000). In essence, a compact form of human settlement uses less arable land, which is a precious non-renewable resource for the sustenance of all ecosystems. In addition, the compact human settlement has a lower unit cost for most kinds of infrastructure such as roads, drainage, piped water and sanitation.

During the 1990s a systematic way of comparing the benefits and costs of different kinds of human settlements was published. Known as the ecological footprint it is an analytical tool that can be used to calculate the resource consumption and waste assimilation requirements of a specific human population (e.g. a compact or a dispersed city) in terms of a corresponding fertile land area (Wackernagel and Rees, 1996). In any human settlement the production and use of goods and services depends on various types of ecological productivity. These ecological productions can be converted to land-area equivalents. The total land requirement for all significant categories of consumption and wastes related to food, housing, transportation, consumer goods and services equals the estimated ecological footprint for a specified population. For example, Wackernagel and Rees (1996) calculate that the residents of the Lower Frazer Valley Region in British Columbia, Canada, use the productivity of a land area 19 times greater than their region in order to satisfy their consumption of food, forest, consumer products and fossil fuels.

4.2. Building adaptability for reuse

The second set of principles deals with the inherent adaptability of the existing building stock so that old buildings can be reused to accommodate the needs of contemporary daily life. This is not a new principle but it is too easily forgotten by architects, town

planners and public officials who want to demolish rather than renovate existing buildings. The mistakes that were made in many European cities in the 1950s, 1960s and 1970s should not be forgotten. The vernacular buildings in all regions of the world were rarely made redundant as quickly as many architect designed buildings constructed during the 20th century. The inherent adaptability of many traditional buildings could serve as a fine example at the beginning of the 21st century.

It is extremely difficult to adapt existing buildings, neighbourhoods and transport systems that were constructed during a period of relatively low cost fossil fuels and steady economic growth during the last half of the 20th century. There is a need to consider how it could be possible to meet the recent goals of the European Commission to lower uses of non-renewable resources, lower greenhouse gas emissions and lower solid waste disposal. This shift will require creativity and imagination by professionals in order to renovate and reuse individual buildings as well as plan for sensitive in-fill projects on urban and suburban sites.

4.3. Patterns and exemplars from history

It is possible and necessary to identify principles of good practice from historical examples of building construction and the layout of human settlements (Boyden et al., 1981). Many European cities have already accommodated a wide range of ethnic, cultural and political regimes over thousands of years. Sustaining human settlement means ensuring the maintenance of those buildings and facilities that make a city a pleasant and safe place to live in. It involves guarantees to protect the magnificent natural and built landscape which is a combination of unique aesthetic, cultural and ecological characteristics. There is much to be learnt from good examples of vernacular buildings and the layout of historic towns. This knowledge can be used for diverse purposes such as the promotion of “ecological technology” that can reintroduce natural energy flows and local materials back into building construction.

At the beginning of the 21st century there is still insufficient professional knowledge that can help to explain why it is important to conserve and protect natural and cultural resources. Such knowledge is still rarely translated into professional practice. For example, building design and construction together with the layout of traditional towns, should explicitly account for:

- water cycles that collect and reuse rain water and grey water in buildings and adjoining open spaces;
- natural ventilation in contrast to mechanical systems of air-conditioning for all kinds of buildings;
- reusable materials, such as wood clay brick, should be used instead of non-biodegradable synthetic products in new building construction and renovation projects.

Innovative approaches of this kind not only help promote the local environment and protect the cultural heritage of human settlements. In addition they could be a catalyst for a new kind of tourism and economic investments at the local level.

4.4. Interrelated scales form a web

The interrelations between different geographical scales of all architectural and urban/rural projects from the scale of the room and building to the block and the neighbourhood to the city or town, the regional, national and global levels need careful consideration (Boyden et al., 1981). For example, energy consumption and our dependence on fossil fuels is closely linked to the way we construct our buildings, layout our cities and towns, and service them by infrastructure and transportation systems. In turn these characteristics of human settlements impact on the quality of air in the local environment, ambient noise levels, and the local climate. They also contribute to green house gas emissions and the depletion of the ozone layer at the global level.

