ECOLOGICAL PRUDENCE AND MODES OF RESOURCE USE

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CES Technical Report - 59

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January 1990

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PRUDENCE AND PROFLIGACY

A major theme of our project is ecological prudence and profligacy. The human species differs strikingly from the rest of animal creation in this context, for biologists have concluded that animals uniformly lack any restraint in their resource use, harvesting as much as they profitably can to satisfy their immediate interests. It is also believed that all animals breed as rapidly as they can, so that their populations are always pressing against the limits of food, disease, catastrophic mortality and all that works as a constraint upon population growth. The behaviour of our own species differs from that of our animal relatives in two important ways. Firstly, human societies occasionally do show restraint in resource use as well as on population growth. Secondly, human behaviour is far more variable. While some societies, in some phases of their history show restrained resource use or restrained reproduction, other societies at the same time, or the same society at different times may exhibit no such restraint. In the course of this exposition we hope to explore the forces that have shaped this remarkable mosaic of human behaviour.

Of Moose and Wolf

The well documented history of the moose and wolves of Isle St Royale on Lake Superior is considered as typical of what is happening everywhere in the living world (Mech 1966). Moose first crossed over to this island 540 square kilometers in dimension,

when a stretch of water separating it from the mainland was frozen solid early this century. Since there were no other large herbivores or predators, such as wolves, on the island, the moose, freed of competition or predation, multiplied quickly. The moose population was initially low in relation to its food resources, and the vegetation was undergrazed. However, as their numbers increased, the moose began to overharvest their food, there being no other limiting factor. At one point, therefore, the moose population reached numbers variously estimated between 1000 and 5000, a level at which the vegetation was tremendously overgrazed. Plant food then became a major limiting factor for the moose population which crashed to a low of less than 400-500 animals by 1936. It was thus evident that moose, presumably feeding as much as they could and breeding as fast as possible had tended to overharvest their plant food resources when their population was not checked by any other factor. As the vegetation grew back, the herd again expanded rapidly and suffered a second low of 200-500 by the mid-forties.

In 1949 Isle Royale was again linked to the mainland by an ice bridge. At this time a pack of timber wolves crossed over to the island. Like the first group of moose, these wolves found themselves in the midst of an abundant food resource, namely the moose population. With a high moose/wolf ratio, food was readily available and the wolf population, too, increased presumably at as high a rate as possible. During this phase the wolves seem to have been harvesting moose at levels greater than the annual increment to the moose population, because the moose population

is known to have declined. As the wolf population went up and the moose population went down, the moose/wolf ratio plummeted, increasing the cost of hunting moose. The moose and wolf populations are now stabilized at 600 to 1000 moose to 20 to 25 wolves, a level at which the wolves manage to make about one kill every three days, providing food just sufficient to maintain the wolf population at that level. The wolves have thus reduced the moose population, as unrestrained foragers are expected to do, to a level yielding just sufficient food to support them. With moose reduced to this low level, the vegetation has recovered and shows no sign of overgrazing. In fact it is likely that, with their population being controlled by another factor, predation, moose are currently underharvesting their plant food.

Leaf cutter ants

Biologists believe that the Isle Royale example is typical of what happens generally. This is because animal behaviour is moulded by forces of natural selection that act primarily at the level of the individual. An individual that feeds or uses other resources such as shelter at levels lower than what it needs to fully realize its potential to survive and reproduce, will on average leave behind fewer offspring than animals who show no such restraint. Hence, prudent behaviour if it has a hereditary basis, would slowly tend to disappear from the population which would be taken over by profligate competitors. There can however be exceptions. If animals are strongly territorial and remain in control of a given area over much of their life span, or perhaps

even generation after generation, then restrained resource use could indeed help them leave behind more offspring.

The leaf cutter, a remarkable group of South American ants provides a possible example of this (Cherett 1983). These ants live in large colonies that occupy a given site for as long as twenty years. An ant colony is a group of closely related individuals. This means that the genetic interest of individual ants, the bulk of whom are non-reproductives, is congruent with that of the kin group as a whole. The leaf cutter ants live on fungi grown on pieces of leaves brought from trees in the vicinity of the colony. The demands of the ant colony for the leaves are enormous and can lead to the killing of trees entirely stripped of their leaves. Remarkably though, such complete stripping of leaves, leading to the destruction of trees, does not occur in the natural rain forests where these ants live. Now if the ants were merely maximizing immediate resource gain they would first concentrate on the most suitable tree, the one nearest their colony. After completely exhausting its leaf resources, they would then turn to the next nearest tree, and so on, in a gradually widening circle. This would be an instance of <u>sequential exploitation</u> of the resource base. But such harvesting behaviour could seriously depress the fitness of the leaf cutter ant colony over its long life span. The ants do not fully strip and kill trees, so that the cost of travelling to a tree for leaves does not keep on mounting as the ant colony grows older.

