AN INTRODUCTION TO HUMAN ECOLOGY RESEARCH ON AGRICULTURAL SYSTEMS IN SOUTHEAST ASIA

Edited by A. Terry Rambo *and* Percy E. Sajise

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Foreword

The importance of the human ecology perspective as it relates to the study and understanding of tropical agroecosystems is just beginning to be recognized by both natural and social scientists. It is based on the premise that human activities significantly affect the natural resource base and the understanding of these interactions between the social system and the natural system would form the basis for the rational management and development of our tropical ecosystems.

As a new and emerging perspective, materials dealing with human ecology which can be used in research and teaching is very much needed. This book is supportive of this need. It offers both the theoretical basis and some case examples of how this perspective is used in research on agroecosystems conducted mainly in Southeast Asia.

The units of study where this perspective has been found useful is also varied: homegarden in Indonesia, rainfed and irrigated cropping systems in Thailand and upland ecosystems in the rural areas of the Philippines. The theoretical framework and actual case studies were also enriched by the research experiences and scholarly work of scientists outside of the region but who have worked in Southeast Asia. The disciplines that they represent is also varied and truly reflective of the broad perspective that human ecology represents.

This book represents the joint efforts of the members of the Southeast Asian Universities Agroecosystem Network (SUAN) and the Environment and Policy Institute (EAPI) – East-West Center. SUAN is a loose and informal network of institutes and programs from academic institutions in Thailand, Indonesia and the Philippines linked with the Environment and Policy Institute (EAPI) – East-West Center in Hawaii, U.S.A. and the Imperial College Center for Environmental Technology (ICCET) in London, England. Its member-institutions in the region are involved in the promotion and conduct of transdisciplinary research using the human ecology perspective in rural resource management and development.

A final challenge is also posed among researchers adopting this perspective to make their outputs more meaningful by relating it to policy issues of rural resource management and development. And more importantly, to prove the usefulness of this new perspective, its research results should redound to the improvement in the productivity, and socioeconomic well being of the rural community.

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Preface

This volume is intended as a general introduction to human ecology research on tropical agricultural systems in Southeast Asia. It is aimed at both natural and social scientists with the objective of helping them to better relate their professional expertise to holistic, transdisciplinary research on human-agroecosystem interactions.

Materials in this volume have grown out of a series of workshops on human ecology jointly organized by the East-West Environment and Policy Institute (EAPI) and member institutions of the Southeast Asian Universities Agroecosystem Network (SUAN).* The first of these workshops was held at EAPI in Honolulu in May to June 1981; the second, jointly organized by EAPI and the University of the Philippines at Los Baños (Program on Environmental Science and Management), was held at Los Baños in December 1981; the third, a joint activity of EAPI and the East-West Population Institute, was held in Honolulu and Kuala Lumpur in May to July 1982; and the fourth, under the joint sponsorship of Khon Kaen University and EAPI, was held at Khon Kaen, Thailand, in April to May 1983.

In carrying out these workshops, the lack of suitable published materials on concepts and methods of human ecology research became apparent. Therefore, from out of the materials presented during the four workshops, selected papers were expanded to constitute this volume. In addition, six chapters were solicited to fill gaps in the original materials and to provide more case studies from the region that illustrate the human ecology perspective. These are Chapter 5 by Hutterer on the "Ecology and Evolution of Agriculture in Southeast Asia," Chapter 13 by Lovelace on "Cultural Beliefs and the Management of Agroecosystems," Chapter 16 by O. Soemarwoto and I. Soemarwoto on "The Javanese Rural Ecosystem," Chapter 17 by Chapman on "Medical-Geographic Aspects of Agroecosystems," and Chapter 18 by B. Rerkasem and K. Rerkasem on "The Agroecological Niche and Farmer Selection of Rice Varieties in the Chiang

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*SUAN is a loose and informal association of six institutes and programs from academic institutions in the region involved in the promotion of transdisciplinary research using the human ecology perspective in natural resource management and rural development. It is supported by the Ford Foundation. The following constitute SUAN: Cropping Systems Project (CSP)/Farming Systems Program (FSP) at Khon Kaen University and the Multiple Cropping Project (MCP) at Chiang Mai University in Thailand; Center for Natural Resources Management and Environmental Studies (CNRMES) at Institute Pertanian Bogor (IPB) and the Institute of Ecology (IOE) at Padjadjaran University in Indonesia; Program on Environmental Science and Management (PESAM), University of the Philippines at Los Baños, and Cordillera Studies Center (CSC), University of the Philippines College at Baguio (UPCB) in the Philippines.

Mai Valley, Thailand." Chapter 1 is also new, written by the editors especially for this volume in an effort to show how these very diverse materials and viewpoints can be integrated within a human ecology framework.

There are three main parts in this volume: conceptual approaches, topical and disciplinary perspectives, and integrative case studies.

Chapters 1 to 3, which comprise Part I, "Conceptual Approaches," introduce the human ecology perspective and systems analysis in the study of tropical agroecosystems. Chapters 4 through 14, which constitute Part II on "Topical and Disciplinary Perspectives," deal with specific aspects of the natural and human aspects of tropical agroecosystems.

Part III, consisting of Chapters 15 through 19, discusses specific cases where the human ecology and systems perspectives were used in the analysis of different types of agroecosystems in the region – the Orang Asli interactions with the tropical rain forest of Malaysia; the homegarden and the rural population in Java; the relationships between agriculture, nutrition, and goiter in Java; and the agroecological niche and farmer selection of rice varieties in the Chiang Mai Valley, Thailand. Finally, Chapter 19 discusses the organization of transdisciplinary human ecology research using the example of an upland research program in the Philippines.

It is hoped that this volume can serve as a helpful material not only in research but also in teaching that involves the human ecology perspective in the region.

Particular thanks are due to the efficient and hard-working EAPI secretaries who patiently typed and put to order the several drafts of this volume: Avery Dubay and Betty Schweithelm (Human Interactions with Tropical Ecosystems program secretaries), with the assistance of Karen Ashitomi, Laura Miho, Lyn Moy, Joan Nakamura, Shawn Uesugi, Carol Wong, and Norene Yamamoto.

Special thanks are due to Dr. Harold J. McArthur, Jr., and Dr. Charles H. Lamoureux for their constructive criticisms and thorough review of the first draft. Last, but certainly not least, Helen F. Takeuchi, Assistant Editor in the East-West Center's Publication Office, deserves our grateful recognition for the skill and speed with which she edited this volume.

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Contents

PART I: CONCEPTUAL APPROACHES

PART II: TOPICAL AND DISCIPLINARY PERSPECTIVES

PART III: INTEGRATIVE CASE STUDIES

List of Figures

Part I

CONCEPTUAL APPROACHES

CHAPTER 1

Introduction: Human Ecology Research on Tropical Agriculture in Southeast Asia

A. Terry Rambo and Percy E. Sajise

This volume is an introduction to the study of human interactions with tropical agroecosystems in Southeast Asia. Its conceptual perspective is that of "human ecology" – the study of relations between people and the natural world in which we live. It is intended to help both social scientists, whose ordinary concern is with human affairs, and natural scientists, whose normal focus is on physical and biological phenomena, to better see how their separate subject matters are deeply interrelated in the real world of the Southeast Asian farmers. Thus, while one may spend an entire career in a university studying only society or only nature, it is our conviction that applied research on agricultural and rural development, particularly in the tropical regions of the world, can be best carried out by closely integrated, transdisciplinary teams employing the common conceptual framework offered by human ecology.

THE HUMAN ECOLOGY PERSPECTIVE

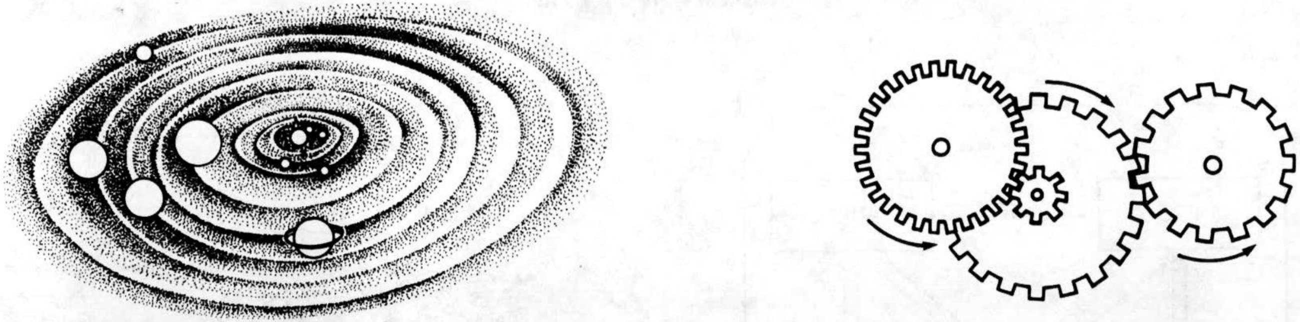
Human ecology is not a new discipline designed to supplant any of the existing social or natural science disciplines. In strict usage there are no such specialists as human ecologists either; there are instead anthropologists or geographers or botanists or agronomists who employ a human ecological perspective in their work. This perspective is distinguished from other conceptual frameworks by a number of major features: (1) it employs a systems viewpoint on both human society and nature, and (2) it describes both the internal behavior of ecosystems and social systems and their interactions with each other in terms of flows or transfers of energy, materials, and information. It is, moreover, concerned with understanding (3) the organization of systems into networks and hierarchies, and (4) the dynamics of systems change.

THE SYSTEMS VIEWPOINT

The nature of systems is discussed at some length in several chapters in this volume (Chapter 2 by Conway; Chapter 3 by Rambo; Chapter 4 by Marten). For present purposes, it is sufficient to say that a system is made up of two or more mutually interacting components; i.e., components that exert mutual influence on each other's performance (Figure 1.1). The Solar System is a system because each body within it, from the Sun down to the smallest asteroid, is influenced by and exerts its own influence on the motion of every other body. The Solar System and the distant Pleiades constellation of stars do not, on the other hand, constitute a system in any meaningful sense because neither entity exerts significant gravitational influence on the other.

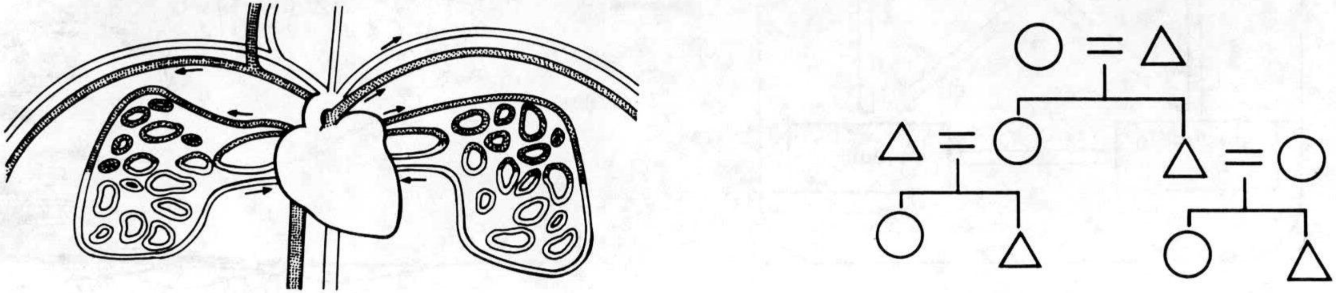
An ecological system is also made up of mutually interacting components, describable in broad terms in this case as climate, soil, water, plants, and animals (Figure 1.2) rather than stars and planets. Again, we refer to these separate elements as comprising a system because each individual component exerts influence on and, in turn, is influenced by every other component. Climate, for example, affects the growth of vegetation but, in turn, is modified by the action of plant life (e.g., trees serve to reduce wind speed and increase relative humidity levels). Soil is formed through a combination of climatic and biological actions but, in turn, affects the growth of plants and animals. One can go on almost without end, exploring the complex interactions of the components making up even the smallest ecosystem.

Human social systems are also made up of interacting components. For simplicity's sake we will speak of only four of the many possible components: population, technology, social structure, and ideology (Figure 1.3). Again, as in the case of the bodies in the Solar System or the physical and biotic components of an ecosystem, each component of the human social system exerts an influence on every other component and is also influenced in its own behavior by those other components. The form of religion, an aspect of ideology, for example, is influenced by the character of the social structure. Hierarchical societies, such as the chiefdoms of ancient Polynesia, frequently have an equally hierarchical pantheon of gods, whereas egalitarian tribal societies, such as the Dayak groups of Borneo, usually worship a diver-



1a Solar system

1b Mechanical system



1c Circulatory system

1d Kinship system

Figure 1.1. Examples of systems.