During recent decades, academics, policy decision-makers and city planners have ignored the interrelations between the characteristics of human settlements. They have also ignored complexity, especially the web of economic, ecological, health and other social characteristics of precise localities. For example, in the 1950s, urban planners and traffic engineers developed programmes and projects for public transportation that often gave a higher priority to private vehicles than to diverse kinds of public traffic circulation (Kenworthy, 2000). In some cities, extensive networks of tramways were removed. At the same time, vast urban development projects based largely

on spatial and functional segregation by zoning land uses were planned. These included hectares of roads and parking allotments for commuters who were compelled to travel between neighbourhoods that accommodated specified and segregated urban activities. These programmes and projects not only changed the biological, ecological and human components of urban environments because they have also been self-defeating in some respects (Kenworthy, 2000). For example, despite the large increase in the volume of roads, traffic congestion is a daily dilemma experienced by many commuters around the world. The impact of traffic accidents are more extensive than injury, death, or damage to property. Moreover, a heavy dependence on cars with fossil fuel consumption has contributed to high levels of air and noise pollution which have both short- and long-term consequences on the health of citizens and the sustainability of urban ecosystems. Finally, zoning and mono-functional uses do not serve the capacity of a city to accommodate change easily; when applied at a large scale they generate constraints for future generations.

4.5. Bio-diversity and urban agriculture

Bio-diversity in human settlements can serve numerous purposes. For example, extensive tree planting can act as wind breaks, create a cooler micro-climate, absorb some atmospheric pollutants and surface water after heavy rains. Recycled water can also be used for plants. An integrated approach to bio-diversity and land use would most likely include specific areas of land for local food production and consumption (Boyden et al., 1981). Sustainable resource use and health can be promoted by policies that encourage the local production of fresh foods. This approach can also promote food security and sustain local populations, as is the case for some fruits and vegetables grown on the outskirts of many market towns.

Food security means that all people continually have physical and economic access to enough food for an active, healthy life. It implies that food production and consumption are sustainable, governed by principles of equity and that "the food is nutritionally adequate and personally and culturally acceptable; and that food is obtained (and consumed) in a matter that upholds basic human dignity" (Pederson et al., 2000, p. 231). Generally, low technology is used and the harvested food is consumed locally. This custom should be contrasted with intensive farming geared to the mass production of packaged foods that are harvested, and then transported long distances before their purchase by consumers in supermarkets. Today, the large majority of urban populations in the world are totally dependent on imported foods from far beyond the hinterlands of their city.

4.6. Cultural and social diversity

Another set of principles stresses that professionals should not forget the social and cultural diversity of human settlements. Today, policy decision makers, social scientists and design professionals need to use a range of complementary methods for the collection of information and data in order to improve their understanding of the cultural and social determinants of housing projects and other kinds of development. The cultural values and the social and ethnic diversity of populations should be understood by using both qualitative and quantitative analytical methods, as well as participatory approaches (Feldman and Westphal, 2000).

One reason why human perceptions, goals and values have not been adequately addressed by architects and urban planners is that they are often considered too difficult to measure. This claim can be challenged. Although time frames for change and developments in new social values, relationships, services and products appear to emerge unforeseen, research shows that they often evolve over a number of years. This can be illustrated by ongoing changes in household structure and size during this century. These changes are related to numerous factors including higher divorce rates, more mothers working in the labour market, adolescents leaving home, postponed childbearing and lower birth rates. Today, households with male–female couples and two or three children form a minority of all households in western European countries. These changes show that households are becoming more multidimensional owing to an increasing blend of ages and genetic relationships. This trend has placed an unforeseen demand on the housing stock which is required to be more flexible to provide appropriate accommodation for a growing variety of households. Unfortunately, in many western countries, most post-war housing and urban policies have produced residential

neighbourhoods that are incompatible with current demands because they were meant for nuclear families. These families were considered to be the norm with a lifestyle based on average income, expenditure and mobility.

This example shows that there is an urgent need for studies of social values and lifestyles related to the components of human settlements that will enable policy makers and professionals to predict and plan for social change. With this kind of understanding a new, innovative interpretation of the qualities of the built environment could be formulated.