One interpretation of this is that the ants exhibit genetically programmed restraint in resource use in the long term interest of the colony. This interest is measured in terms of numbers of reproductives produced by the colony. Colonies with "prudent" traits are then expected to produce a larger number of reproductives than those with "profligate" traits. If this is true, then this behaviour of leaf cutter ants is an example of restrained resource use in the long term interest of the kin group. There is, however an alternative explanation. This invokes the fact that leaves of tropical rain forest trees are often rich in toxic chemicals. The concentration of such chemicals can vary with the age of individual leaves, as well as with the seasons. It is therefore possible that the leaf cutter ants do not fully strip a tree because the untouched leaves have high levels of such chemicals (Bristow, 1988). Similarly they may bypass an apparently suitable tree close to the nest because at that time it carries an unacceptably high toxic load. More data are obviously needed to resolve the issue; but it shows how difficult it is to be certain of whether a behaviour pattern is indeed favoured by long term as opposed to immediate advantage. Since the latter is expected to prevail in a vast majority of cases, the benefit of doubt tends to be given to the short term explanation.

Group selection

The behaviour of an individual harvester, or a group of harvesters is only a part of the story of the maintenance of

balance between the harvester and the resource. An animal may exhibit restraint in terms of harvests, yet leave behind such a large number of offspring that the next generation inevitably eats into the resource base. The question then is do harvesters both moderate their own harvesting behaviour, and also put a brake on their rate of reproduction ? In a highly controversial treatment of the subject, Wynne Edwards (1962) contended that animals do indeed exercise such restraint in a variety of ways. He proposed that they do so because in the long run overexploitation of the resource base adversely affects the well being of the group of which they are a part. This raises two issues, first, whether there are conditions under which forces operating at the group level override those operating at the level of an individual, and second whether there is any empirical evidence of restraint on reproduction in the interest of the group.

Biologists have attempted to answer the first question by modelling the behaviour of populations made up of a large number of local populations. Suppose now that restraint on reproduction by some members of a local population reduces the risk of that population going extinct. However, if that local population also includes individuals that do not exercise restraint on reproduction, the latter would leave behind more offspring. Restraint on reproduction would therefore be a disadvantage at the individual level. The question is : would the advantage gained by individuals exercising restraint on reproduction by running a lower risk of mortality through extinction of their

rather than between the two groups. On the other hand, a number of cultural traits differ strikingly between the two groups, although they vary little within a group. Food taboos, rituals, dialect, dress all provide examples of this. Halakki Vakkals, quite uniformly, eat fish, shellfish, meat. Havik Brahmans, on the other hand, equally uniformly consume no animals. Halakki Vakkals sacrifice animals to their Gods and engage in a ritual communal hunt once a year. Havik Brahmans only offer vegetarian food to their deities and never hunt animals. They dress differently and speak distinct dialects of Kannada language. As Boyd and Richerson (1985) argue this very different distribution of genetic and cultural variation within and between groups favours group level selection for cultural traits much more than in the case of genetic traits.

Cultural traits that positively contribute to the well being of the group as a whole are therefore quite likely to be encountered in human societies. This could promote ecological prudence under certain conditions. Consider, as a possible instance, hunter gatherer populations of a stable, productive habitat such as a humid tropical forest. The most efficient way of utilizing the resources of such an environment for a human group may be to remain restricted to an area of a few hundred square kilometers and keep out all other human groups. The biological resources of such a territory will be largely sedentary, so that the level of resources at a future time may be strongly affected by the current level of harvest. In such an environment the availability of the resources to any particular

human group may also depend critically on its ability to keep members of other groups out of its territory. Acute territorial conflict may be a characteristic feature of the life of such groups (Rappaport, 1984; Vayda, 1974). Humans reproduce at a very slow rate and cannot rapidly convert high levels of resource harvest into a larger, more vigorous adult population. The ability of a group to hold its territory may then critically depend not on the ability to harvest resources rapidly, but on the maintenance of an adequate level of resources on a long term sustained basis, so that the territorial defence force is never excessively weakened by serious resource shortages. The probability of extinction of a local human group, at least as a cultural entity in such an environment, may be strongly linked to the existence of cultural traditions of restrained resource use, and perhaps restrained reproduction as well.

Individual and group interests

Whenever an individual's interests conflict with those of the group, he/she may try to pursue them even if there is a group level effort to curb such attempts. The outcome could depend on a number of factors :

(a) In a small group, with regular face to face contact amongst the members, the group would be more effective in enforcing its interests. Thus group interest may be more easily implemented in small colleges compared to large universities.

(b) If the membership of the group is stable over long time intervals, the group interests would be implemented more effectively, for instance, in a hunter-gatherer tribal group as opposed to a conscript army .

(c) If the members of the group greatly depend on each other's co-operation in several contexts, it would be easy to punish an individual acting against group interests, and thereby enforce group interests. Thus in a traditional Indian village society, each member may depend on others for help in timely completion of farming operations at the onset of the monsoon. In such a situation, it would be easy for the group to punish a cheater without incurring heavy cost for the group as a whole.