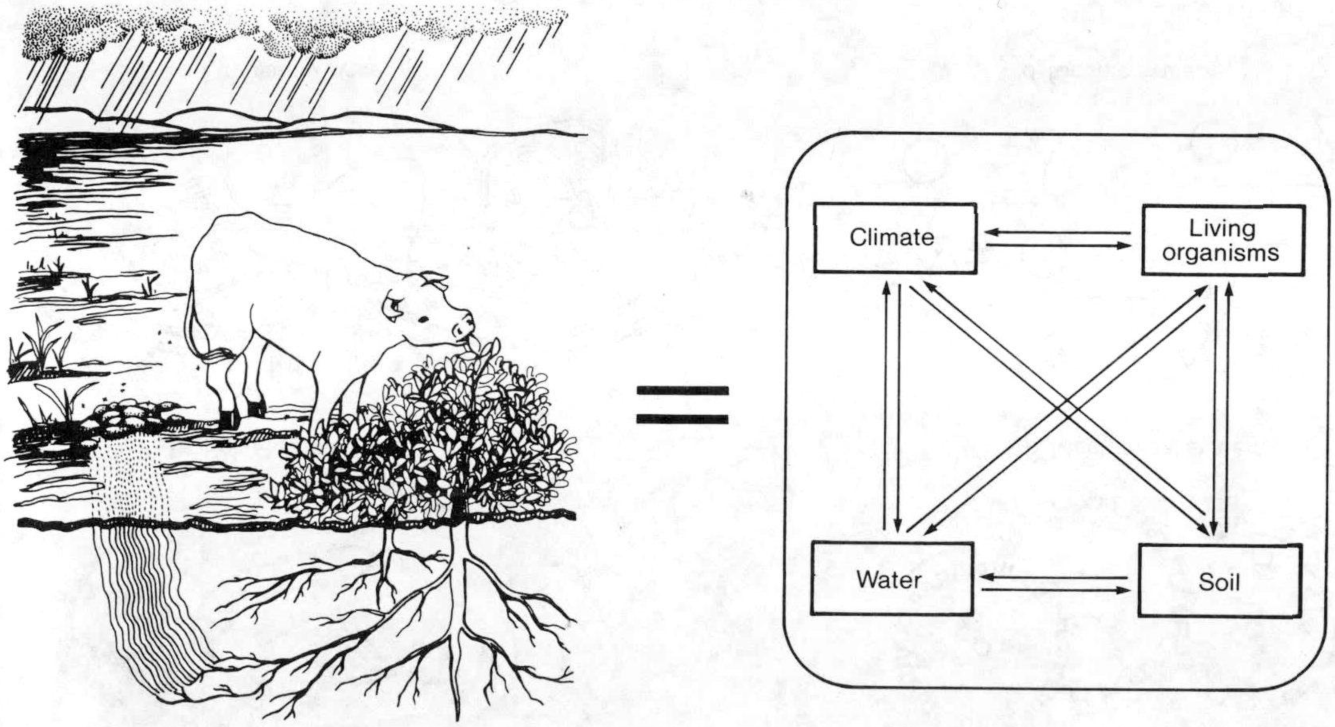


Figure 1.2. An ecosystem

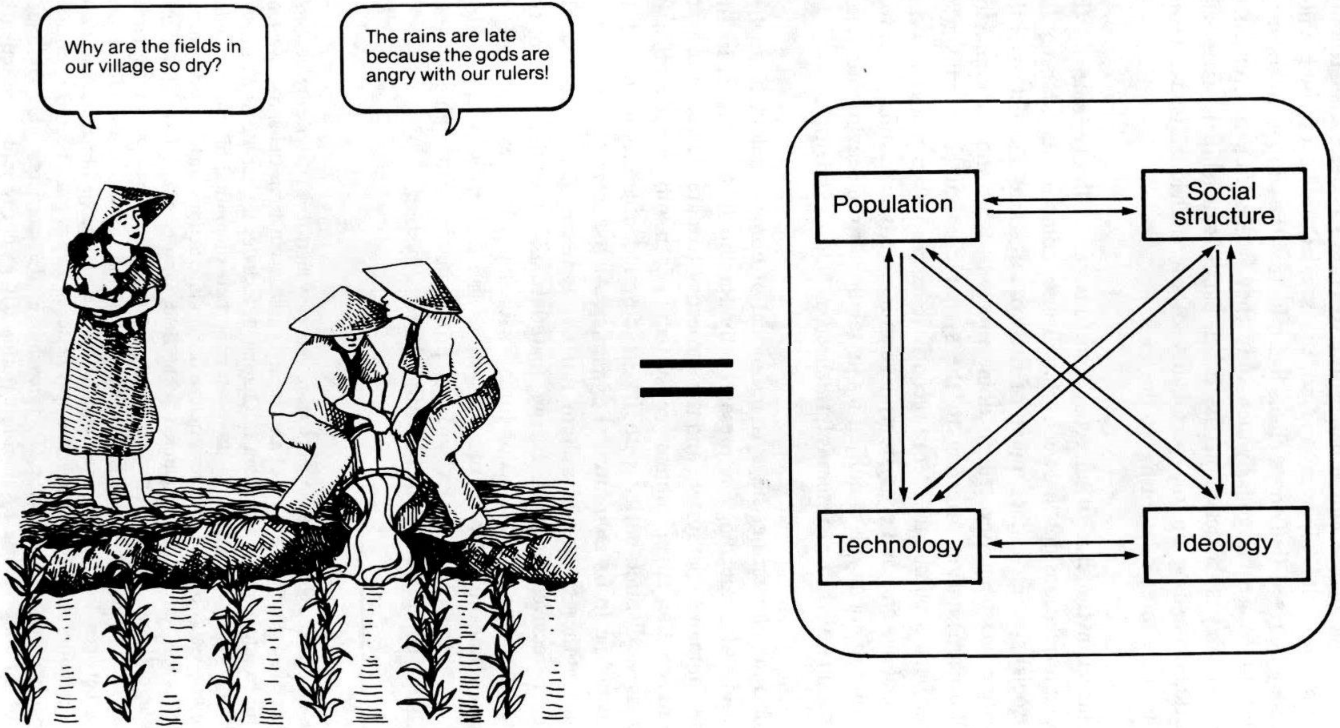


Figure 1.3. A human social system.

sity of essentially equally powerful spirits. At the same time, ideology, in the form of religious beliefs and ritual, works to reinforce the social structure (e.g., commoners in Polynesia obeyed the secular orders of their chiefs because they believed that these chiefs had inherited the support of the most powerful and dangerous gods, which only they had sufficient strength to worship). In Dayak society, on the other hand, leadership is essentially charismatic, depending on the personality of the individual leader rather than on his structured relationship to the gods.

Again, as in the case of an ecosystem, one can endlessly trace out the complex interrelationships between the diverse components of even the smallest social system. In fact, much of the work of social scientists over the past century has been devoted to doing precisely that, and an impressive body of documentation attesting to the systemic character of human societies has been accumulated. More recently it has also been recognized that human social systems and ecosystems have an interactive relationship, so that the structure of society is modified by its relations to the environment, just as the structure of the ecosystem is influenced by human activities.

A diagram illustrating this systems model of human ecology as applied to the study of agroecology is presented by Rambo in Chapter 3. In this model, the human social system and the agroecosystem are treated as distinct subsystems of the larger human ecosystem.[1] Each subsystem retains its integrity as a distinct entity with its structural configuration subject to change according to its own internal dynamics. At the same time it is recognized that neither the social system nor the agroecosystem is completely closed. Each receives inputs of energy, materials, and information from the other, and these inputs are a major force for change within each subsystem. The interrelationship between the subsystems is a dialectical one. Causality is therefore extremely complex with no prime mover status being assigned *a priori* to any component or force within the total system.

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[1] Not all agroecosystem researchers share our view that it is analytically desirable to treat humans as forming a distinct and separate subsystem from the agroecosystem. Conway, for example, in his discussion in Chapter 2, includes the farmer as an integral part of the agroecosystem. Although there are important theoretical differences underlying these two views of how to conceptualize human interactions with agroecosystems, in practice, at least in research conducted at the field, farm or village level, differences in empirical outcomes are insignificant. At this stage in the development of human ecology research, we believe that it is premature to attempt to achieve total theoretical consistency between diverse researchers coming from a wide range of natural and social science backgrounds. Instead, we feel that it is better to give as full a hearing as possible to proponents of different conceptual approaches in the conviction that continued exposure of differing models to empirical testing will gradually lead to selection of those best meeting the needs of agroecosystem research in Southeast Asia.

The interaction of the agroecosystem with the social system is exemplified by the Javanese homegarden as described by O. Soemarwoto and I. Soemarwoto in Chapter 16. The homegarden, which structurally and functionally mimics the tropical rainforest, is highly diverse in species composition and has a multilayered canopy. Plants are grown for ornamental, food (fruits and vegetables), spices, medicinal, and industrial uses. It accounts for 17 to 30 percent of the income of farmers. Products of the homegarden are also partly used for social and religious functions. In turn, species composition and other structural features of the homegarden are influenced by the social status, source of income, and educational background of the owner.

Interactions within and between social and ecological systems occur as a result of the flows of energy, materials, and information. The study of these flows is a major concern of human ecology.

THE FLOW OF ENERGY, MATERIAL, AND INFORMATION

According to current cosmological thinking, the universe was created some 20 billion years ago in what astronomers refer to as the "Big Bang" – an explosion of something out of nothingness (Weinberg 1977). Initially, the universe was made up of essentially pure energy, a period referred to as the "radiation dominant era." Only after the first several minutes had passed did the rapidly expanding universe cool sufficiently for matter to take form. Initially, this matter was in the form of randomly distributed elementary atomic particles, but after the first three minutes these particles fused and formed atomic nuclei of helium and hydrogen. It was not, however, until after another 700,000 years had passed that temperatures fell low enough for the nuclei to hold electrons in the form of stable atoms, the beginning of the process of galaxy and star formation. Only at this point did the universe begin to acquire material structure, the prerequisite for the existence of information.

Energy, materials, information: these are the three fundamental functional aspects of all natural systems, from the entire universe on the one extreme down to the smallest virus or bacterium at the other. Ecosystems and social systems are no exception, and it is in terms of these three ecological flows that we describe their functioning.

Energy Flow

Energy flow as an aspect of human ecology is discussed by Rambo in Chapter 9. In brief, energy refers to the ability to do work (i.e., to change some aspect of an existing system from one state to another state). Without free energy, which in the case of Earth's ecosystems is provided by the Sun's light, nothing can change or develop or evolve. Energy is needed to organize materials into more complex structures capable of carrying larger quantities of information, a process often referred to as evolution.

Ecologists have devoted a great deal of effort to describing how energy flow is involved in ecosystem functioning. Unquestionably, applying thermodynamic principles to ecology has greatly enhanced understanding of previously puzzling questions of why, for example, larger carnivores are always much rarer than the herbivores that provide their food. The answer is found in the Second Law of Thermodynamics, according to which conversion of energy from one state to another (e.g., from the flesh of a herbivore to the flesh of the carnivore) can never be 100 percent efficient but always involves the qualitative degradation of some of the initial stock of energy. It is, of course, this same law that explains why 10 hectares of farmland planted to rice and soybeans can support 100 vegetarian Chinese, whereas the same area of pastureland can support only enough livestock to feed a single meat-eating American.

The Chinese farming system is also more energy efficient in another way than the American farm in that it requires a much lower input of work energy to produce an equivalent output of food energy. This may be surprising to those who are used to thinking of Chinese farming as extremely labor intensive, using up to 400 man-days of work per hectare of rice paddy per year, while in comparison, a Kansas corn farm may use as little as two or three man-days/ha/yr. The key difference, of course, is that the American farmer substitutes the labor of machinery for that of human muscles. These machines not only consume large quantities of fossil fuel energy but they also require energy for their construction and maintenance. When these energy costs are added together with the energy costs of producing the chemical fertilizers and pesticides, which are also needed to make an American farm system function, then calculation of the relative efficiency balance shifts radically with one calorie spent on work producing only from two to five food calories in contrast to the 20 to 50 calories of food that one work calorie produces in the traditional Chinese farming system. These relationships between energy inputs and outputs in traditional and moderm farming systems are explored in depth by Rambo in Chapter 9 with the overall conclusion that, in farming systems as in any other thermodynamically based system, there can be no such thing as a "free lunch." Instead, one must always trade off the need for human labor against other, often hidden, requirements for energy inputs to make the system function.

The interplay between the supply of human labor and the development of agricultural production has been a major concern in theoretical approaches to human population growth, as is discussed by Pirie in Chapter 7. In the conventional Malthusian view, any increase in food production triggers the automatic growth of population that inevitably outruns the ability of agricultural systems to supply adequate food. Increased poverty and famines are the ultimate outcomes of increasing food supplies. Successful rural development, therefore, is contingent on achieving population control. According to an alternative hypothesis proposed by Ester Boserup, however, it is population growth that is the driving force behind intensified farming systems so that rural development is dependent upon population growth. As Pirie observes, neither theory offers an adequate model of the real world. Boserup is certainly correct in arguing that more labor is necessary to allow intensification, but she fails to recognize that intensification is only possible under certain ecological conditions. Thus, while wet rice farming on good alluvial soils may profitably absorb very large labor inputs, rain-fed agriculture on poor upland soils may have a very limited potential for intensification. Attempts to increase productivity may lead to the breakdown of such agroecosystems with Malthusian results for the human populations that depend upon them.

Other implications of energy flow analysis for the functioning of human social systems are explored by Rambo in Chapter 3. Particularly important are questions about the relationship between the ability to capture and utilize energy sources and the evolution of increasingly complex human societies and the linkages between differential control over energy and the extent of social stratification both within and between societies.

While analysis of energy flows is rightly one of the major concerns of human ecology, it is not the sole, or even, in our view, the most important concern, as some ecologists, most notably Howard T. Odum, have viewed it. It is true that, without energy continually flowing through it, no ecosystem or social system can function and, in that sense, energy is the prime mover. The development of ecosystems and even the maintenance of agroecosystems require a certain pattern of energy and material flow as described by Sajise in Chapter 8 and Marten in Chapter 4. But without materials there can be no structure, and without structure there can be no information – one can argue that the evolution of the universe has followed a path away from the dominance of energy and toward the ever-increasing importance of matter and information.

Material Flow

Until Einstein revolutionized physics, energy and matter were thought of as two totally different aspects of reality. True, one could metabolize food to get one's body energy or burn wood to obtain heat energy, but it was recognized that those processes did not actually destroy any matter; they simply broke the chemical bonds between its constituent atoms or molecules, releasing stored energy in the process, but the original atoms or molecules remained intact somewhere in the system, waiting to be reassembled into more complex structures.

It is now realized, of course, that energy and matter are merely different states of an underlying physical unity, and that each can be transformed into the other, as is described by Einstein's famous formula $E = MC^2$ (where E is energy, M is matter and C is a number representing the velocity of light). In 1945, theory became practice and the world entered, for better or worse, the Nuclear Age, with consequences for ecological theory that have still not yet been fully explored. Certainly in the realm of human ecology, the discovery of the fundamental physical unity between energy and matter has vast implications. Fortunately, however, for those of us unable to fully understand the Theory of General Relativity in all its complexity, most ecological analysis can still be done employing the conventional distinction between energy and matter.

The movement of matter through the ecosystem is usually referred to as the nutrient cycle or biogeochemical cycle. As Marten shows in Chapter 4 on the tropical rain-forest ecosystem, the term *cycle* is used because basic nutrient elements such as nitrogen, phosphorus, and potassim move virtually endlessly back and forth among the various components of the system. The nitrogen (N) in a leaf is consumed by a herbivore and incorporated into its body's protein. The herbivore is eaten by a carnivore which captures the N to build its own tissues. The carnivore dies and its corpse is eaten by scavengers who in turn pass the N into the soil as feces and urine where it is recaptured by the roots of the plant and used to grow a new leaf which is in turn consumed by a herbivore and so on.

This cycling of materials is in fundamental contradistinction to the movement of energy in the ecosystem which is always essentially linear, entering the food chain at one end as solar radiation, and ultimately after passing through one or two or three transformations, exiting the chain at the other end as dispersed heat. In the time frame appropriate to human ecology, however, the distinction between flow and cycle is often less clear. Soil erosion, for example, as described by Panchaban in Chapter 10 is ultimately part of the global biogeochemical cycle – soil washed into the sea from mountain slopes today will reemerge many millions of years from now in the process of new mountain building. From the human time perspective, however, soil once lost is lost forever so that erosion is perhaps more realistically treated as a flow rather than a cycle. In any case, for purposes of simplicity, we have chosen in this work to refer to all three basic aspects of ecocystems functioning – the movement of energy, materials, and information – as "flows."

As was suggested earlier, material flows are important because it is by combining materials with energy that complex biological structures are created. Thus, a plant requires solar energy to grow but it also needs water, carbon dioxide, and a large number of nutrient elements. If any of these physical factors is not available in sufficient quantity, then the growth of the plant will be accordingly retarded – an ecological principle usually referred to as Leibig's "Law of the Minimum" or the concept of "limiting factors."

In arctic ecosystems, all physical factors are limiting – energy is unavailable during the 6-month-long arctic night, water is locked up as ice for most of the year, and nutrients once captured in the biomass may take centuries to recycle due to the cold-retarded pace of decomposition. In desert ecosystems, on the other hand, solar radiation provides abundant energy and soils are often extremely rich in nutrients, reflecting the absence of leaching by rainfall. It is shortage of water that limits biological activity, hence the often extremely high productivity of desert agricultural systems when adequate irrigation water can be provided.

In tropical rain-forest ecosystems, solar energy and water are usually abundantly available but nutrients are the most important limiting factors. As Marten describes in Chapter 4, continued heavy rainfall, although providing ample water for plant growth, rapidly leaches soluble nutrients from the soil. Tropical rain-forest plant species have developed nutrient retention mechanisms to cope with this problem, but once an area is cleared of its native vegetation and agricultural crops planted instead, nutrient shortages quickly become limiting – a problem that is often made more acute by soil erosion stemming from improper land-use management, an issue explored in Chapter 11 by Bartolome.

Because nutrients are such important limiting factors in tropical ecosystems and because, as Marten discusses in Chapter 4, storage is primarily in the biomass rather than in the soil as in the case of temperate zone ecosystems, understanding the process of succession is particularly important with regard to tropical agricultural systems. As Sajise shows in Chapter 8, succession is the process by which a disturbed community is restored over time to its original state. Shifting cultivators clear a field and plant annual crops in a patch of rain-forest. After the harvest, the nutrient-impoverished soil will support only grasses and herbs. As years pass the soil fertility is gradually restored and the grasses and herbs are shaded out by pioneer tree species. These trees act as pumps bringing up nutrients from deep in the subsoil to the surface, thereby creating a favorable growing medium for climax forest species that eventually grow up and shade out the pioneer species. After some 50 to 100 years, the patch has returned to a forest stand, indistinguishable from neighboring primary forest.

Obtaining adequate supplies of nutrients is not just a problem for plants: it is also a fundamental problem for tropical animal populations, including humans. Proteins, complex nitrogen-based compounds necessary for growth and maintenance of human tissues, are often in short supply. Thus, a key objective in agricultural development should be not just to increase total yield, measured in terms of calories, but also to ensure production of adequate high quality protein.