4.7. Participatory approaches

Participatory approaches for decision-making about housing, urban planning, environmental conservation policies and public health have been increasingly advocated by international conferences and organisations during the 1990s. They have been applied at the local level by municipal governments and non-governmental organisations (NGOs) on the understanding that complex issues should not be interpreted in democratic societies by one set of criteria or values. In 1992, this trend was endorsed by Agenda 21, which advocates citizen participation in decision-making. In 1993, the Eight-Action Programme on the Environment was launched by the European Commission. It includes a strong commitment to public participation, which is considered to be the condition *sine qua non* for achieving sustainable development at the local level.

There is no consensus about the definition and methods of participatory processes (Feldman and Westphal, 2000). Participation can be interpreted as a broad term that refers to dialogue between policy institutions and civic society in order to formulate goals, projects and the allocation of resources in order to achieve desired outcomes. A wide range of techniques and methods can be used including civic forums, focus groups, citizen's juries, surveys, role playing and gaming. These methods can be applied using aids or tools such as maps, plans, photographs, small- or large-scale simulation models and computed aided design kits (Marans and Stokols, 1993). The main contribution of participatory approaches is that they facilitate the formulation and evaluation of a range of options from different viewpoints. Participatory approaches complement expert knowledge and advice by including the life experience of citizens and social norms. They are one way that enables professionals and politicians to establish "a new social contract with society" (Gibbons et al., 1994).

4.8. Communication, information and public awareness

Human settlements should be constructed and managed by decision-makers who can refer to reliable sets of data that are incorporated into co-ordinated information systems (Castells, 1989). A dynamic data set is required covering a wide range of sectors across several administrative levels and geographical scales. Geographical Information Systems (GIS) are one type of data set that have grown in use by local authorities during the 1990s. This trend is noteworthy given the limitations of traditional approaches and statistics for data collection which are an institutional barrier to the formulation, implementation and evaluation of integrated approaches.

In principle, there is a broad consensus that three basic types of information ought to be obtained. These include:

- quantitative and qualitative data at the scales of the nation, region, city and neighbourhood;
- dynamic data intended to diagnose and monitor conditions at these scales over an extended time period;
- surveys of the local populations' expectations, lifestyle, values and living conditions.

Given this wide range of information, there is an urgent need to develop and apply Co-ordinated Information Systems. No single-focus information system can equal the potential of a Co-ordinated Information System to support integrated policies and programmes.

4.9. Prospects and future directions

Today a fundamental rethinking is necessary of the relationships between the social, economic and health inequalities and other kinds of problems in urban and rural areas. The interrelations between architecture, urban planning, health, social and environmental policies have been poorly articulated until now (Lawrence, 2000). However, it is crucial to acknowledge the important role of human settlements as localities for the

management of resources, as places for accommodating diverse ways of life and as forums for inventions of all kinds.

Our capacity to deal with human settlements is insufficient for several reasons including their diversity and complexity; the difficulty of identifying and measuring the interrelations between them and all their components; and the need to understand the relative importance of these components in precise localities at different geographical scales and over time. Therefore, it is suggested that it is necessary to shift from multidisciplinary to interdisciplinary concepts and methods.

Today the relationship between researchers and practitioners in different disciplines, especially in the human/social and the basic/natural sciences, is often considered to be a source of conflict. Nonetheless, this need not be the case as Julie Thompson Klein (1996) has shown. She illustrates how crossing disciplinary boundaries can lead to the development of new terminology, innovative concepts and new knowledge. This is an important challenge if human ecology is to be applied effectively at the beginning of a new millennium.

5. Conclusion

People–environment relations are multi-dimensional and complex. No single discipline or perspective can understand and explain these relations in a comprehensive way. Collaboration and co-ordination of contributions is necessary. However, the study of people–environment relations in general, and human ecology in particular, still remains divided between the social and natural sciences as well as between the theoretical and applied approaches in each of these sciences. Today the main obstacle that hinders an integrated framework is the compartmentalised disciplinary focus of scientists and professionals who do not share definitions and interpretations but adopt exclusive interpretations. There is a need to replace the addition of multiple disciplinary contributions by interdisciplinary approaches such as human ecology.

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