(d) To be enforced effectively the group must be able to perceive its interests clearly. Thus it may be easier to perceive and therefore enforce group interest in maintenance of a woodlot as compared to microbial pollution of a drinking water source.

(e) To enforce group interests effectively, a group should have reasonably firm control over its environment and its own future. Thus in a homogeneous hunter-gatherer society, each tribe may control its own territory. In such a situation any restraint on hunting, say, releasing of pregnant does trapped may pay off in improved catches later. However, if the hunter-gatherers are surrounded by a technologically more advanced society, poachers with guns may invade their locality from time to time wiping out the deer populations. In that case the hunter-gatherer group may be in no position to impose any restraints in group interest.

Variety of human groups

The nature of human groups has undergone a sea change from the time people gave up total dependence on hunting and gathering. Till that time humans were organized in small face to face kin groups involved in a whole range of co-operative activities. Such groups would undoubtedly have possessed many culturally transmitted behavioural traits favouring group interests, even at some cost to individual interests. Cultivation of plants and domestication of animals, for the first time, began to generate surplus resources which could be usurped and used elsewhere by other groups. This has allowed the sizes of human groups interacting with each other to grow, with diminution in face to face contact and greater division of labour. The spatial scale and division of labour of human societies has steadily grown with further technical advances, especially the release of energy in fossil fuels for human use.

Human societies today comprise a whole range of nested, overlapping groups. Thus a Halakki Vakkal from the west coast of India may in different contexts be a member of a kinship based caste group, a member of a multi-caste village society, a member of the profession of school teachers, a member of a religious sect, a member of the Government bureaucracy, a member of a political party and so on. In some of these contexts his behaviour may largely be in pursuit of individual interests, in others of group interests when the two clash. He may for instance much more readily act against the group interests of his village community, than that of the professional body of school teachers.

By and large the interests of more organised groups would tend to be given more weightage than those of more diffuse, poorly organized groups of which any individual is a member. On the whole, as the scale of the society has grown, locality and kinship based groups are no longer very effective in implementing group interests. In their place, other kinds of groups based on division of labour - be they priesthoods, industrial corporations, army squadrons or state bureaucracies - have become much more influential and can mould the behaviour of individual members to favour group interests even if these may occasionally go against individual interests.

What promotes prudence ?

We thus have a broad picture of groups at different stages of human society and the relative efficacy of individual and group interests. How would the pursuit of these individual or group interests relate to our two themes of restraint in reproduction and harvest of resources ? This depends greatly on the way any human group relates to its resource base. For some groups the resource base may be circumscribed, with grave danger to the group if the demands on the resource base become excessive. Hunter gatherer societies of stable environments with strong tribal territories, or peasant societies of an old agricultural civilization where all cultivable land has been brought under cultivation and where technologies are stagnant would be examples of these kind of groups. In a way, they resemble the K - strategists of ecology, examples of which include trees in a

closed canopy rain forest or microbes like tubrercular bacilli causing chronic diseases. Europeans colonising the American continent in 16th century, or Brazilians colonising the Amazonia in the 20th, are representatives of a second category, of groups that are in no danger even if their demands on the resource base escalate substatially. They are like the r - strategists of ecology, analogous to weeds springing up along roadsides or microbes like smallpox virus responsible for outbreaks of epidemic diseases (Macarthur and Wilson, 1967). Limitation on resource demand would then be in group interest for the former and may promote restraint on reproduction or resource harvests; it is unlikely to be the case for the latter.

What then of human groups which are so structured that individual interests override group interests ? Can the pursuit of individual interests ever lead to restrained reproduction or restrained harvests ? It appears that this could be so in present day industrialized countries. Thus the population of United States is growing at rates well below the current potential; the forest cover of United States too stands at a level higher than it has ever been over the last century. We suggest that two distinct phenomena are involved here. As human social groups have grown in size, the pursuit of social prestige has become increasingly important. In modern industrialized societies where all objects have become commodities on the market, this social prestige is related to the acquisition of more and more commodities relative to other members of the society. The allocation of resources at the disposal of an individual to this

goal for himself / herself affects his / her ability to produce offspring. Furthermore it becomes important to endow the offspring with a high ability to acquire commodities on their own when they grow up - what has been termed the "quality" of children. Large investments are required in this too, which ultimately cuts down the total number of children produced, strictly out of individual choice, to well below the biological potential (Becker and Tomes, 1976). Some forms of restraint on resource harvesting is also notable for countries such as United States, in spite of the fact that their resource consumption (individual and aggregate) is continually on the upswing. This restraint is therefore only imposed and that too partially, on the land of the country itself, with the burden of resource harvesting being shifted to other parts of the world such as Amazonia or Southeast Asia. This willingness to go further away for resources relates to the greater value individuals have come to attach to other objectives such as wilderness related recreation.

Such then is the broad outline of how different degrees of individual or group interest can affect the way human groups regulate reproduction and especially resource use. This theoretical analysis is further strengthened by defining four distinct forms of <u>modes of resource use</u> which have prevailed in different societies and historical epochs. We believe that this "modes of resource use" framework provides a powerful tool for organizing human history, complementing the Marxist framework of modes of production.