Shortage of other nutrients can also have profound impact on human welfare. Iodine is often absent from old, highly leached tropical soils. Although iodine is not a limiting factor for plant growth, it is needed in small quantities by people to prevent thyroid imbalance leading to formation of goiter. However, as Chapman describes in Chapter 17, some common crops, particularly members of the cabbage family *(Brassica sp.)* and cassava *(Manihot esculenta)*, especially when grown on high sulfur soils, contain compounds that inhibit iodine utilization. Thus, their consumption by humans can result in abnormally high incidence of goiter even though iodine intake is considered adequate by normal nutritional standards. This is a particularly difficult health danger to detect because the goitergenic plants appear, to the unaided human eye, no different from safe-to-eat plants. Our information collecting capability, in this case, is inadequate for its task.

Information Flow

When the universe first exploded into existence in the Big Bang, there was only energy but no matter or information. Later, matter formed but there was still no information, since the particles were wholly unorganized and scattered at complete random through the primal plasma. Only much later did the elementary particles begin to coalesce into organized structures – atoms, molecules, gas clouds, stars, galaxies – and only with the evolution of structure did information become an attribute of the universe.

As is discussed in Chapter 12 by Rambo, "information" refers to any sign about the past, present, or future state of some aspect of reality. It is transmitted by means of energy or material flows: The photons reaching our eyes from a distant star inform us of its location; the perfume molecules carried to our nostrils on an air current alert us to the presence of a flower. Information may thus be viewed as a derived phenomenon, dependent for its functioning on the prior existence of energy and material. Paradoxically, however, the emergence of intelligent life has shifted preeminence to information as an evolutionary factor. This need not be interpreted as reflecting any preordained cosmic design as was advocated by Teilhard du Chardin – the universe was not necessarily created in order that we might have the chance to reach the Omega Point – but once sensate beings evolve, the character of energy and material flows is qualitatively changed, and obtaining better access to the flow of information becomes a primary selective priority in evolution. The difference between modern man and the lower primates, such as the apes and monkeys, is not with regard to our biological relationships to energy and matter – ape metabolism is little different from human metabolism – it is in our very different capabilities to obtain, analyze, and respond to information about our environment.

Many human interventions into ecosystems are aimed at manipulating the flow of information between ecosystem components. Thus, a farm field may be managed to produce not only calories and nutrients, but information as well. The very layout of the field, its shape, and the arrangement of crop species within it project significant information. Compare, for example, a Malaysian aborigine garden plot with a Chinese vegetable plot. The aborigine plot contains 20 to 50 varieties of plants scattered seemingly at random within its irregular boundaries, whereas the Chinese plot has only one variety planted in dense lines within its absolutely rectilinear borders (Figure 1.4). Any human observer immediately can tell the difference between the two, a fact the Chinese guerillas learned to their own great cost during the Emergency in Malaya, when British aerial observers were able to distinguish guerilla camps in the jungle from neighboring aborigine settlements simply by looking at the layout of their associated garden areas. Only after being bombed many times did the guerillas adapt by changing the layout of their gardens to resemble the aborigine patterns (i.e., they manipulated information flow to mimic something they were not). The Thai farmers in the Chiang Mai Valley in Northern Thailand as described by B. Rerkasem and K. Rerkasem in Chapter 18, know that each of the 42 rice varieties grown in the area has distinct characteristics that allow it to grow under particular environmental conditions and particular circumstances and needs of the farmers. This is information that allows the Thai farmers to select the appropriate rice variety to plant in areas with high water levels most of the time throughout the year, the appropriate rice variety that yields adequate amount of straw for the next crop of garlic, the rice variety with the proper growing period or sensitivity to daylength, which will allow the farmers to plant a second crop of soybean or a rice variety with the proper growing period that does not compete with the available labor of the farmers during certain periods of the year. Introduction of improved rice varieties may not be acceptable to the Thai farmers in the Chiang Mai Valley if it does not fit their social and environmental circusmtances.

It is not only the human observer who seeks information – insects and other crop pests are also consumers of information flowing from the garden, using it to guide themselves to desired food plants. Again, the aborigine and the Chinese gardens offer very different situations. The insect that locates plant A in the aborigine garden (Figure 1.4) is likely to have trouble finding plant B, located as it is halfway across the plot behind a thick screen of other species, which the pest does not eat and some of which may be repellant to it. In contrast, the insect that finds plant A in the Chinese plot will have no difficulty in finding plant B since it may be able to see, smell, and touch it without further searching.

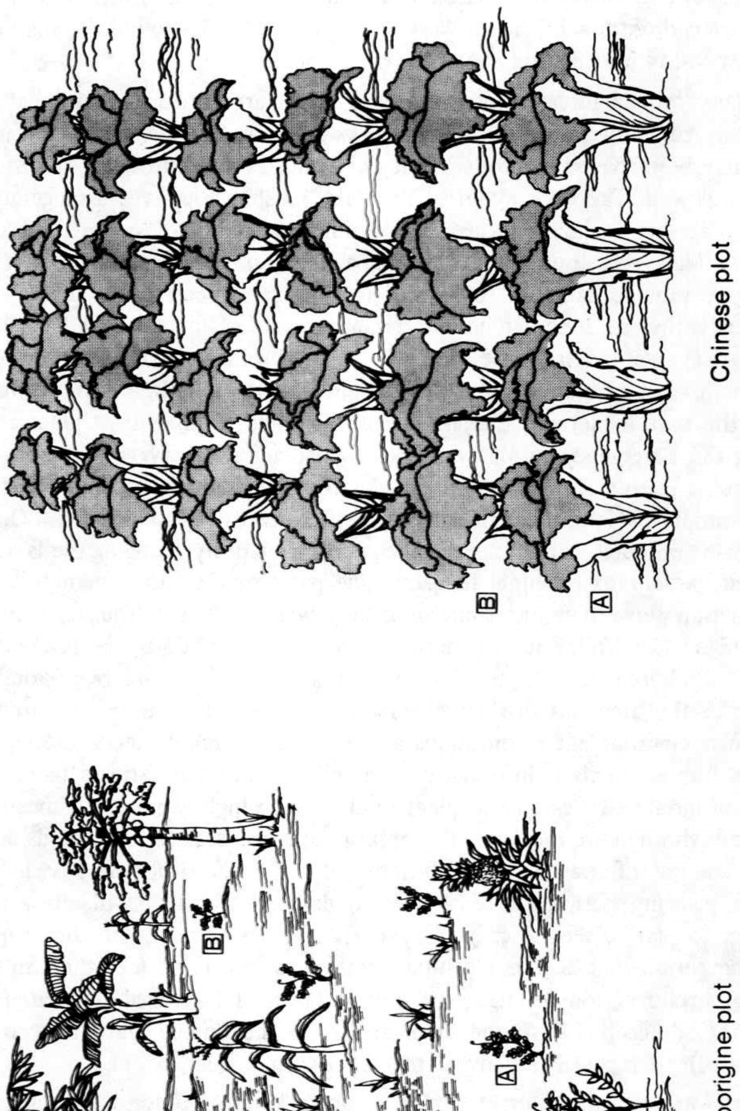

Figure 1.4. Comparative layout of aborigine and Chinese garden plots.

The study of information flow in ecosystems is perhaps the least developed aspect of ecology. With regard to human ecology, however, it is also clearly the most important aspect, a reality given recognition by the great attention paid to *ethnoecology* by anthropologists and geographers. As is discussed in Chapter 13 by Lovelace, ethnoecology is the study of how different cultural groups conceptualize their environments. Although attention has primarily been paid to describing folk taxonomy (i.e., how people classify and name plants, animals, and other ecosystem components), ethnoecology research in principle should also be concerned with understanding the totality of folk knowledge about ecosystem structure and functioning. Such traditional ecological knowledge may have great significance for scientists trying to design improved agroecosystems.

In the mountain areas of northern Luzon in the Philippines, for example, farmers have traditionally planted taro on some of their steep hillslope plots. Scientists from the University of the Philippines at Los Baños measured soil erosion rates and found taro plots to suffer the highest losses. They recommended that the farmers stop planting taro only to learn from the people that taro was the only crop likely to survive a typhoon, the powerful tropical cyclones that devastate northern Luzon every few years. In this case, the farmers were taking a wider range of ecosystem variables into account in their decision making than were the scientists. If they had followed the scientists' advice, they might have retained more soil on their fields but suffered considerably after the next typhoon.

The point of the above story is not that traditional farmers are always ecological experts managing agroecosystems that are perfectly adapted to their specific environmental conditions. That is simply not true as is demonstrated by the extensive environmental destruction caused by agricultural mismanagement in ancient Greek, Roman, Chinese, and Aztec civilizations, to name just a few well-documented cases. Rather, the point is that traditional farmers often have a relatively comprehensive understanding of their agroecosystem, which includes factors often ignored by specialized scientists, a difference discussed by Conway in Chapter 2. In particular, farmers are likely to be aware of the possibility of occurrence at irregular intervals of major pertubations (typhoons, floods, droughts, epidemics, wars); unpredictable threats to system productivity that are all too often ignored by scientists. By using ethnoecology to tap farmer beliefs and knowledge, the scientist, in effect, is able to take advantage of hundreds of years of field trials under the extreme selective pressure of real world conditions.

One very profound shift has been occurring over the past several hundred years in the character of human perception of ecological information flow: That is the ever-increasing use of cash value as the key unit of measurement. On the modern capitalist farm, this has reached the point where all ecosystem components are assigned a worth based on their market value, and farm management is aimed at short-term maximization of this value. Thus, in a frontier situation where land is essentially a free good, but labor is expensive, it is economically rational for the farmer to use highly erosive cultivation techniques if they give high yields with minimum labor input. The farmer who tries to conserve the "free" soil by using costly labor-intensive methods will quickly go bankrupt. The problem, therefore, is not one of the farmers being stupid or irrational or lacking information about the ecological effects of their behavior. It is instead that the modern capitalist social system is concerned with measuring only one type of information, that of short-term cash returns to the individual enterprise. Usually ignored, however, are all of the off-site or long-term implications of current individual actions, implications that economists refer to as *externalities.* As Worachai discusses in Chapter 14, a major goal in environmental economics is to find ways to assign realistic values to externalities and force individual enterprises to pay all of the real costs arising from their management or mismanagement of ecosystems.

The issue of externalities brings us to consider another major distinguishing characteristic of the human ecology perspective on agroecosystems: Its concern with the organization of systems into networks and hierarchies. It is not enough to look simply at the structure of a particular farm, but it is instead necessary to analyze how it interacts with other systems, both neighboring units and the larger scale systems in which it is enmeshed.

SYSTEMS ORGANIZATION

Neither ecosystems nor social systems are ever totally closed systems; instead, each specific local system is always interacting with neighboring local systems (horizontal integration into system networks) and systems of lesser scale below it and greater scale above it (vertical integration into system hierarchies).

Horizontal integration into networks may be illustrated in terms of two neighboring farms, Farm A and Farm B. Farm A is on the hillside above the valley where Farm B is located. If Farmer A cuts all the trees on his land and plants maize in vertical rows, rain will wash large amounts of soil downslope into Farmer B's wet ricefield. Depending on the quantity and quality of the soil, this may improve or lower the productivity of Farm B but in either case it will certainly alter the functioning of the system. Conversely, Farmer B may engage in a poorly planned pesticide spraying program, which will generate chemical resistant varieties of pests that will then migrate into Farmer A's fields, with obvious consequences for their productivity (these are all examples of environmental externalities as discussed by Worachai in Chapter 14). Horizontal interactions also occur between neighboring social systems (e.g., Farmer A may respond to the disruption of his farm by the actions of Farmer B by (1) abandoning his land and migrating elsewhere, (2) bringing a lawsuit against Farmer B, or (3) attempting to shoot Farmer B).

Vertical integration refers to the fact that any particular social or ecological system occupies a specific level in what Conway describes in Chapter 2 as the "system hierarchy." Agroecosystems form a hierarchy that ascends in scale from the individual field to the farm to the community to the region to the nation to the biosphere. Social systems have a comparable hierarchy moving upward from the individual farmer to the household and then to the community, the province, the nation, and the global system. What happens to a system at any particular level may be influenced by, and exert influence on, the functioning of systems above and below it in the hierarchy.

A dramatic example of vertical integration of agroecosystems may be offered in the not too distant future by changes in productivity of individual farms resulting from climatic warming due to global increase in carbon dioxide levels in the atmosphere (the "greenhouse effect"). That the hierarchical relationship is a two-way entity is illustrated by the fact that it is the burning of swidden fields by individual farmers that is the source of some of the added atmospheric carbon dioxide.

Vertical integration of social systems is, if anything, more obvious than it is in the case of agroecosystems. No individual farmer exists in isolation. Instead, virtually all of his decision making is done in terms of his relationships with other levels in the social systems hierarchy – the area he plants will reflect the size and age structure of his household, along with the norms of his community regarding exchange of labor to help him out at peak work times. The crops he plants will reflect the demands of the provincial market, which is in turn influenced by the national and world economy. Whether or not he uses fertilizer or pesticides is determined by national decisions about price structure while availability to him of high yielding variety seeds is due to the existence of an internationally supported agricultural research institute.

In analyzing any particular social or ecological system, therefore, we must always take into account its position with relation to other systems, assessing the influences exerted by both its horizontal and its vertical relationships. In asserting the need for such contextual analysis, we are not, however, arguing for a return to the impossible ideal of a holism where nothing can be explained until everything else has been explained first. It is true that one cannot explain why a farmer in Northeast Thailand decides to plant cassava rather than rice without knowing something of the prices he expects to receive for these crops in the provincial market. One need not, however, also have a full understanding of how the mechanisms employed by the European Economic Community (EEC) to set cassava import quotas or the rice export policies of the Royal Thai Government function to set these prices. At the farm system level of analysis, these higher level systems can be treated simply as "black boxes." What is important is how their "outputs" influence the specific system we are analyzing, not how they themselves function. In ecosystem analysis a comparable case is provided by the relationship between the sun and life on earth. No ecosystem can function without a continuing supply of solar radiation, a fact that every ecologist recognizes, but no ecologist needs to understand the processes by which the sun generates this radiation. The sun can be treated as a black box with no loss in analytic power at the terrestrial ecosystem level.

Recognition that any specific system is operating in a horizontal and vertical matrix of other systems provides a viable conceptual basis for empirically analyzing some of the most troubling questions in human ecology research – the issues of social, economic, and political dominance and exploitation. As developed by Western social scientists, human ecology has largely had a Leibnitzian character, portraying every society and every institution as perfectly adapted to the best of all possible worlds. Even cannibalism has been explained as a happy solution to the problem of endemic protein shortage in the tropics. Almost wholly ignored have been issues of competition, conflict, exploitation, and resulting human misery, although we all know that in the real world not every individual or every system prospers equally but that some do better than others, often at the expense of others. It has been easy to make charges of exploitation, however, but difficult to demonstrate its occurrence empirically.

By measuring the flows of energy, materials, and information between systems, it becomes possible to determine empirically whether or not an exploitative relationship exists. If a Thai farmer must labor for ten hours to grow rice, which when sold will enable him to buy a polyester shirt that a British worker was able to produce in one hour, then in purely human energy terms the exchange is unequal. Suppose, however, the farmer instead raises cassava, a low labor input crop, so that one hour of his work produces a sufficient return to buy a shirt that took the worker one hour to produce. In energy terms the exchange is equal (nonexploitative), but it may still be highly unequal in material terms. The ton of cassava the farmer must sell to buy his new shirt takes with it out of his field 6 kilograms (kg) of nitrogen, 1 kg of phosphorous, and 11 kg of potassium. Obviously the shirt he brings home from the provincial market does not replace these nutrients so that, in order to maintain the productivity of his farm, over the long term, he must purchase chemical fertilizers in equivalent quantities to replace the nutrients lost through export of his crop. The market price for cassava, however, while high relative to the energy cost of production, is low relative to the material cost. In fact the value of nutrients, if purchased as chemical fertilizer, may be close to the sales price of the cassava (which may explain why cassava farmers rarely use any fertilizer). In material flow terms, therefore, one could say that cassava farmers in Northeastern Thailand are "exploited" by the EEC livestock farmers who import their cassava chips as low-cost feed.