Modes of production and modes of resource use

Many social scientists have found the Marxist concept of modes of production useful in differentiating between societies characterized by varying forms of technology and productive organization. Undoubtedly the original scheme of primitive communism - slavery - feudalism - capitalism, derived largely from the European experience, has been modified by increasing sophistication within the writing of the histories of non-western cultures. The problems in applying European models of feudalism to societies such as India and China and the continuing debates around the so-called Asiatic mode of production notwithstanding, the framework itself remains very much in favour. It is perhaps at its strongest in delineating the features of the capitalist mode of production. And with the emergence of capitalism as a "world system" it is enjoying a revival in the far flung corners of the globe where the clash between precapitalist relations of production and the capitalist ethos is only now gathering momentum.

Among the important criticisms of the mode of production scheme, one may single out three. The first, made by Marxists themselves, relates to the relative lack of emphasis on political structures and struggles. In his widely noticed interventions in the "transition" debate, Robert Brenner argued that the form and intensity of political conflict, rather than changes in production technology or expansion in trade, better explain the

nature of the transition from feudalism to capitalism in different parts of Europe (Brenner, 1976 and 1978). Other scholars have suggested a supplementary concept of "mode of power" to more accurately capture the structure of power and domination in different societies (Chatterjee, 1983). Second, there are those criticisms which while accepting the relevance of the scheme to European history, have expressed reservations about its application elsewhere. While the European model of feudalism does not fit the Indian experience, for example, the Asiatic mode is of hardly any use either, for the state played by no means as important a part in the provision of public works and irrigation facilities for agricultural production as it suggests. Finally there are the criticisms of non -Marxists (and non - economists), that whatever the merits of the mode of production concept in explaining differences in economic structure, it is of little use in interpreting differences in the religious, cultural, and ideological attributes of different societies.

While all these criticisms are compelling, they do not quite go far enough. An ecological approach, in fact, suggests that the mode of production concept is not adequately materialistic in the first place. This may seem an ironic accusation to make against a doctrine as supposedly materialist as Marxism, yet a moment's reflection bears it out. Marxist analyses usually begin with the economic "infrastructure" - the so-called relations of production and productive forces - without investigating the ecological context (i.e., the soil, water, animal, mineral and vegetative bases of society) - in which it is embedded. As recent

political and economic histories of modern India (both Marxist and non Marxist) exemplify, a serious lacuna in existing scholarship is an inadequate appreciation of the ecological infrastructure of human society.

The absence of an ecological perspective in the writing of Indian history was the raison d' etre for this work. As we set the stage for our empirical analysis, we would like to propose a complement to the mode of production, the concept of modes of resource use. While focusing on spheres of production such as the field and the factory, most analyses of modes of production have ignored the natural context in which the field and factory are embedded, which they respond to, and which they in turn transform. While extending the realm of production to include flora, fauna, water and minerals, the concept of mode of resource use asks very similar questions. With respect to the relations of production, for example, it investigates the forms of property, management and control, and of allocation and distribution, that govern the utilization of natural resources in different societies and historical periods. And with respect to productive forces, it analyses the varying technologies of resource exploitation, conversion and transportation characteristic of different social orders. While complementing the mode of production framework, the mode of resource use incorporates two additional dimensions. Firstly, it examines whether one can identify characteristic ideologies that govern different modes. More importantly, it identifies the ecological impacts of alternate modes, assessing their consequences for the pattern,

distribution and availability of natural resources.

Three caveats are in order here. First, the mode of resource use concept, like the mode of production concept, is an "ideal type" - the identification of distinct modes does not preclude the existence of more than one mode in any given social (or more accurately, socio-ecological) formation. However, it is usually possible to identify the dominant mode within a socio-ecological formation. Second, our treatment is largely restricted to human use of living resources - i.e., flora and fauna, both husbanded and in their natural state. However the framework can be extended to incorporate other natural resources like water and minerals. Finally, one important respect in which our scheme differs from the Marxian mode of production scheme is that here the industrial mode of resource use includes both capitalist and socialist societies. While there are significant differences between socialist and capitalist paths of development - e.g. with respect to property and the role of the market - from an ecological point of view the similarities are more significant. These pertain to, for instance, structural similarities in the scale and direction of natural resource flows, technologies of resource exploitation, patterns of energy use, ideologies of human-nature interactions, specific resource management practices and ultimately, their cumulative impact on the living environment. Consequently, it makes sense to treat industrial socialism and industrial capitalism as being ecologically speaking, simply two variants of one industrial mode of resource use.

Four historical modes

From the long sweep of human history, we can distill four distinct modes of resource use : gathering (including shifting cultivation), nomadic pastoralism, settled cultivation and industry (Harris, 1980; Lenski and Lenski, 1978). In what follows, we examine the distinctive characteristics of each mode across different axes, for instance, aspects of technology such as sources of energy and material accessible to it and the knowledge base relating to resource use; aspects of economy such as the spatial scale of resource flows and modes of resource acquisition; aspects of social organization, such as size of social group, division of labour, and mechanisms of control over access to resources; aspects of ideology including broad perceptions of man-nature relationship as well as specific practices promoting resource conservation or destruction; and finally the nature of ecological impact. We then outline the characteristic forms of social conflict between and within different modes of resource use, and conclude with some reflections on the forms of reproductive behaviour typical of different modes.

Gathering

Technology : The largest period of human history has been spent in the gathering mode of resource use, during which hunting of wild animals and gathering of vegetable matter were the mainstays of subsistence. Gathering continues to be significant during the phase of shifting cultivation as well (cf Elwin 1939; von Furer

Haimendorf 1943a), and we may include societies practicing shifting agriculture also under this rubric. In the gathering mode societies depend almost exclusively on human muscle power and wood fuel as sources of energy, and on naturally available plants, animals and stones to fulfill their material requirements. Their knowledge base is quite limited with nature viewed as almost totally capricious and not subject to human control. Abilities to store food and other materials are also very limited, as are abilities to transport materials over distances.

Here the economy is based on resources acquired within a small area of at best a few hundred square kilometers; only a very small range of resources such as shells and peacock feathers or flint tools may be transported over larger distances. Although the diversity of plant and animal matter consumed from the social group's immediate surroundings is high, given this restrictive spatial scale and limited abilities to process resources the variety of resources used in toto is small; and the quantities consumed are restricted to subsistence needs. Societies pursuing the gathering mode of resource use are highly susceptible to variation in resource availability in space and time, and respond to such variation by fine tuned adaptations to local conditions. In the harsher, more variable environments they subsist as nomadic bands; in the more productive and stable environments as tribal groups confined to relatively small territories. Such territorial restriction continues with a switchover to shifting cultivation as well.

Social organization : The sizes of social groups amongst hunter-gatherer-shifting cultivators are small ; kin groups of the order of a few hundred perhaps, largely in face to face communication with each other. They have hardly any transactions outside of such social groups; the relationships with all aliens would largely be those of conflict, often over territorial control (Rappaport, 1984). The division of labour within these is minimal, primarily based on age and sex, and to an extent on knowledge and leadership abilities. There would however be little variation amongst members of a group in terms of access to resources, and notions of private property are very poorly developed indeed. Within a group no individual is in a position to dominate and coerce others to any significant degree. While within-group differences would thus tend to be low, the differences between groups may or may not be equally low. Till ten thousand years ago, before plants and animals began to be husbanded, between group differences were undoubtedly at a low level. The human populations of any region might then have been divided amongst a large number of endogamous group competing with each other for control over land and waters. This competition would be intense in productive stable environments, such as tropical rain forests, where intertribal warfare over territorial rights might be a routine occurrence. On the other hand, the limits of territories are likely to have been much fuzzier in harsher, highly variable environments such as tropical deserts or coniferous forests of higher latitudes, where intertribal conflicts would also be far less acute. With the beginnings of

cultivation and animal husbandry, and later the industrial revolution, people pursuing the gathering mode would be at a greater disadvantage vis-a-vis people with access to advanced levels of technology.

Economy : We may characterize the economy of gatherers as a natural economy, in so far as it draws all its resources directly from nature (Dasmann, 1988; Worster, 1988a). Here, the flows of resources are largely closed on spatial scales of a few hundred or at best thousand square kilometers, over which each endogamous social group of gatherers would range (fig. 1). While there may be some flows of materials such as shells or stone tools over longer distances, these are insignificant (in terms of physical mass) compared to food and other resources utilized by the human groups concerned. The material flows would therefore not only be closed, but also balanced on a fairly restricted spatial scale. This balance is apt to be disrupted when gatherers come in contact with people practicing more advanced modes of resource use. The latter are then likely to organize net resource outflows from regions inhabited by gatherers, and perhaps also affect such regions through inflows of wastes - i.e., of materials discarded by them.

It is plausible that the gatherer societies in the past, with their low levels of demands and largely closed material cycles, would have tended to maintain an equilibrium with their resource base. From time to time there may have been instances of such societies encountering large new resource bases, as in the

first colonization of the Americas, or of having to adjust to a steady shrinkage of resources due to climatic fluctuations associated with the advance and retreat of glaciers. The gatherers have of course had to adjust to a steadily shrinking resource base since the evolution of more advanced modes of resource use beginning some 10,000 years ago.

Under conditions approaching equilibrium with their resource base, gatherers exist in kinship based small viscous groups more or less tied to specific localities depending on the variability of the environment. Such an organization might be broken up when the gatherers come in contact with people of more advanced modes of resource use and consequently have to adjust to a shrinking resource base. In the former case, the group members would tend to be involved in a network of co-operative behaviours and be very sensitive to group interests. In the latter case, such co-operative behaviour and perception of the significance of group interests may tend to dissolve.