It is when dealing with information flow balances that analysis of exploitation becomes most problematic. It is easy, at least in theory, to compare the energy or material value of a kilo of cassava with that of a polyester shirt. Production of each commodity, however, is also dependent on information – in the case of the cassava the genetic information stored in the plant's chromosomes that guides its growth, and the cultural information stored in the brain of the farmer that guides his management of the farming system. In the case of the shirt, there is obviously the acquired skill of the worker in running the machine, but there is also the much larger cultural pool of technological information on which the designers of the machines drew freely. In some sense, then, it appears that the farmer gets the better part of the bargain in terms of information flow, exchanging a commodity requiring a relatively low level of information input for its production for a product needing a much higher level of information. There is a critical difference, however, between the flow of information on the one hand and energy and material on the other. In selling his cassava, the farmer has lost forever the energy and materials that went in its production. In selling the shirt, no information is lost to the producer who retains the ability to continue making more shirts according to the same pattern. It may be, therefore, that the only system costs that can fairly be assigned to information flows are those associated with the discovery of new information. Only in the case where the costs of discovery are incurred within one system with the benefits exported to another without adequate compensation can one speak of "exploitation" with regards to information flow. Thus, if commercial plant breeders collect crop varieties developed over generations of farmer trial and error and use these to develop proprietary seed lines, which are then sold back to the farmers at high prices, one might legitimately view this as a case of exploitation in the area of information.

As should be clear from the foregoing discussion, we are not proposing a "cookbook" solution to assessment of exploitation. We are suggesting, however, that the issue is an important one in human ecology research, and that it is necessary to develop better empirical measures that go beyond current assessments using monetary values alone.[2] Looking at relative balances of trade between systems in terms of energy, materials, and information exchanges may be one useful approach. In particular, such analysis may help us to better understand long-term shifts in the structural relationships between these systems and better illuminate why so many well-meaning attempts at agricultural development have failed to improve the lives of the farmers. This concern with understanding the processes of agroecosystem change leads us into consideration of system dynamics.

SYSTEM DYNAMICS

Analysis of how systems function is both interesting and important, and much of the effort of both ecologists and social scientists for the past 50

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[2] Discussions with Manu Seetisarn and Shalardchai Ramitanondh, both of Chiang Mai University, have particularly influenced our thinking on this issue.

years has been expended on tracing out these intricacies. Even more important from our point of view, however, than understanding how a system works at any one point in time is analysis of its dynamics so as to understand how it changes or fails to change over time. Hutterer in Chapter 5 well illustrates the value of such an approach in his analysis of the evolution of agriculture in Southeast Asia.

In dealing with questions of system dynamics, ecologists have had a great advantage over social scientists in that their work has been guided by Darwin's evolutionary theory, the most powerful explanatory model of change used in the life sciences. It is founded on the recognition that competition between organisms for scarce resources inevitably favored the survival of those individuals having superior competitive abilities, and hence ensured that their characteristics would be passed on to future generations, resulting in enhanced adaptation of the species to the environment over time. If, however, environmental conditions change, then the nature of the selective pressures also changes, and wholly different characteristics may confer competitive advantage and thus be favored by natural selection. For example, as is suggested by Rambo in Chapter 15, the dark skin color of the Semang aborigines in Malaysia may have served to camouflage them when hiding from slave raiders in the dark shade of the rainforest and would therefore have had great selective value. Under present peaceful conditions when the Semang are being resettled in agricultural development projects where they have to work all day in the full glare of the sun, however, dark skin color ceases to be adaptive and, instead, because it significantly increases the body's heat load, comes under negative selective pressure.

As can be seen from the preceding example, the course of evolution is unpredictable, depending as it does upon changes in environmental selective forces. Adaptation, therefore, is a continuous process rather than something that occurs once and then is eternally fixed. There is no goal to the game of life except to continue playing, and the only rule that can be known in advance is that any change in conditions with which the species is unable to cope will knock it off the playing field and into the fossil record. In this regard, it is somewhat sobering to recognize that it is the all-star champions of preceding innings that we now observe in paleontology museums. And the practical question that this raises is, "How do we design agroecosystems that have maximum ability to adapt to conditions of rapid and largely unpredictable environmental change?"

Social scientists have been hampered in their research by the lack of any generally accepted theory of change in social systems comparable to Darwinian theory in the biological sciences. In fact, structural-functionalism, the dominant paradigm in British and American social science for the past 50 years, is a static model with no built-in mechanisms for explaining the occurrence of change. Marxism, the only major competitive theory to structural-functionalism, is explicity concerned with explaining change but, in our view, is based upon underlying assumptions that are incompatible with the Darwinian model employed in ecological analysis.

In contrast to Darwinism, which is probabilistic, multilineal, and continuous, Marxism, at least in its more dogmatic variants, is deterministic, unilineal, and finalistic. In the Marxist model, all societies must necessarily pass through a fixed set of stages (primitive communism, Asiatic and ancient slave society, feudalism, capitalism) on the way to achieving the final stage of communism. One might compare this view to the Darwinian evolutionary one by using the metaphor of two travelers. The Darwinian is a hitchhiker setting off across the unmapped terrain of a developing country where the roads are being constructed as he travels. Each time he reaches a junction, he must choose a new road that takes him ever farther toward an unknown and unknowable destination that he can never reach. The Marxian traveler, on the other hand, holds a prepaid ticket on the state railways. His route will inevitably take him through the stations at points A, B, C, and D along the line until he finally arrives at the glorious capital city at the end of the line. The only question is that of the schedule – it is well known that trains do not always run on time – so that some travelers may take longer than others to complete the same journey. There is also, of course, the possibility of derailment, but then it is just a matter of waiting patiently for the line to be repaired. Worst of all, of course, is the fate of the traveler who mistakenly boards a train moving down the line in the wrong direction – he is fated to be demolished by the fearsome "locomotive of history."

From the Darwinian perspective, however, there can be no locomotive of history because the tracks into the future have not yet been laid, and their course can only be determined by the actual process of building them. Evolutionary theory can only explain events that have already occurred; it cannot predict what will happen in the future, although analysis of past successes and failures can provide useful guidelines for designing systems that have a higher probability of withstanding future selective pressures.

We have no specific model of social system change of our own to propose, but we believe that one of the most important tasks of social scientists concerned with human ecology research on agroecosystems is to develop an approach that is compatible with the Darwinian model employed by their ecologist colleagues. This is particularly important because agroecosystem research, unlike much pure ecological research, is ultimately policy oriented. It is intended not just to describe how existing systems function but to suggest ways in which they may be changed in order to achieve specified human goals. Avoidance in future agricultural development programs of the social and economic problems attributed by some to the Green Revolution (increased wealth differences between large and small farmers, accentuation of differences between favored and marginal regions, etc.) will require us to have a far better understanding than we now possess of the dynamics of social system change in relationship to agroecosystem change.

SOME KEY QUESTIONS FOR HUMAN ECOLOGY RESEARCH ON TROPICAL AGROECOSYSTEMS

Granted that human ecology research should be policy relevant, the question remains of which particular problems should be addressed with what relative priorities. Given the complexity of the real world of the Southeast Asian farmer, there is almost an infinity of questions to consider. The strategic problem, in view of the limited scientific resources available in the Southeast Asian countries, is to choose wisely where to concentrate one's research efforts most productively. There can be no single correct solution because the needs of each country and region are different and the available scientists in each have differing interests and capabilities. It seems to us, however, that the following key concerns are of great relevance throughout Southeast Asia:

1. Assessment of the ultimate carrying capacity of various types of agroecosystems: As Conway discusses in Chapter 2, our ability to predict the point at which agroecosystems will collapse from being overstressed is sadly inadequate. Yet as productivity is increasingly pushed toward its biological limits, the danger of such breakdown increases. We need to know much more than we do about the causes of agroecosystem collapse, the indicators of its impending occurrence, and its social system consequences. These questions are nontrivial; we should remember that at least two great tropical civilizations, the Khmer of Angkor and the Maya of lowland Mesoamerica, are believed by many scholars to have broken up following catastrophic collapse of their subsistence systems.

2. Development of strategies for regenerating overstressed systems: In many areas in Southeast Asia, ecosystem productivity has already fallen as a consequence of human mismanagement. This is particularly a problem in the uplands, especially where swidden agriculture has been intensified beyond the limits the system can support. A key question, therefore, is to find strategies for regeneration of such degraded ecosystems that are both ecologically sustainable and socially feasible. In particular, it is necessary to design strategies that can be implemented with locally available resources and labor and that will provide the resources needed and desired by the affected human population.

3. Analysis of relationships between changing agroecosystems and the quality of human life: Much conventional development planning assumes the existence of a linear relationship between increased agricultural productivity and increased well being of the human population. Actual experience, however, is more problematic, as is the case of the unanticipated impact of the "Green Revolution" in some areas of increasing wealth, effecting inequalities between large and small farmers with consequent shifts in the social and political power of each class. Our present understanding of the linkages between environmental, technical, and social change is wholly

inadequate for predictive purposes, but there is certainly a great need for studies designed to increase our comprehension of these linkages.

4. Designing systems to cope with an unpredictable future: Given the obvious instability of the world's natural and social environments, with occurrence of wars, epidemics, natural disasters, and economic depressions a constant threat, a major research concern should be to design agroecosystems that offer maximum buffering capacity against such unpredictable perturbations. Again, such an approach goes in the face of conventional agricultural development thinking with its monistic emphasis on optimizing productivity of single cash crops. One key consideration may be to find ways to build variability into both ecosystems and social systems, a task of formidable difficulty in a world system that increasingly encourages both ecological and cultural homogenization.

DESIGN AND IMPLEMENTATION OF HUMAN ECOLOGY RESEARCH PROJECTS

A point repeatedly made throughout this book is that human ecology research is inherently an interdisciplinary endeavor, requiring contributions from both natural and social scientists. As Rambo states in Chapter 3, this does not mean that individual scientists should abandon their disciplinary interests and skills and become "human ecologists" instead. The skills of specialists are far too precious to be cast aside so lightly. What is needed, however, as Sajise discusses in Chapter 19, is for the research team as a whole to take on a "transdisciplinary" character. By this, we mean that all its members need to share a common framework within which to organize their individual and often highly specialized investigations.

A prerequisite for the development of such a transdisciplinary orientation is that all participants share at least a minimum common understanding of the aims and methods of human ecology research. It is particularly important to grasp the nature of systems in general (see Conway, Chapter 2), that of ecosystems (Marten, Chapter 4) and social systems (Rambo, Chapter 3) in particular, and the interactions that occur between these systems (the subject of the bulk of the chapters in this volume). Gaining such an understanding necessitates learning at least something about a wide range of disciplines. This is not an easy task given the specialized jargon and body of esoteric concepts that all of the specialized disciplines rely on for their internal communications. It is our hope, however, that the chapters in this book will help to make the development of a transdisciplinary perspective as painless and intellectually rewarding as possible.

Going beyond agreement on a common human ecology perspective, it is also necessary for all team members to achieve concensus regarding the specific goals of the research project. While in principle a relatively easy thing to accomplish in the natural sciences, this becomes extremely difficult when the social sciences become involved, given the political implications (using political in its broadest sense) of all research activity involving human beings as subjects. This issue becomes particularly acute in applied research projects where the goal is not just to understand reality but to discover ways to change it.

There is a continuing debate about the extent to which objectivity and value neutrality is possible in science. On the one hand, many natural scientists see science as wholly objective and value neutral; on the other hand, many social scientists, particularly those holding Marxist orientations, see science as inevitably value loaded, reflecting the class interests of the scientists and their sponsors. Our own position is somewhere in the middle. We recognize that scientific research inevitably has social implications and often does serve the interests of the more powerful sectors of society; therefore, we believe that scientists must consciously choose what and whose ends they wish their research to serve. At the same time, we believe that research itself must be done in as value free and objective a manner as possible. By this we mean that while the choice of objectives in an agroecosystem research project should be explicitly "political," the research itself should never be so. Those who believe otherwise might reflect on the consequences for Soviet agricultural development of imposition of dialectical materialism on the crop breeding program by Lyshenko and his followers.

Finally, we would like to emphasize that scientists engaged in human ecology research on tropical agroecosystems need to be concerned with the dissemination and application of results. Regardless of whether the intended client is the Minister of Agriculture or the poor farmer himself, the scientific findings of the project will go unused unless they are translated into terms understandable by the intended users. This means that either the scientists themselves must be willing to adapt their work so as to make it accessible to nonspecialists, or they must include specialists in their transdisciplinary team whose primary concern is with the dissemination. We advocate no specific solution to this problem, but we feel that it is one that demands attention.

CONCLUSION

In this chapter we have outlined a broad and comprehensive approach to human ecology research on tropical agroecosystems in Southeast Asia. As scientists who are ourselves deeply involved in such work, we are acutely aware of the tremendous gap between the ideal model that we have proposed and our present capabilities for implementing it. We are also all too aware of just how contingent our understanding is of the nature of human interactions with tropical agroecosystems. There is much that we do not know and, even more of a problem, much of what we think we know may be in error. It is our hope, however, to attract more scientists into this young field in the belief that through their involvement they will contribute new and better models for future use by all of us, regardless of discipline or nationality.

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CHAPTER 2

What is an Agroecosystem and Why is it Worthy of Study?

Gordon R. Conway

THE FARMER'S WORLD

To answer the questions posed in the chapter title, I feel it is best that we begin with the farmer and his farm. Figure 2.1 illustrates most of the components of a generalized small farm in Southeast Asia. At the core of a farm is the farm household; the farm boundary contains all the farm resources that the household owns. The household utilizes these resources, plus a variable number of inputs to produce crops, livestock, crafts, and other farm produce, which are either consumed by the household or marketed as the farm output. The farmer and the farm also interact with many other "systems" outside the farm (e.g., markets, the local community, technology).

This is the farmer's world. It is the heart of agriculture. We know why we study agriculture: It is in the belief that we can help farmers and their families achieve higher standards of living and a better quality of life, through our knowledge of better techniques and methods and by providing improved inputs and improved demand for outputs. But why do we need to study agricultural systems?

Fifty years ago we would not have needed to ask such a question. Then, virtually all agricultural scientists came from a farming background, and in their courses at universities and agricultural colleges, they learned about all aspects of agriculture. If you took them away from their universities and gave

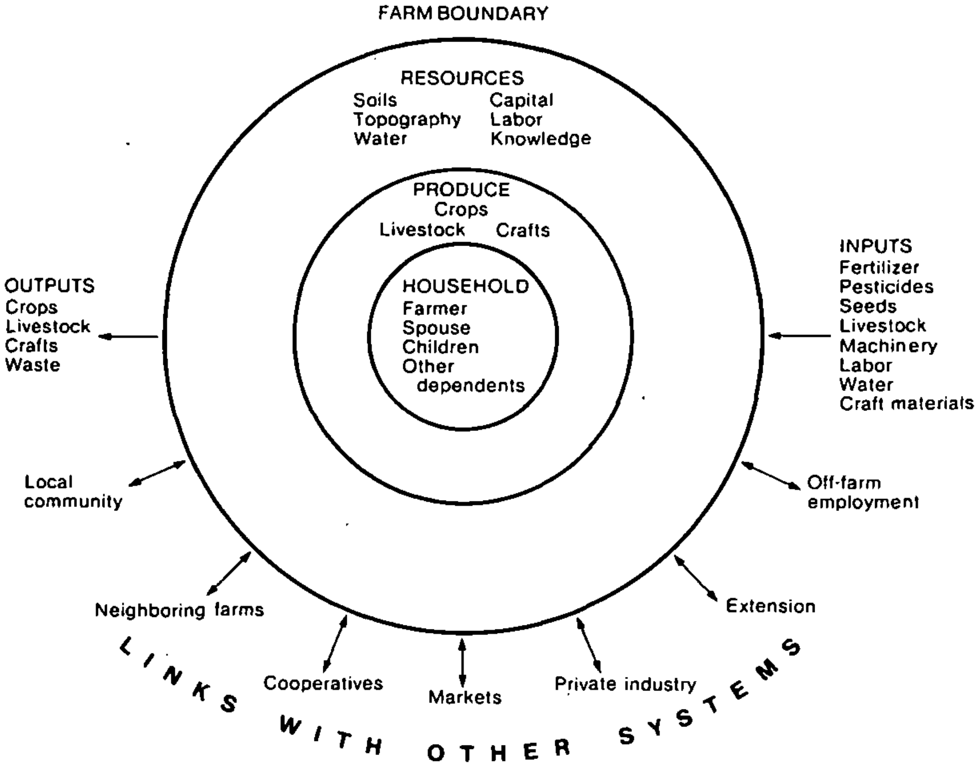

Figure 2.1. Generalized model of Southeast Asian farm.

them a plot of land, they would probably have made a good living as farmers. Today, however, agricultural science has become complex. Many students come from urban backgrounds, and their university training rapidly becomes highly specialized. They become plant breeders or entomologists or agricultural economists, and they soon lose sight of the farm as a system. They come to ignore the "forest" because they look too closely at the "trees." If you took them away from their universities and gave them a plot of land to farm, they would probably starve to death.