Ideology : To gatherers, with their limited knowledge base, nature follows its own capricious ways, hardly subject to human control. They typically regard humans as merely part of a community of beings that includes other living creatures as well as landscape elements such as streams and rocks. Especially where gatherers are attached to particular localities, as in productive stable environments like tropical humid forests, they attribute sacred qualities to individual trees, ponds or mountain peaks, or to all members of a plant or animal species such as Ficus trees. They often treat plants, animals or landscape elements as kin or

as being in relationships of mutualism or antagonism. Thus rivers may be considered as mothers and totemic animals like bears or antelopes as brethren; specific trees may be inhabited by demons that need to be placated. Gatherers therefore enter into a whole range of often positive relationships with these other "beings" of their own locality. By the same token, they have no relationship with plants, animals or landscape elements outside their own locality (Martin, 1978; Macleod, 1936).

Restraint : real and apparent : At a more concrete level, these ideologies of nature worship are buttressed by specific social practices which orient societies in the gathering mode toward the prudent use of nature. Thus, many gatherer - shifting cultivator societies have a variety of practices which regulate their behaviour towards other members of their community of beings, and which seemingly contribute towards ensuring the long term sustainability of resource use (McNeely and Pitt,1985; Ruddle and Johannes, 1985). It is of interest to examine these practices in order to assess whether they could be better explained in terms of harvesting for short term gain, and if not, whether they could indeed lead to enhanced availability of resources to the group as a whole in the long run. These practices, studied by anthropologists and ethnobiologists, involve a variety of restraints on harvesting; in terms of quantity, locality, season, and life history stages. They also involve differential harvest by age, sex, or social class. It is of course possible that such apparent restraint may have nothing to do with long term conservation of the resource base. A harvester interested in the

calculus of immediate return may still not use a resource if the net gain obtainable from it is below a certain threshold that would depend on the net gain obtainable from alternative resources. We must therefore examine each supposed instance of restraint to assess whether it could involve such a discontinuation of resource use, for instance, because the cost of harvest has increased excessively (Smith, 1983; Borgerhoff Mulder, 1988)

The whole range of practices of restrained resource use by humans may be classified under ten broad categories :

(i) Quantitative restriction on the amount of harvest of a given species, or from a given locality by harvesters. The imposition of such quotas implies that harvest is halted at resource densities greater than those at which individuals would find the net gains too low to continue harvest. As a corollary these quotas are likely to enhance total yields on a long term basis, at the sacrifice of some immediate return. These are therefore likely to be genuine instances of restraint.

(ii) Harvesting a certain resource may be abandoned when the resource densities fall. Thus in New Guinea the hunting of Birds of Paradise is reported to be abandoned for a period if their populations decline (Eaton, 1985). Such a response is expected from harvesters attempting to maximize short term net gain, since a fall in resource density would progressively increase the cost of harvest. It is possible, though perhaps less probable, that

harvesting may be abandoned well before this level is reached in the interests of long term yields.

(iii) Harvesting from a certain habitat patch may be abandoned if yields from that patch are reduced. Thus in the Torres Strait fishing in certain regions may be stopped if the fish yields there have declined (Nietschmann, 1985). This again is a response expected from a forager attempting to maximize immediate net returns, and could be related to long term resource conservation only if concrete quantitative evidence is available that harvest is abandoned in advance of the returns reaching a value low enough to justify abandoning harvests.

(iv) Harvesting from a certain species may be abandoned in a certain season. Thus in India many communities observe a taboo on hunting certain animals in the four months from July to October (Gadgil, 1985a). It is possible that this taboo is a consequence of returns that are too low to justify harvesting for immediate gains in that season. Conversely, if in fact net returns in that season are expected to be relatively high, it is likely to be a conservation measure.

(v) Harvesting from a certain habitat patch may be abandoned in a certain season. Again, this could possibly be a response to an excessively low level of net gain from that habitat patch in that season. This should be verified by comparing it with net gains in other seasons, and if possible by a quantitative assessment.

(vi) Certain life history stages, by age, sex, size or reproductive status may be immune from harvest. Thus in many

parts of India, eg. in the village of Kokre - Bellur in the state of Karnataka birds breeding at a heronary may be left unmolested, though they may be hunted elsewhere and at other seasons (Gadgil, 1985b). If such protected stages appear to be critical to population replenishment, and if they are likely to yield as high or higher net returns than the unprotected stages, it is reasonable to assume that this measure is designed specifically to conserve the resource. On the other hand, if these stages are likely to yield lower net returns in comparison with the unprotected stages, then they might be left out of harvest simply in the interest of maximizing immediate net gains.

(vii) Certain species may never be harvested, either because of the relative difficulty of procuring them, risk of injury during hunt, or because they may carry parasites that can affect humans. If these conditions do not operate, then conservation can indeed serve long term interests of human resource use if the species thus protected enhances the availability of some other species that are harvested by humans. This is likely for some widely protected species such as trees belonging to the genus Ficus, but much less likely for a wide variety of species protected as totemic to given tribal groups (Gadgil, 1989).