THE PROBLEMS OF SPECIALIZATION

We are all aware of the many problems this overspecialization creates. Here I will give three examples.

I recently carried out an experiment on rice. In the course of the experiment, I noticed there was something wrong with my rice plants – the older leaves were turning orange from the tip downward. I consulted a soil scientist and we analyzed the leaves and the soil; I consulted an entomologist and we searched for insects; I consulted a plant pathologist, who also looked at the plants carefully. After several weeks we decided it was probably a bacterial infection although the pathologist was a fungal expert and could not be sure. The farmer, of course, cannot afford to consult all these experts. He has to look at a problem, decide what it is, and what he should do quickly. With luck he may be able to find an extension worker who knows all the problems of rice and can advise him in much the same way that a veterinarian can tell him why his cow is sick, irrespective of whether the problem is a pest or disease or the soil.

Another problem is that many branches of agricultural knowledge have become so specialized that they are incomprehensible even to other agricultural scientists. Soil science is a particularly bad offender (although there are others as bad, including my own discipline, entomology). Soil science is complex and has developed its own special jargon, especially in soil taxonomy. If you ask a soil scientist what the soils are in an area, you will probably be given a complex soil map, covered with numerous strange symbols or a lengthy explanation that leaves you none the wiser. Often the agronomist gives up and continues with his or her agronomic work largely ignoring the soil, except perhaps for nitrogen, phosphorous, potassium, and hydrogen.

A third problem concerns social science. Here the problem has a different twist to it; our specialization tends toward a kind of blindness. We all acknowledge that we need entomologists or soil scientists, but because we are human we automatically believe we fully understand other human beings and that we do not need social scientists to tell us how farmers or any other class of people behave. When asked what motivates a farmer, we usually reply "profit" or perhaps in some cases "subsistence" and leave it at that. When confronted with an apparently irrational act, we assume the farmer is either not well informed or the practice derives from an old tradition that has lost its relevance. Usually, in both cases, the answer is much more complex; indeed, as complex as the answer to a problem in soil chemistry. We need social scientists who can carry out *rigorous analysis* on these and other questions and provide comprehensible answers.

AN INTERDISCIPLINARY APPROACH

My argument, of course, is not that we should do away with specialization. Agriculture is complex and we need specialists of all kinds (including social scientists). However, what we also need are ways of getting specialists to understand each other better and to work together efficiently on problems that they agree, and the farmers agree, are important. We also need a few people who will spend most of their time trying to understand agricultural systems as a whole and not from some highly specialized aspect.

Harwood (1979) describes farm systems and their needs clearly in his book. I would like to quote the foreword to the book by C. McClung.

> In much of the tropical world, when one looks over the countryside, he sees not uniform fields of waving grain but a patchwork of small fields containing mixtures of crops. And even in regions where a crop like wheat or rice dominates the landscape for a few months, farmers are likely, immediately after harvest, to plant a totally different crop or combination of crops. The small farmer in the tropics employs intricate farming systems to adjust to seasonal changes in temperature, rainfall, marketing conditions and the availability of family labor. Through these systems, also, he survives the unpredictability of his environment.
>
> The interactions in tropical farming systems are complex. A small change made at one point in the system may set off far reaching tremors elsewhere in the system. Science has much to contribute to these farming systems. But to do so, researchers must be usually adept at seeing the world from the farmer's vantage point.

The farmer, of course, lives with this complexity. He is accustomed to it and for much of the time it does not frighten him. He even profits from it, learning to utilize subtle interactions to get better crops. Let me cite an example. In one of our experiments at Chiang Mai, we found that under certain conditions, a local rice variety gives higher yields if it is drought stressed. Recently in visiting a village we observed that in some fields the farmers regularly and deliberately drought stress the rice plants and get better yields.

What the farmer does is partly learned from his ancestors, handed down by generations of farmers, and it is partly the result of his own trial and error learning. Most farmers are innovative in at least some aspects of farming, although it may not be very obvious. Many things farmers do are done consciously and can be clearly and logically explained by the farmer himself; many actions the farmer is barely conscious of, however, and if questioned can provide little rational explanation.

Compared to the farmer, the individual agricultural scientist has a narrower range of knowledge, but it is deeper and within its range more complete. There is much the specialist knows that the farmer is not aware of and the farmer can probably use. But, where the farmer tends to be superior, at least at the practical level, is in those areas of knowledge where the specialist disciplines overlap (Figure 2.2), and it is precisely here that knowledge is most crucial in improving the performance of the farm.

THE SYSTEMS VIEWPOINT

The challenge is, "How do we improve our cross-disciplinary knowledge, particularly as it relates to what the farmer does or would like to do?" One answer is simply to put many disciplines together to work on a single problem. They can then rub shoulders with one another, perhaps argue with one another, and, hopefully, something useful emerges. This is a multidisciplinary approach but it is not necessarily efficient and the insights gained are often mundane and superficial.

What is needed to improve efficiency are to organize concepts or frameworks that encourage the disciplines to interact with one another in a way that produces insights, which significantly transcend those of the individual disciplines. In other words, we are seeking concepts that promote a truly interdisciplinary approach. The appropriate concepts, I believe, are those of the system, the ecosystem, and the agroecosystem.

There are two schools of thought about what constitutes a system. Spedding (1979) defines a system as:

> . . . a group of interacting components, operating together for a common purpose, capable of reacting as a whole to external stimuli: it is unaffected directly by its own outputs and has a specified boundary based on the inclusion of all significant feedbacks.

This is essentially an anthropocentric definition. The investigator first defines the purpose and then draws the boundary accordingly. If the purpose is to provide food, the boundary is drawn in one way: if it is to produce cash, it is drawn in another and so on. It does not assume that systems actually exist in the real world but that a system is a convenient way of looking at the world and organizing the information available.

I prefer to believe, based on my experience of ecology, that systems actually exist in the real world – even if they may be difficult to detect and identify. The central notion is that in the real world a set of separate elements or components interact to produce a higher level of organization, which, in

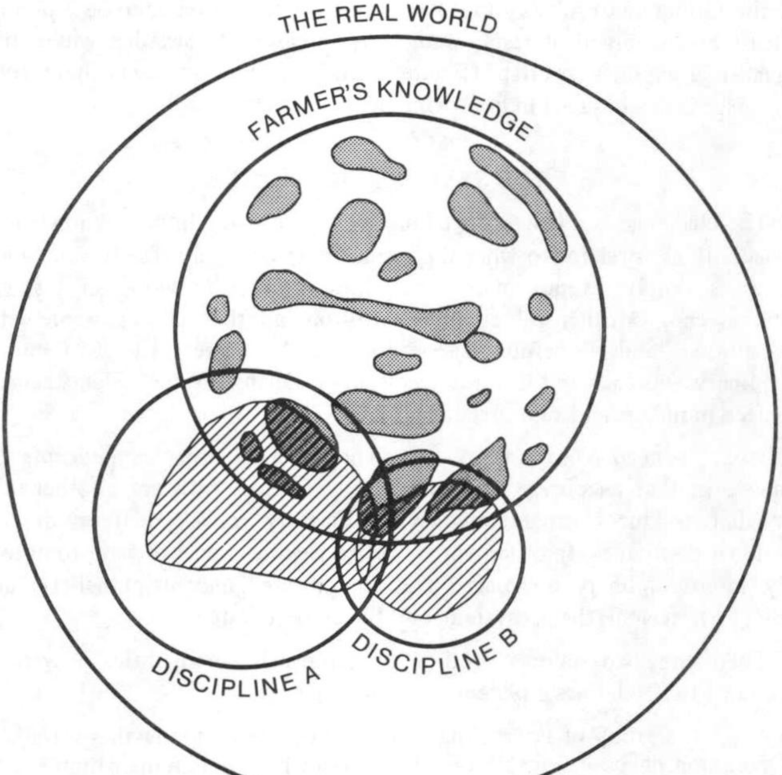

Figure 2.2. Overlapping knowledge of the farmer (shaded areas) and specialist agricultural disciplines (striped areas).

some sense, is "greater than the sum of the individual components." Let us consider, by way of illustration, a simple plowing system (Figure 2.3). It has many components – the legs of the buffalo, the body of the buffalo, the head of the buffalo, the legs of the man, the body of the man, the head of the man, the arms of the man, the coulter of the plow, the handles of the plow, the rope that links the plow to the buffalo, and so on. The individual components have little significance of their own; jumbled together they are also meaningless but arranged in a certain pattern and linked by particular interactions they can efficiently plow the soil. They become a system.

I prefer to define a system as a set of components linked by many strong functional relationships to produce a behavior of the whole which is distinctively different from that of the individual components acting in isolation. In particular, the behavior of the system is less variable than the behavior of the individual components.

The second sentence explicitly links the notion of homeostasis with that of systems. It is a concept we are all familiar with. We know, for example, that the body temperature of the system we call a human being is constant at 98.4°F (37°C); it is much less variable than the temperatures of the individual cells, tissues, and organs that make up the system. Similarly in a plowing system the individual legs and arms and pieces of wood can go in all directions, but they are constrained by the feedbacks inherent in the system to operate so as to plow the land.

Homeostasis, however, is not the only system property. The human body exhibits a property of growth; the plowing system shows efficiency. Each system possesses a range of properties or behaviors, and which of these we focus on depends on our interest.

ECOLOGICAL SYSTEMS AND AGROECOSYSTEMS

In nature we can identify three kinds of ecological systems: populations, each consisting of a set of individuals; communities, each consisting of a set of populations; and ecosystems, consisting of populations and the physicochemical (abiotic) components of the environment with which they interact.

The basic components of an ecosystem are shown in Figure 2.4. The example most commonly cited in textbooks is the pond or lake. It is easily recognizable, largely because the physical boundary, the edge of the pond, is very clear. Apart from the inflow and outflow of water, there is little interchange across the boundary. The significant interactions, which produce the pond's distinctive behavior, occur within this boundary.

From such a natural ecosystem, it is a relatively short step conceptually to the agroecosystem. Take, for example, the plot of wet rice, the ubiquitous agroecosystem of Southeast Asia. The boundaries are the bunds or dikes and, apart from the inflow of irrigation water and sunlight, the significant

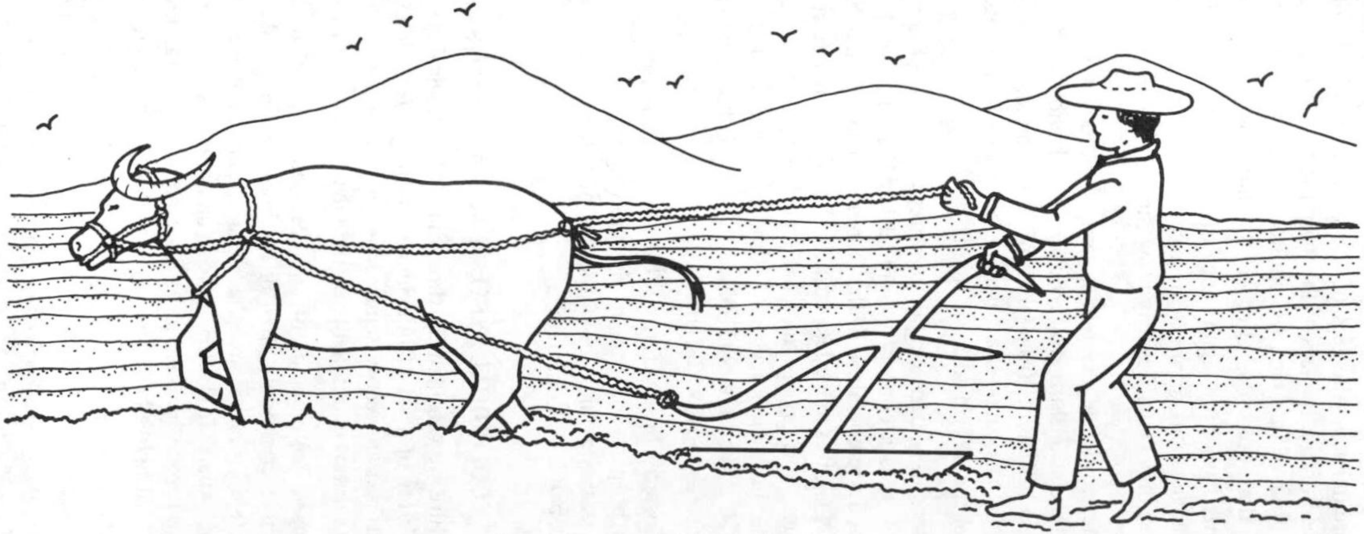

Figure 2.3. A simple plowing system.

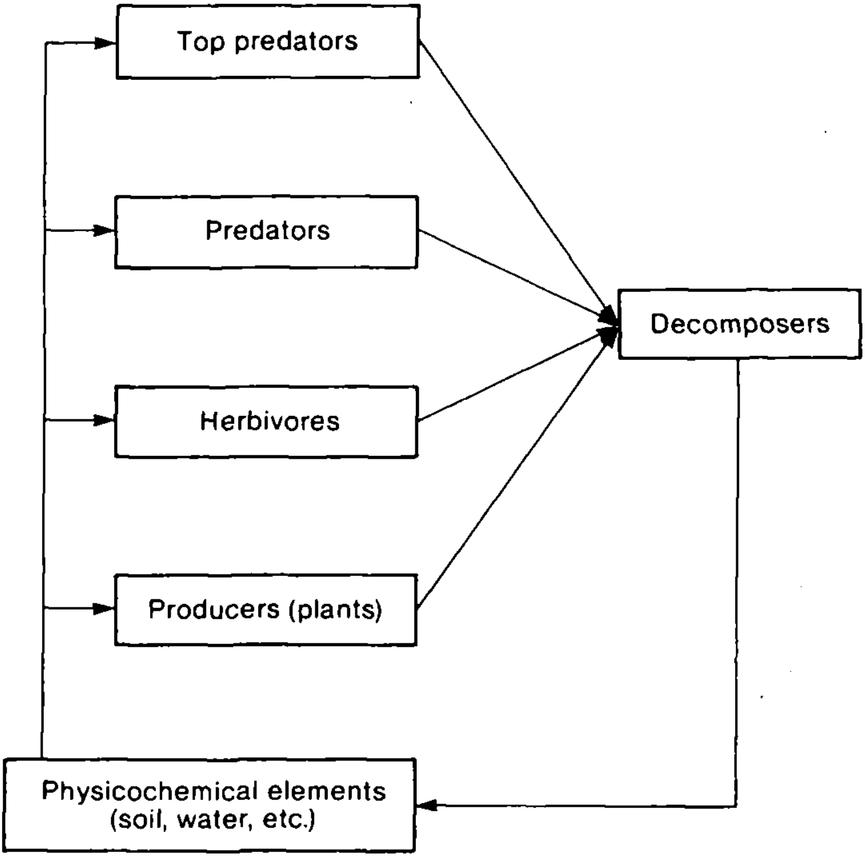

Figure 2.4. A generalized ecosystem.

interactions that give the ricefield its distinctive properties are contained by the bunds. Within the boundary nitrogen is generated, nutrients are drawn from soil and the plants, their pests and diseases compete for these in a struggle for life, growth, and reproduction. The transition from ecosystem to agroecosystem, however, involves several significant changes. First, the system becomes more clearly defined. Man makes the boundaries more sharp and less permeable. Second, the numbers of natural or biological components are reduced. Third, the important interactions are modified and regulated by man. Fourth, and finally, the inclusion of man in the system, his social, cultural, and economic activities, reintroduces considerable complexity but of a different nature.[1] It is this rich, new complexity, and the new system properties it generates that are the subject of this book.