(viii) Certain habitat patches may either never be harvested, or subject to very low levels of harvests through strict regulation. It is extremely difficult to arrive at workable prescriptions on quantitative quotas, closed seasons or protected life history stages that would decidedly guard against resource

decimation. Providing refugia (sacred groves, sacred ponds etc) may then be the most easily perceived and most efficient way of guarding against resource depletion (Gadgil and Vartak, 1976; Joshi and Gadgil, unpublished manuscript).

(ix) Certain methods of resource harvest may be totally prohibited or strictly regulated. Thus fishing by the use of poisoning river pools is severely regulated by tradition in many parts of India (Gadgil, 1985a). If these methods are likely to provide as high as or higher net returns than the permitted methods, their regulation may serve interests of long term resource conservation.

(x) Certain age - sex classes or social groups may be banned from employing certain harvesting methods, or utilizing certain species or habitat patches. Thus in New Guinea adult males are banned from hunting rodents (Rappaport, 1984). This could contribute towards long term resource conservation by moderating the total amount of harvests. It could also assist in long term conservation by restricting access to a limited number of individuals who may more readily come to use the resource in a prudent fashion. It is of course quite possible that such restrictions merely benefit certain segments of the community in positions of power, without serving the interests of long term conservation.

Simple rules of thumb

As we will discuss in greater detail later, precise prescriptions for the prudent use of living resources are difficult; and detailed quantitative ones might be impossible to arrive at even in the present state of our knowledge (Clark, 1985). This is particularly so if the entire prey population is continually subject to harvesting. On the contrary, some simple prescriptions for averting resource collapse seem easy to formulate, and should have a significant effect in enabling sustainable use. These prescriptions are fivefold : (i) Provide total protection to some habitat patches, representing the different ecosystems, so that resource populations are always maintained above some threshold (ii) Provide total protection to some selected species so that community level interactions are minimally disrupted, (iii) Protect such life history stages as appear critical to the maintenance of the resource population, (iv) Provide total protection to resource populations at certain times of the year and (v) Organize resource use in such a way that only a relatively small group of people controls or has access to a particular resource population (Johannes, 1978).

Modern ecological and evolutionary theory does indeed suggest that such prescriptions are likely to assist in avoiding environmental collapse, although they would by no means ensure harvest at maximum sustainable yield levels. In his classic experiments on prey-predator cycles of protozoans, Gause showed that prey extinction could be effectively avoided only by

providing the prey a refugium, an area of the experimental arena inaccessible to the predator where the prey could maintain a minimal population and from which other areas could be colonized (Gause, 1969). Sacred groves, sacred ponds, and stretches of sea coast from which all fishing is prohibited are indeed such refugia. Modern ecological theory also stresses the significance of some species that serve as keystone resources or mobile links in maintaining the overall functioning of the community (Terborgh, 1986). The tree genus Ficus to which belong species such as banyan and peepal, widely protected in Asia and Africa, is one such keystone resource genus. Contemporary ecological theory also points to the fact that certain stages in a population are of higher "reproductive value" and therefore more significant for permitting continued population growth. Pregnant does of deer and antelope and nesting birds, again often protected by humans, are such stages (Fisher, 1958; Slobodkin, 1968). Finally recent work on the evolution of co-operative behaviour emphasizes that restraint is more likely to evolve the smaller the number of individuals involved in repeated social interactions (Joshi, 1987; Feldman and Thomas, 1986).

Restricting the number of people having access to the resource has an additional advantage, namely that this group of people are likely to be genetically related. Even otherwise, they are likely to be involved in a series of interactions other than those relating to the harvest of resources. If co-operative behaviour is of more immediate advantage in these other interactions, then the small group is likely to develop social

bonds that would facilitate co-operation in more difficult contexts, such as that of resource harvesting. In particular, strong networks of cooperative behaviour make it easier for the social group concerned to inflict punishment on an individual wanting to go it alone in defiance of group interests (Hirshleifer and Rasmussen, 1988).

It thus appears plausible that over the course of human history there have been human groups whose interests were strongly linked to the prudent use of their resource base, and that such groups did indeed evolve practices of conservation. Many of the practices described above have in fact been reported from different gatherer societies. These conservation practices were apparently based on some simple rules of thumb that tended to ensure long term sustenance of the resource base. These rules of thumb are necessarily approximate. They would have been arrived at through a process of trial and error; with the continued acceptance of practices which appear to keep the resource base secure coupled with the rejection of those practices which appear to destroy the resource base. Practices observed by other social groups may also be adopted if they appear to be successful in resource conservation. Such a process is likely to lead to the persistence of a whole range of practices, some beneficial from the point of view of resource conservation, but also others that are neutral, and perhaps some that might once have been beneficial or neutral but are currently harmful due to changed circumstances.