SYSTEM HIERARCHIES

The next question is, "How do we go about analyzing such systems?" I will confine myself here to two fundamental points.

The first point is that, in nature, systems are characteristically arranged in a hierarchical order. A good example is the hierarchy of biological systems (Figure 2.5). Here each system is nested in the systems above it; one system becomes a component of the next in the chain. An important feature of such hierarchy is that as you go up from one system to the next you pass to a higher level of organization. Each system, to some extent, controls the others beneath it. Most importantly, new and distinctive systems properties and behavior emerge at each level, and these are not readily recognizable simply by examining the systems below. It is not, for example, possible to discern or understand the behavior of a human being solely by looking at his genetic system, nor to understand an ecosystem by studying individual populations. This is a fundamental philosophical point with important practical implications. It is the basic justification not only for a systems approach but for interdisciplinary study.

Just as natural ecosystems are arranged in a hierarchy, so are agroecosystems, from the plant-soil-water system at the bottom, through the field, farm, village, watershed, province, to the national, and world market at the top (Figure 2.6). Again the principle of hierarchic control operates, and part of our task is to identify the new and distinctive system properties that emerge at each level.

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[1] Conway includes man and his social, cultural, and economic activities within the boundaries of the agroecosystem. The reader will note that this is a different approach from that advocated by the editors in the preceding chapter and by Rambo in Chapter 3. The latter treats humans and their activities as comprising a distinct subsystem that interacts with the agroecosystem but is not actually part of it. Although this difference may be significant when studying higher levels in the system hierarchy, at the farm and village level, where most agroecosystem research has been done to date, the two approaches produce essentially similar empirical results.

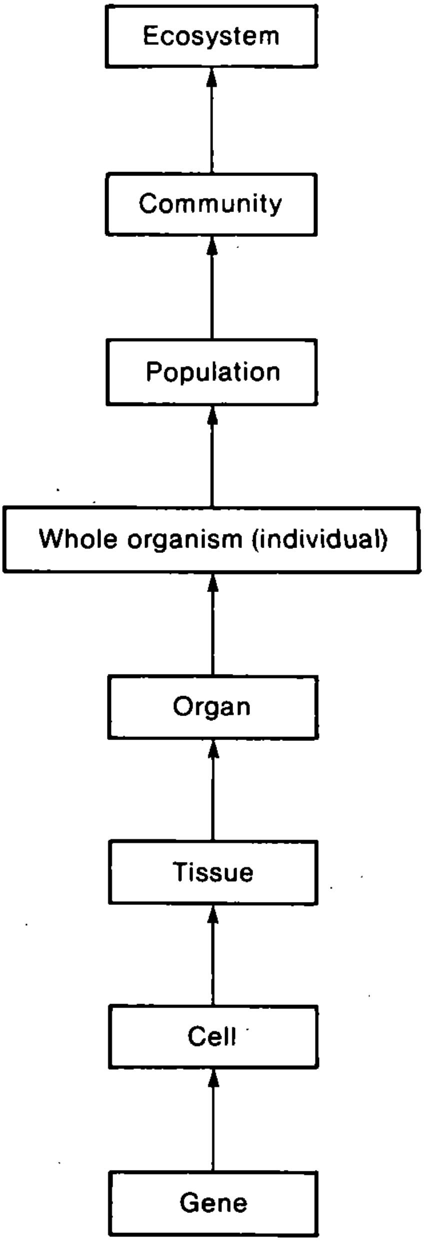

Figure 2.5. The hierarchy of biological systems.

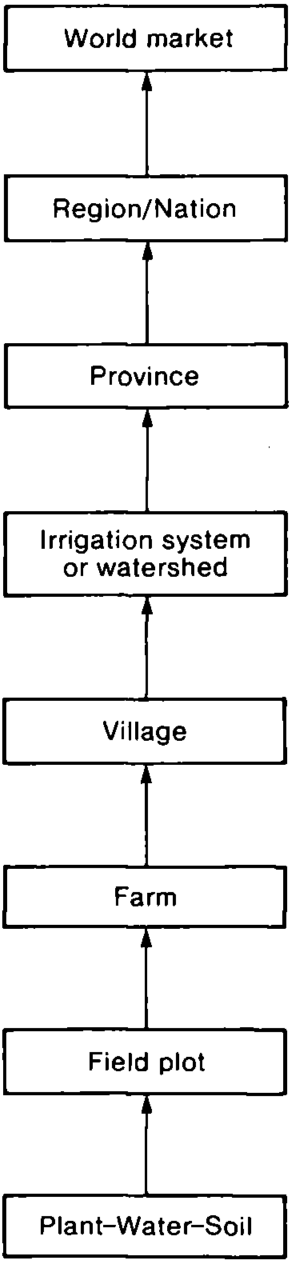

Figure 2.6. Hierarchy of agroecosystems.

SYSTEM PROPERTIES

My second point is that in studying agroecosystems with a view to improving their performance I believe we should focus on four major system properties. These are productivity, stability, sustainability, and equitability. They are easily defined, although not equally easy to measure. Their importance is that they provide a powerful focus for interdisciplinary study.

Productivity is simply the desired output of a system, measured in terms, say, of crop yield or net income. It is clearly a system property. We can appreciate, for example, that the yield of a field of rice is not the simple sum of the yields of individual rice grown alone but is a complex outcome of the process of competition for light, water, and nutrients within the population of rice plants in the field.

Stability is the property of short-term homeostasis. How constant is the productivity in the face of environmental change? We can measure it by the coefficient of variation of yield or net income. It is also clearly a system property. For example, the stability of yield of a rice field is partly a function of the process of herbivory existing between the rice plants and their pests, which in turn is a function of the process of predation existing between the pests and their natural enemies.

The third property is sustainability. This is the ability of a system to persist in the face of repeated stress or a major perturbation. For example, can an agroecosystem resist collapse given deteriorating soil structure, growing pollution, or the sudden appearance of a new pest or disease? Unfortunately, the interactions within a system that confer sustainability are difficult to identify, and the property itself is not easy to measure. It is easy to observe that a system has collapsed but not to determine how resistant to collapse a given system is. This is particularly unfortunate because an understanding of the sustainability of agroecosystems is becoming increasingly important for the future of tropical agriculture, an issue discussed by Rambo in Chapter 3.

The final system property is equitability. By this I mean the pattern of distribution of the products of the agroecosystem among the human beings who interact with it. This is also easy to measure; it is also clearly a system property, produced by some function of the relationship of people to capital, land, and to other resources, as well as to each other. It is far more than the other properties, primarily a property for social scientists to measure and understand.

These four properties can be used to characterize different agroecosystems (Table 2.1). We can think of A as a traditional system, B as a Green Revolution system, C as an improved Green Revolution system with a new emphasis on stability, and D, perhaps, describes the final goal of agricultural development.

Table 2.1. System Properties of Agroecosystems at Different Stages of Development

	Productivity	Stability	Sustainability	Equitability
A	Low	Low	Medium	Medium
B	High	Low	Low	Low
C	High	High	Low	Low
D	High	Medium	High	High

The task of development is to go from A to D. One of the problems is that these different properties are intimately linked to one another.

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CHAPTER 3

Human Ecology Research by Social Scientists on Tropical Agroecosystems[1]

A. Terry Rambo

INTRODUCTION

Beginning some ten thousand years ago, the domestication of plants and animals began to change man's relations with the Southeast Asian environment. This transition is often labeled by historians as "the agricultural revolution" although, as Hutterer shows in Chapter 5, it is more correctly viewed as a gradual evolutionary process. In the course of this process, man became the ecologically dominant species in the region, with numbers and biomass exceeding that of any other large terrestrial mammal. A human population that probably did not reach one million before agriculture numbered some 150 million by 1940 (Dobby 1950).

Following World War II and the subsequent national liberation struggles, a second agricultural revolution began – a revolution that is having even more profound social and environmental impacts than did its predecessor. Unleashed by new technological forces and driven forward by exponentially

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[1] This is a revised version of a paper entitled "Human Ecology Research on Tropical Agroecosystems in Southeast Asia," which appeared in the *Singapore Journal of Tropical Geography* 3 (1) 1982:86-99. Reprinted by permission of the publisher.

expanding human populations with ever greater demands for resources,[2] this second agricultural revolution is again transforming man's ecological role. No longer simply a dominant species in terms of being most numerous, *Homo sapiens* has become an environmental manager, assuming responsibility for designing, constructing, and maintaining the ecosystems on which he depends for his continued survival. This shift from dependence on self-regulating natural ecosystems to anthropogenic systems requiring continuous human management is particularly important with regard to production of food and other biologically-derived resources. Agricultural ecosystems or, to use the shorter term, agroecosystems, are prototypical neosystems and it is on successful management of these highly complex systems that the present and future welfare of Southeast Asia's human population depends.

As Conway pointed out in the preceding chapter, successful management of systems having the great complexity of tropical agroecosystems represents an immensely difficult task, one requiring far greater scientific understanding than is currently available. Not only is it necessary to understand the interactions between crop plants, soils, weather, water, livestock, weeds, diseases, and animal pests that make up any particular agricultural ecosystem, but one must also take into account the behavior of the human beings who both manipulate the system and depend on its products for their survival. The problem is, therefore, fundamentally one of human ecology – the study of human interactions with the environment – and its solution requires large-scale, long-term cooperative research by both natural and social scientists working together in the context of a common human ecological perspective on tropical agroecosystems.

Natural scientists working in Southeast Asia have already made substantial progress in studying agriculture as an ecological problem, that is, applying the concepts developed in the study of natural ecosystems such as forests and grasslands to better understanding the structure and dynamics of tropical agroecosystems (Conway 1979, Conway and Romm 1973). Social scientists, however, have not yet been as successful in analyzing human interactions with these systems. This paper is concerned with showing why social scientists should be concerned with this problem and suggesting ways in which they may contribute to its solution.

THE SECOND AGRICULTURAL REVOLUTION IN SOUTHEAST ASIA

The transformation that the second agricultural revolution is making in man's relations with the Southeast Asian environment is proceeding on two

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[2] By 1980, some 350 million persons were living in the region, a number, which, given the rate of increase of 2 to 2.5 percent, will more than double by the turn of the century. For purposes of this paper, Southeast Asia is considered to include Brunei, Burma, Indonesia, Kampuchea, Laos, Malaysia, the Philippines, Singapore, Thailand, and Viet-Nam.

fronts through expansion and intensification. Expansion refers to the continual increase in the area of land devoted to agriculture, a process somewhat inelegantly referred to by agricultural economists as "extensification." Expansion has occurred primarily at the expense of the tropical rain forest, which formerly covered as much as 90 percent of the region. The pace of forest land conversion to agricultural use is dramatic: In Peninsular Malaysia, forests covered 74 percent of the country in 1957 but only 55 percent in 1977, with some 2,850 square kilometers (km^2) cleared for agricultural use during each of the last five years (Myers 1980, 81-83). Likewise in the Philippines, where three-fourths of the land was still forested at the end of World War II, only 38 percent was still under trees in 1976 with conversion to agricultural use continuing at the rate of more than 500 km^2 per year since (ibid., 95-97). Equally rapid conversion rates apply to Indonesia, Thailand, and Vietnam. Only Burma and Laos have failed to significantly expand the area devoted to farming (FAO 1980, 50-52).

Concurrent with this vast expansion of the area of land devoted to agriculture has been a pronounced increase in the intensity with which existing lands are cultivated as farmers strive to get ever higher yields from the same surface area. The process of intensification is perhaps best known to the public in the guise of the Green Revolution, based upon use of high yielding rice varieties, heavy application of chemical fertilizers and pesticides, and multiple cropping involving the raising of several crops per year on a single plot. Intensification, however, is also being practiced by swidden farmers in the uplands of the Philippines and Thailand who, in the face of growing population pressures, are shortening the fallow cycle, reclearing plots before mature forest can be reestablished, and by rubber growers in Malaysia and Indonesia who force up latex yields by application of chemical stimulants to their trees.

It should be recognized that the processes involved in the second agricultural revolution in Southeast Asia are comparable to those that over the past 150 years produced a great increase in agricultural productivity in the temperate zone countries. The tremendous rise in Western food production in this period reflected both expansion of area under cultivation, particularly in North America, Australia, and Argentina, and the simultaneous intensification of cultivation practices in western Europe and, considerably later, in the United States. Seed selection and breeding improvement programs, crop rotation and better tillage practices, use of pesticides and ever increasing rates of application of chemical fertilizers all resulted in a continuous rise in production per unit of land. Only in the early 1970s, with fertilizer application rates reaching several hundred kilograms per hectare, did the yield curve for American farmers begin leveling off. Production has now apparently reached a plateau, but at a very high level at that, and assuming energy supply limitations can be overcome so as to be able to continue the high level of inputs required to sustain such yields, no marked decline is likely.

ADAPTATION OF AGRICULTURE TO THE TROPICAL ENVIRONMENT

The second agricultural revolution must be carried out in Southeast Asia under much more difficult conditions than prevailed in the West, however, reflecting the different agricultural environment of the tropics. On the whole, the environment of Southeast Asia is an unfavorable one for farming, requiring very different management strategies from those employed in the temperate zones (Chang 1968, Janzen 1973). Outside areas of recent volcanic activity such as Java, soils are generally thin and nutrient poor, leached by millenia of heavy rainfall and depleted of organic matter by the frenetic bacterial action accompanying constant high temperatures. The same high temperatures and lack of seasonal cold spells encourage the proliferation of pests and diseases, both those that directly attack crops and, perhaps even more damaging in the context of human-managed agroecosystems, parasites like malaria and amoebas that sap the energy of the farmers themselves. The harshness of the environment for agriculture is shown by the fact that nowhere in Southeast Asia, even in the most carefully managed experimental plots, have yields consistently achieved levels considered average in the more temperate Asian countries such as Japan and Korea. Unless, therefore, agroecosystems are designed specifically to fit these conditions, they are unlikely to perform adequately on a sustained basis.

In the face of this gloomy assessment, the counter argument, with some justification, may be made that agriculture has in fact been successfully practiced for far longer periods in Southeast Asia than in the temperate zones. As Hutterer points out in Chapter 5, after more than thousands of years of trial and error experimentation, two extremely stable forms of agriculture have evolved in the region; wet rice cultivation in areas suitable for terracing, and shifting cultivation or swiddening in forested areas.[3]

It has been suggested that these traditional systems are successful because they mimic natural ecosystems: The rice paddy is a synthetic swamp and the swidden field resembles the rain forest which it replaces (Geertz 1963). In this view, they are stable because they are pseudo-climax communities. An alternative view is that presented by Sajise in Chapter 8. These traditional systems are sustainable because the farmer is able to use essentially free natural energy (the force of water in the paddy field, the force of fire in the swidden) to set back the succession to a pioneer stage favorable to the growth of crop species.

The ecological sustainability of traditional tropical agroecosystems is purchased at a price, however, and that price is low food productivity. This

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[3] A third system based upon cultivation of perennial tree crops was also locally important in the form of homegardens but gained tremendously expanded significance beginning in the nineteenth century with the spread of rubber and oil palm plantations producing industrial crops for international markets (Pelzer 1948).

was an acceptable price to pay as long as population densities were low and human expectations limited, two conditions that no longer apply in most of the region. Simultaneous growth in human numbers and human demands has forced the pace of agricultural development, and government planners and individual farmers alike have sought to increase production at all costs.

Results have been initially favorable with a marked increase in total food production in the past decade. Thus, calculated against a base of 100 for 1969-1971, the per capita food production index in 1979 stood at 108 for Indonesia, 120 for Malaysia, 108 for the Philippines, and 123 for Thailand. Only Burma (96), Kampuchea (34), and Laos (98) suffered reverses (FAO 1980, 79-80). Increased production has been purchased at a price, however, with both expansion of acreage under cultivation and more intensified exploitation of existing farm land resulting in many unanticipated negative social and environmental impacts.

DISRUPTION OF EXISTING SYSTEM BALANCE: ENVIRONMENTAL AND SOCIAL CONSEQUENCES OF AGRICULTURAL EXPANSION

The social and environmental consequences of the rapid expansion of the acreage under cultivation are numerous but poorly understood and documented. Poorly planned forest clearance alters hydrological cycles, reducing absorptive capability of upland catchment areas and increasing the magnitude of downstream flooding following heavy storms. Availability of water in dry periods may also be lessened although this effect is less well documented (Hamilton 1981). Many agricultural uses also produce much higher soil erosion rates with consequent increase in the rate of siltation of dams and lowland irrigation works. Clearing forest reduces supplies of timber and fuelwood. It may also lower the availability of protein for human consumption by destroying the habitats of game animals. A major concern is the increased rate of extinction of many poorly known wild species with consequent loss of their genetic resources (Myers 1979). Replacement of forests by cultivated crops also results in local climatic change, with increased diurnal temperature variation and decreased relative humidity (Rambo 1980b) and may even contribute to long-term global temperature changes through decreasing albedo with increased retention of solar radiation.

The social consequences of agricultural expansion in Southeast Asia are equally profound. Large-scale movement of settlers belonging to dominant national ethnic groups into frontier areas traditionally inhabited by cultural minorities may cause conflicts, as exemplified by the on-going struggle between Christian settlers and Muslim inhabitants in Mindanao and similar conflict over the past 50 years involving ethnic Vietnamese moving into the forested upland areas traditionally controlled by the montagnard tribes. Even where the expansion process has been essentially peaceful, as in the case of Indonesian transmigration projects and the FELDA schemes in Peninsular

Malaysia, social costs have often been high, including the development of heavy settler dependency upon the government (Rokiah 1978), increased vulnerability to market fluctuations, and a serious lowering of health and nutritional status (Meade 1976).

OVERSTRESSING SYSTEM CAPABILITIES: SOME LOCAL AND ENVIRONMENTAL CONSEQUENCES OF INTENSIFICATION

Intensification of agriculture in Southeast Asia is also producing profound environmental and social consequences. Among the more readily visible social consequences are decreases in the autonomy of local communities and their increased dependence on imported farm inputs, particularly petroleum, fertilizer, and pesticides (Soemarwoto 1978), increased social and economic inequality, and disruption of traditional village welfare institutions (Collier and Sòentoro 1978). Environmental impacts include the loss of irreplaceable genetic resources as locally-adapted cultivars are displaced by a few improved varieties, greatly increased pest and disease problems, and contamination of soil and water with chemical pesticides. Even more disturbing is the emergence of evidence that intensively worked tropical agroecosystems may be beginning to break down as they come under mounting environmental stresses.

In the Chiang Mai Valley in Northern Thailand, for example, plots that yielded approximately 4 metric tons of paddy per hectare under traditional management practices initially responded to intensified management yielding up to 7 tons. After ten years, however, yields had fallen back to traditional levels *despite continued high inputs of lime and fertilizer.* Yields of legumes planted as the second or third crop have also fallen dramatically, reflecting runaway increase in soil acidity. The scientists of the Chiang Mai University Multiple Cropping Project who have been conducting this experiment conclude that "...the problem is a very complex one, the decline in soil stability being related to the increased cropping intensity under high input 'improved' management" (Gypmantasiri et al. 1980, 92).

Complexity is the key word with regard to the problems that must be confronted in attempting to improve the productivity of Southeast Asian agriculture.[4] It is necessary to understand not only the immensely complicated interplay between the crop plants, soil, climate, pests, water, and animals making up these agroecosystems but also the even more complex interactions between these biophysical components and the humans who

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[4] Persons familiar only with monocultural temperature zone agricultural systems may have some difficulty in grasping the enormously greater complexity that characterizes many tropical agroecosystems. An Iowa cornfield has only one dominant crop species, *Zea mays,* with perhaps a dozen weed species and as many more kinds of insects. A swidden plot in the Philippines may have as many as 80 cultigens (Conklin 1957), plus a large but uncounted number of weed and insect species. A Northeastern Thai paddy field may include as many as 600 plant and animal species, of which at least 18 are directly consumed by man (Heckman 1979).

attempt to manage these systems and who depend on their yields for their survival. The problem of agricultural development in the region is thus not simply a technical agronomic one, or even an ecological one; it is preeminently an issue in human ecology, involving the study of human interactions with tropical agroecosystems. As such, its solution cannot be achieved by scientists from any single discipline, but instead requires the contributions of natural and social scientists from a wide range of disciplines, working together within a common, human ecological perspective.

THE HUMAN ECOLOGICAL PERSPECTIVE

As was discussed in Chapter 1, human ecology is not a discipline and there are no such specialists as "human ecologists." Instead, human ecology is a perspective, a way of looking at man's relations with the environment, that can be employed by researchers drawn from almost any discipline. Historian McNeill, for example, in his recent book *Plagues and Peoples* (1979) has employed a human ecological framework in his pioneering exploration of the influences exerted by disease organisms on history. Anthropologist White (1943), biologist Odum (1971), and biologists Odum and Odum (1976) have examined the implications for social development of increases in human ability to capture energy from the environment. Social historian White (1967), geographer Tuan (1968), and biologist Hardin (1968) have discussed ways in which religious and philosophical beliefs may influence human management of the environment. All of these scholars, representing a variety of natural and social science disciplines, have been concerned with problems falling within the domain of human ecology, and all can be said to have employed a human ecological perspective.

The common characteristic of these studies is that they are concerned with interactions between what are normally thought of as wholly separate and distinct aspects of reality, the natural world and the social world. This division between man and nature represents a fundamental dichotomy in modern Western thought patterns, and, if one is to accept the views of the French anthropologist Claude Levi-Strauss, is an inherent cognitive schism in all cultures, primitive or modern, eastern or Western. In any case, it is a basic division in the organization of modern scientific thought regardless of the nationality of the scientists. In Southeast Asian universities, as in Western universities, natural scientists are placed in separate departments and almost always work in physically separate buildings from the social scientists. One group deals with nature, the other culture, and never the twain shall meet. And yet, if complex problems of human interactions with tropical agroecosystems are to be understood, ways must be found to bridge this gap and generate genuine transdisciplinary human ecology research.

There is, however, a fundamental obstacle in the way of scientists seeking to engage in human ecological research: That is the lack of a common paradigm or framework around which to organize their individual studies. As Sajise points out in Chapter 19, developing such a framework is essential for the carrying out of transdisciplinary research. All may agree that it is important to study the current transformation of Southeast Asian agroecosystems but that does not ensure that the sociologist and the soil scientist, the geographer and the agronomist, the anthropologist and the plant geneticist are going to be able to effectively integrate their individual research efforts into an effective interdisciplinary attack on the problem. Instead, each specialist will tend to phrase his research in terms of the conventional assumptions of his own discipline and is likely to have great difficulty in relating his own work to that of scholars from other disciplines.

What is badly needed is a single conceptual framework for human ecology research that clearly indicates the relationships between the diverse facets of reality studied by scientists from different natural and social science disciplines. Several alternative frameworks have been proposed (see Rambo, 1983, for a review of these major paradigms). Of these, a systems model of human ecology appears to have particular utility from the standpoint of designing interdisciplinary research projects on human interactions with tropical agroecosystems.

The systems model of human ecology was designed in recognition of the fact that social scientists and natural scientist are professionally equipped to study distinct conceptual entities. Social scientists are best prepared to deal with ecological systems, including agroecosystems. Therefore, it makes little sense for sociologists to take soil samples or for agronomists to survey farmer attitudes and values. Rather, each specialist should continue to work within his area of professional competence but always bearing in mind the need to relate his own research to the overall goals of the agroecosystem research project team as a whole. The systems model of human ecology is useful in that it suggests plausible points of interconnection between social and ecological systems. These linkages involve flows of energy, materials, and information, both from one system to the other, and between the individual components of each system (Figure 3.1). It is these linkages that constitute particularly strategic targets for interdisciplinary research on the human ecology of tropical agroecosystems.[5]

The greatest value of this sort of model is that it encourages scientists from diverse disciplines to phrase their research in terms of certain common analytical currencies and thus permits communication across disciplinary lines. Ecologists can and do study the flow of energy between components of an ecosystem but social scientists can equally well study energy flow between components of a social system, and scientists from both camps can be concerned with analysis of the flow of energy between their respective

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[5] Much research also still needs to be done on individual components of both the social and ecological systems (e.g., studies of kinship systems or land tenure patterns, species diversity or reproductive cycle) but such work, however important and scientifically useful, falls clearly within the domains of established disciplines and is therefore not included in the present discussion.

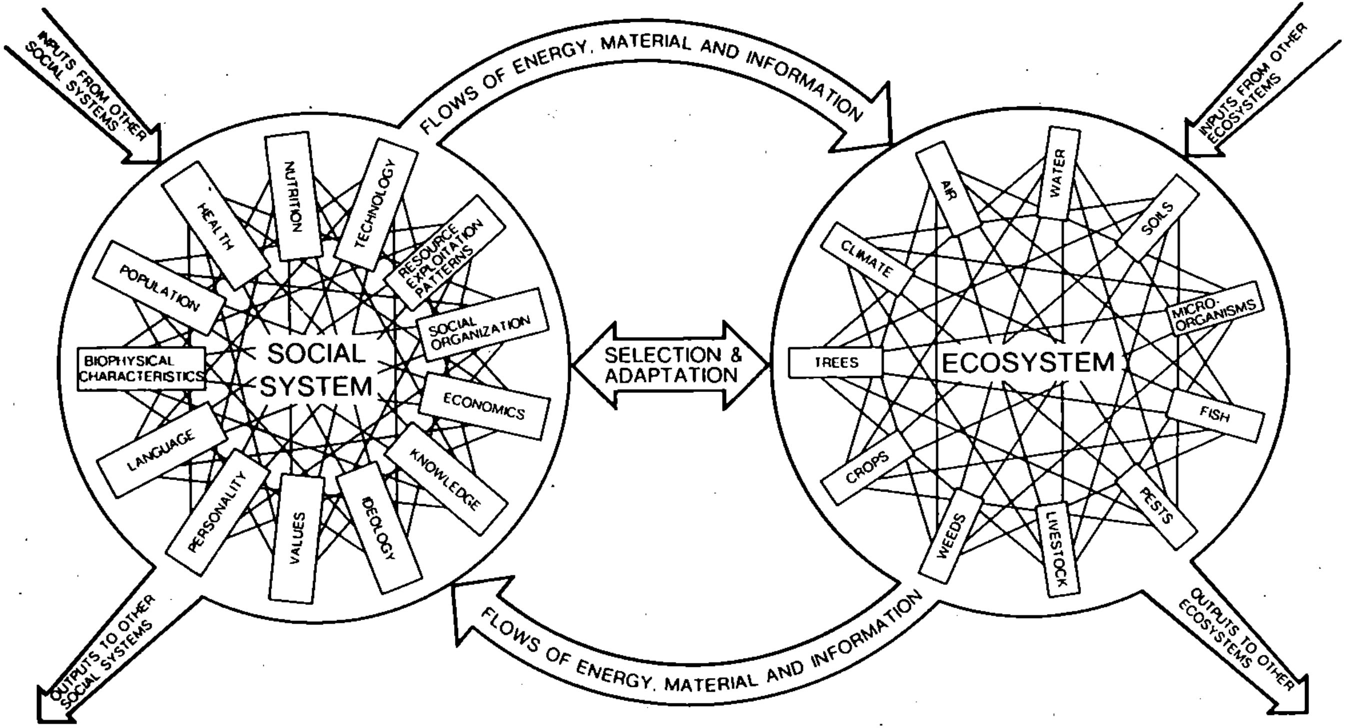

Figure 3.1. Social system-ecosystem interactions.

systems. The same is true with regard to analysis of material and information flows. Ultimately, of course, the goal should be to understand the total relationship between social systems and agroecosystems so as to see how each exerts selective pressure on the other. Such holistic understanding will be necessary if the long-range objective of developing better mutual adaptation between the two systems is to be achieved. An approach of this type is probably beyond present limited human ecology research capabilities in the region, however, so that the remainder of this paper focuses more narrowly on some specific questions that social scientists may profitably investigate with regard to the flow of energy, materials, and information between social systems and agroecosystems in Southeast Asia.

Energy Flow

In simplest terms, energy is the ability to do work and all systems, natural or social, require energy in order to function. Beginning in the 1940s with the publication of Lindeman's key paper on "The Trophic-Dynamic Aspect of Ecology," the analysis of the flow of energy through ecosystems has been a central concern of ecologists, but only recently has the importance of energy in agricultural development been widely recognized.

Recently, techniques for studying energy flow in natural ecosystems have been applied to analysis of the functioning of agroecosystems, with results both surprising and disturbing. It has been found that modern mechanized agriculture is immensely costly in energy terms with inputs of fuel needed to power farm machinery and produce fertilizer and pesticides sometimes equaling or even exceeding the energy value of the food produced. According to one set of calculations (Steinhart and Steinhart 1974), when the operation of the whole American food production/processing/distribution system is taken into account, anywhere from two to ten calories worth of fossil fuel energy must be used to provide a single calorie of food to the consumer.

Given the growing cost and scarcity of fossil fuels, assessment of energetic efficiency has obvious significance for research aimed at improving the productivity of Southeast Asian agriculture. Already, some farmers in the Chiang Mai Basin have had to stop growing a dry season crop on higher elevation paddy fields because they can no longer afford to purchase gasoline to power their irrigation pumps. Therefore, ways must be found to run tropical agroecosystems with minimal dependence on fossil fuel inputs.

Some studies have suggested that traditional tropical agricultural systems are, in fact, already highly energy efficient. Rappaport (1971) has claimed, for example, that shifting cultivation by the Tsembaga in New Guinea yields 16 food calories for every calorie expended in agricultural labor. As is discussed in more detail in Chapter 9, his calculations omit the value of biomass energy consumed in burning the field; yet, it is the fire that actually performs most of the essential work in swidden agriculture (clearing the ground, softening the soil, providing fertilizer in the form of plant ash, and, most importantly, destroying pests and weeds). Inclusion of the energy of the fire in the efficiency calculations reverses Rappaport's findings with more than ten calories of work energy required to produce a single calorie of food (Rambo 1980a).

Other traditional systems of agricultural production may well turn out in fact to be more energy efficient than modern mechanized farming. Nguu and Palis (1977) found, for example, that cultivation of lowland irrigated paddies in the Philippines using water buffalo and human labor gave yields of 9.8 food calories per each work calorie, whereas cultivation using gasoline-powered tillers and chemical pesticides yielded only 7.9 food calories per each work calorie. The topic is clearly one deserving intensive investigation by social scientists, particularly agricultural economists and economic anthropologists who already have considerable expertise in studying farm household time and labor budgets, which can readily be adapted to more comprehensive analyses of agricultural energetics.

Of particular concern in developing improved management strategies is understanding the ability of the social system to channel energy efficiently back into making the agroecosystem work as planned. Some ecologically desirable sustained yield strategies may simply be unfeasible in practice because the farmers cannot mobilize sufficient energy to implement them. Schemes to reduce upland soil erosion in Thailand and Indonesia by extensive bench terracing of hill slopes, for example, cannot in practice be carried out without massive external subsidies because several thousand man-days may be required to construct a single kilometer of terrace, an energy expenditure far beyond the capacity of the population actually living on the land.

Ability to utilize available energy sources (both human and other) may also be constrained by cultural attitudes and values. For example, there is a continuing debate about the ecological impact of sacred cattle in India. Harris (1966, 1975) has argued that the supposedly excess animals resulting from the ban on cow slaughter actually serve to capture energy from the environment that would otherwise be wasted and transform it into forms useful to man (e.g., dung for fuel and fertilizer and traction power for farm work, a view given empirical support by Odend'hal's [1972] analysis). Others (Diener et al. 1978, Whyte 1968) have challenged this assessment, however, arguing that overstocking of cattle has substantially degraded the productivity of the Indian environment, thus effectively lowering the total flow of energy to the human population. The question is far from settled in this case, and there is clearly a more general need for detailed research on how cultural beliefs and values may influence energy utilization.

Another energy flow issue suitable for study by social scientists is that of ascertaining what actually happens to food energy following its harvest. Most discussions of world food shortages are simply based upon averaged estimates of per capita availability of calories, although in reality available food is never divided equally but is instead differentially apportioned between people of different age, sex, social, and class status. Thus, even at a time of bumper harvests, certain disadvantaged groups within a society may suffer from malnutrition. Current analyses in this field often suffer from ideological partisanship as in the case of the book by Lappe et al. (1977), *Food First,* which holds up Cuba, Tanzania, and the People's Republic of China – all massive grain importers – as models of food self-sufficiency, but this is only further argument for more careful empirical research by social scientists on the political economy of food energy flows.

In a more theoretical vein, anthropologists and sociologists have long been concerned with the relationship between man's ability to control energy and sociocultural evolution. White, in his seminal article "Energy and the Evolution of Culture" (1943), advanced the thesis that cultural evolution directly reflects man's increasing ability to harness energy from the natural environment, an argument also made by the sociologist Cottrell in his book *Energy and Society* (1955). White even proposed a simple formula C = E x T (in which C is the degree of cultural evolution, E is energy available per capita, and T is the technological efficiency with which available energy is used to do work). White's thesis has been accepted by many recent writers on the energy crisis, although remarkably little empirical substantiation exists in the form of detailed analyses of actual energy consumption rates in primitive and peasant societies. My own preliminary work on the problem indicates that at least some hunting and gathering and swidden farming peoples have far higher per capita energy use rates than do evolutionarily more advanced peasant farmers, suggesting that the relationship between energy and cultural evolution may be more complex than is allowed for by White's formula.

Analysis of the political implications of differential access to energy supplies is another issue of clear interest to social scientists. Adams (1975, 1978), for instance, has devoted considerable attention to how control over energy may affect political stratification. Lovins has also raised this question in his *Soft Energy Paths* (1977), arguing that adoption of so-called "hard energy" sources based upon centralized, high-technology power generation (nuclear reactors, for example) favors, indeed necessitates, concentration of political power in the hands of a technological elite; whereas reliance on decentralized, low-technology "soft-energy" sources, such as solar and wind power, facilitates the devolution of political power to local communities. The issue may seem a remote one from the swiddens and paddy fields of Southeast Asia, but it is reasonable to assume that similar social issues are raised in village communities by introduction of various alternative energy technologies. Social scientists might well consider, for example, the relative consequences for community autonomy and stratification of electrification through connection to a national grid, installation of biogas plants requiring continuing outside maintenance services, and planting of a community woodlot to provide fuelwood for simple household stoves.

It may be well to end this discussion of energy on a cautionary note. Following a well-established convention in ecology texts, including the present volume, energy flow has been discussed here before dealing with material and information flows, but this should not be taken to imply that analysis of energy flow should always receive priority in research on human interactions with ecosystems. Energy flow is likely to be important only when it results in the activation of materials and generation of new information. It, therefore, must always be studied in a systems context rather than being treated as an inherently significant "prime mover."

Material Flow

Often referred to in the ecological literature as biogeochemical cycling or nutrient cycling, material flow refers to the movement of chemical elements and compounds in the form of oxygen, carbon, nitrogen, water, etc., between the biotic and abiotic components of an ecosystem. Natural scientists studying material flow in Southeast Asian agroecosystems have been particularly concerned with two issues: (1) the supply of nutrients to crop plants, particularly the availability of nitrogen, and (2) the hydrological cycle, particularly with regards to soil erosion and the availability of water for irrigation. These are both areas of major significance for the functioning of social systems as well, offering numerous research questions for social scientists.

Nitrogen is not just important for the growth of plants; it is the basic chemical building block for the amino acids that make up protein, a key material in human nutrition. In addition to the shortage of calories, protein deficiency threatens the health and even survival of large numbers of Southeast Asians, particularly children, pregnant women, and lactating mothers.

Nutritional research in the region is still in its infancy. Such investigations could greatly benefit from participation of field-work oriented social scientists, particularly anthropologists and geographers, who can actually observe nutritional practices rather than exclusively relying on recall surveying. Such field study, for example, may reveal that people are relying on unconventional sources of protein that are omitted from conventional surveys. One of my students, who did a very thorough observational nutritional study of a Temuan Orang Asli Community in Peninsular Malaysia (Koh 1977), found that children obtained much of their own protein by catching small fish in rivers and flooded rice paddies in the course of their normal daily play. These fish were consumed on the spot without parental knowledge and were thus not recorded in conventional nutritional surveys. Obviously, increased use of agricultural pesticides that results in reduced fish populations, as has happened elsewhere in Malaysia (Tan 1978), has profound implications for the nutritional well-being of rural children.

Concern with maintaining supplies of protein may also influence the acceptability of agricultural innovations to peasant farmers. For example, in southern Viet-Nam, farmers refused to cooperate in a major government-sponsored campaign against the rice rat population, even though the rats consumed as much as 10 percent of the yield before harvest. Investigations by

Fred Stone, an International Voluntary Service agricultural adviser, revealed that the farmers involved were tenants who had to give their landlords at least half of the harvest. Rice rats were a major source of protein in their diet and the tenants retained 100 percent of the rats (Rambo 1973, 106).

There is already a considerable body of research by social scientists on how cultural beliefs and practices affect the availability of protein to people, particularly by prohibiting consumption of certain species, as in the case of the Muslim and Jewish tabu on eating pork or the general abhorrence in Western cultures of eating dog meat or insects. Such beliefs have obvious significance for the design of improved agroecosystems that are acceptable to the farmers.

Less obvious is the critical role that religion may play in maintaining the stability of traditional agroecosystems in the tropics. Rappaport (1968) has suggested that religious beliefs and rituals among the Tsembaga, a swiddening tribe in the New Guinea highlands, serve to ensure the maximum flow of protein to the human population during times of illness, injury, and warfare, periods when the body has greatest need for high-quality protein. According to Rappaport, the system works because religious beliefs only permit slaughtering pigs during ceremonies associated with curing rituals and war. McArthur (1974) has convincingly questioned the empirical validity of Rappaport's analysis, but the idea that rituals may regulate the flow of materials between social systems and ecosystems deserves further investigation. Omengan and Sajise (1981), for example, have suggested that Bontoc religious practices may serve to help channel nitrogen from the human population back into the paddy fields. These Philippine mountain people keep pigs for sacrificial use. The pigs are fed with household garbage and human feces, and the manure from the pigs is composted and returned to the irrigated paddies where it represents an input of approximately 250 kilograms of nitrogen per hectare per year.

The hydrological cycle may well be the material flow connecting human social systems and Southeast Asian agroecosystems that has been most carefully studied by social scientists. There is already a large body of research on the organization of irrigation systems and the control of water resources. A major deficiency in these studies, however, as Coward has observed (1980, 8), is the lack of attention paid to the environmental setting in which irrigation systems must operate, although a stronger ecological perspective is beginning to emerge.

Concern has ranged from detailed research on communal irrigation systems in the Philippines (Lewis 1971) to macrolevel theorizing on the influence that water control plays in the formation of despotic agrarian states. Sinologist Wittfogel (1957), for example, has advocated a theory of hydraulic civilizations, arguing that the need for a centralized bureaucracy to design and supervise maintenance of irrigation and flood control systems promoted the formation of a despotic central government in classical China.

The general applicability of Wittfogel's hypothesis has been the subject of considerable debate among historians and social scientists but, just as in the case discussed above of the social consequences of adopting alternative technologies for generating energy, it again calls the attention of social scientists to the need for examining interrelations between environment, technology, and social and political stratification.

In addition to cycling of nitrogen and water, numerous other material flows have direct impact on human welfare. In many upland areas in Southeast Asia, soils are extremely poor in the micronutrient iodine. This deficiency does not retard plant growth but consumption of iodine-deficient foods can lead to high incidence of goiter in humans. Polunin (1953) has suggested that swidden agriculture with its long rotational cycle may have real nutritional advantages under such conditions. There is also evidence that some food crops may actually induce goiter, an issue discussed by Chapman in Chapter 17.

Human agricultural activities in Southeast Asia may also have substantial impact on flows of carbon dioxide and particulate matter into the global atmosphere with potential major long-term impact on worldwide climatic patterns. The complex relationships affecting climatic change are still poorly understood, but it is recognized that burning of swidden fields and grasslands for pastures in the tropics is a major source of both CO_2 and particles – in fact may rival industrial activity as a source of such pollutants (Root 1976).

Information Flow

That ecosystem functioning involves the flow of information as well as energy and materials has only been recently recognized, a matter discussed at greater length in Chapter 12. Concern with information flow was pioneered by Margalef (1985), but the concept has perhaps received its fullest development by social scientists concerned with human ecology, particularly Duncan (1964).

In ecological context, information is simply organized or patterned energy or material, which tells the observer something about the past, present, or probable future state of an ecosystem or its components. Human response to environmental information is unique compared to other organisms in that it largely occurs at the cognitive level where cultural conditioning affects both perception and selection of appropriate response. Therefore, understanding the significance of information flow for human behavior should be of great concern to social scientists.

Most work to date by social scientists on information flow has dealt with ethnoecology and environmental risk perception. Ethnoecology is the study of how peoples in different cultures conceive of and classify their environments (see Chapter 13 by Lovelace). Developed mainly by anthropologists as part of ethnoscience, ethnoecological research has largely focused on folk taxonomy, the description of native systems for classifying and naming ecosystem components, particularly plants and animals.

Considerable research has been carried out on botanical classification systems of traditional agricultural peoples in Southeast Asia, beginning with Conklin's (1955) pioneering study of the plant taxonomy of the Hanunoo, a swiddening group on Mindoro Island in the Philippines. Conklin found that the Hanunoo have extremely detailed botanical knowledge, recognizing some 1,600 named plant varieties where a scientific botanist would identify only some 1,200 species. This difference reflects the fact that the Hanunoo taxonomy employs different principles than those followed in Linnean classification, grouping plants according to life form rather than in terms of genetic relationship.

Ethnobotanical and ethnozoological studies have been made in a number of primitive and peasant cultures in Indochina, Malaysia, and the Philippines but no comprehensive description has been published of the ethnoecology of any single group (this is reviewed in Chapter 12). Attention has also largely been focused on questions of classification and nomenclature to the exclusion of concern with folk knowledge of the structure and functioning of tropical ecosystems. There is considerable evidence, however (Conklin 1957, Dunn 1975, Rambo 1980c) that farmers in many Southeast Asian traditional cultures have detailed knowledge of many aspects of ecology and that such knowledge plays an immensely important role in their adaptation to a difficult environment.

Researchers at the Institute of Ecology in Bandung (Christanty and Priyono 1979) have found, for example, that placement of plant species in traditional Sundanese homegardens accurately corresponds to their actual photosynthetic requirements. They found that the farmers had a well-developed understanding of the light needs of various species and placed them in their gardens accordingly. When deviations occur, as with the planting of shade-loving betel vines in full sun, this is done deliberately in order to induce desired characteristics in the crop; in this case, producing leaves with a yellow color that are believed to taste better.

Farmer perception of environmental risk and consequent selection of appropriate production strategies is another important area for human ecological research on information flow. Geographers have developed interesting methodologies for measuring people's perception of environmental hazards such as floods and storms (Burton et al. 1978). These approaches might usefully be employed in studying why peasant farmers make decisions as they do, a question receiving a great deal of attention from agricultural economists and economic anthropologists (Barlett 1980).

Focusing on information flow may also offer possibilities for relating economics to human ecology through the application of techniques of benefit-cost analysis to agroecosystem research. Economists have traditionally been concerned with a single type of information – price – as measured in conventional monetary units. They have dealt successfully with commodities that have a market value but have generally found it difficult to incorporate environmental components that do not have a direct monetary value into their analyses. As Worachai describes in Chapter 14, benefit-cost analysis seeks to find ways, by focusing on nonmarket preferences and behavior, to assign realistic cash values to such environmental "externalities" so that their true ecological values will be taken into account in decision making about resource utilization (Hufschmidt and Hyman 1981).

As is the case with energy and materials, information can flow from the social system to the ecosystem, as well as from the ecosystem to the social system, but much less attention has been paid to the implications of the former than the latter process. Farmers in Southeast Asia do make at least some attempts to manage the flow of information to their agroecosystems, however, as is illustrated by the widespread use of scarecrows, windmills, and noisemakers to drive birds away from ripening grain fields. The practice of hand picking or stripping the leaves from apple trees in Java to induce fruiting in a nonseasonal environment might also be viewed as a case of human manipulation of information flow in the agroecosystem. It may be worthwhile for social scientists to examine other agricultural practices in the region from this perspective as well.

CONCLUSION

Development of agriculture as the primary mediator in the flow of resources from the environment to human populations in Southeast Asia has transformed man's ecological role from mere participant in natural ecosystems to manager of anthropogenic agroecosystems. Understanding this transformation and its environmental and human consequences represents a major scientific challenge. Many natural scientists have already committed themselves to studying agriculture in its ecological context, but as yet relatively few social scientists have become involved in human ecology research on Southeast Asian agricultural systems.

This reluctance may in part be explained by the fact that many social scientists, particularly those in developing countries, view environmental research with a certain suspicion, fearing that it may divert attention from urgent social and political problems (Beresford 1977). Certainly, in some cases in the Western countries, concern with "ecology" may have drawn attention away from problems of racial inequality, economic injustice, and war and peace. Concern with the welfare of nature can all too readily lead to indifference to issues of human welfare, an outcome rather frighteningly illustrated by some of the questionable notions of "lifeboat ethics" and international aid "triage" espoused by a few biological scientists involved in the environmental movement in the United States in the 1960s.

As I hope this chapter has demonstrated, however, research on human ecology need not represent a diversion of scarce social science resources in

Southeast Asia from concern with problems of human welfare. The majority of people in the region directly depend upon agriculture for their survival. Anything that affects the agricultural environment is therefore of direct and immediate importance for the quality of the life that they lead and consequently should be an issue of prime concern to social scientists.

Moreover, the interactions that occur between social and ecological systems through the exchange of energy, materials, and information have direct impacts on those issues that social scientists view as central to their work (e.g., questions of social, economic, and political stratification and inequality, ethnic identity and cultural beliefs and values, social and cultural change and evolution). To examine how changes in energy requirements of agriculture may affect the dependency of villagers on external agencies, or how religious beliefs may influence human management of natural resources, or how folk classification systems may influence design of farming systems, is not to be diverted by ecological faddism from dealing with significant social and political issues. Instead, it is to relate the central theoretical concerns of social science to the real problems facing the people of Southeast Asia as they seek to adapt to the profound changes in their existence resulting from the second agricultural revolution. It is by professionally coming to grips with these issues that social scientists can make their research directly relevant to enhancing the quality of life of the farmers on whom we all ultimately depend for our existence.

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