Diversity of resources : Gatherer societies are also remarkable for the wide diversity of biological resources utilized. Studies on American Indians of Amazonia have shown that they utilize several hundred different species of plants and animals for food, and as sources of structural materials and drugs. They have distinct names for as many as 500 to 800 biological species (Berlin, 1973). Further, different tribal groups may be familiar with and utilize a different set of species. Thus as early as 30,000 years ago, two Neanderthal groups of Dordogne in France had apparently specialized on different prey species, one group on horses and the other on reindeer (Leakey, 1981). We may therefore conclude that primitive gatherer societies valued a very wide range of biological diversity, and evolved cultural practices which promoted the persistence of this diversity over long time intervals.

Deliberate destruction : While gatherer societies typically have a variety of practices that could help conserve the resource base of their own localities, they may also deliberately destroy the resource base of aliens. Thus when New Guinea highlanders defeat and drive away a neighbouring group from its own territory, they do not immediately occupy this territory. However, they cut down the valued fruit yielding trees from the other group's territory, thereby rendering it far less desirable for recolonization by the losers. The actual territory may be physically occupied only later if it is not reoccupied by the vanquished group (Rappaport, 1984).

Ecological impact : Gatherer societies with their low population densities, low per capita resource demands, cycles of materials closed on limited spatial scales, and a number of practices promoting sustainable resource use, necessarily have low levels of ecological impact. Over long time intervals however these can add up to substantial changes. Such changes are especially likely when the resource base changes relatively rapidly as might have happened with the fluctuations of the ice age, or when a gatherer population encounters a totally new resource base as with the first colonization of the Americas. It has for instance been suggested that the large number of extinctions of large mammalian species during the Pleistocene was a consequence of human overhunting, and that many of the savanna - grassland formations of East and South Africa are a result of fires set over tens of thousands of years by human populations (Menant et al., 1985). Nevertheless, the pace of such impacts would be orders of magnitudes slower than those of populations with more advanced modes of resource use, as described below. Some writers have claimed that hunter gatherers are possessed of an ecological wisdom far in advance of that shown by modern man (cf Shepard 1982) - be that as it may, it is indisputable that the ecological impact of this mode of resource use is minimal.

Pastoralism

Technology : The long period of human history as gatherers began to come to a close with the domestication of plants and animals, coincidental with the withdrawal of glaciers ten thousand years

ago. It is possible that the accompanying climatic and vegetational changes might have prompted human populations to intensify resource use and initiate agriculture and animal husbandry. These two processes began in parallel and have often gone hand in hand. While cultivation of plants has been of greater significance in tracts of moderate to high rainfall and moderate to high temperatures, animal husbandry has held pride of place in tracts of low rainfall and at higher altitudes and latitudes where temperatures are too low to support agriculture (Grigg, 1980). Over large tracts where agriculture is not feasible, it is also difficult to maintain herds of domestic animals in a single locality. Animal husbandry is therefore based in such tracts on moving herds from place to place - often over several hundred kilometers - taking advantage of seasonal abundance of grazing resources in different parts of a region. Nomadic pastoralism thus evolved as a distinctive mode of resource use, a mode that held sway for millenia over large regions particularly in Central Asia and North and Central Africa (Leeds and Vayda, 1965; Forde, 1963).

Pastorals have access to animal muscle power, an important additional source of energy, especially for transport. The animals also serve as a source of food that can be tapped where and when required, thus greatly increasing flexibility in the use of different habitats. With the enhanced control over nature thus made possible the pastorals begin to view it as subject, at least an extent, to human manipulation.

Economy : Nomadic pastorals move over large distances, and with their access to animal energy, have been critical in creating flows of resources over distance scales vastly greater than ones that prevailed in gatherer societies. The resources they moved around have been both high bulk commodities like salt and high value, low bulk luxury items like precious stones and musk. They also served as carriers of information about resources of distant regions and technologies elaborated by other societies. Consequently, pastorals not only continued some hunting-gathering while on the move, and produced meat, milk, hide, wool from their animals, but could also acquire resources, especially from settled agricultural societies in exchange for other materials and information. Even more importantly nomadic pastorals could effectively deploy force to usurp resources from societies of cultivators, as Chengiz Khan did with great success over huge regions of Asia and Europe.

Social organization : Social groups of nomadic pastorals remain limited to kin groups of a few thousands; nevertheless they come in contact with large numbers of other groups over more extensive terrain. Within social groups of pastorals the division of labour is still fairly limited; based on age and sex and leadership qualities which emerge during intergroup conflict. Now, elements of private property begin to emerge - however, while herds are usually owned by separate households, pastures are invariably common property, with individual herdsmen having rights of access and usufruct. However, like gatherer societies nomadic groups are relatively egalitarian (Khazanov, 1984). With this, coercion

within groups remains limited; indeed there is considerable premium on co-operation within the group, especially in the context of conflict with other groups, nomadic or otherwise.

Ideology : By surviving successfully in harsh variable environments and with little attachment to any particular locality, nomadic pastorals were perhaps the first societies to perceive human communities as separate from nature, and in a position to dominate it. With the usurpation of resources under the control of alien settled communities constituting a significant part of their strategy of resource acquisition, they were unlikely to evolve strong traditions of careful, restrained resource use. Indeed ideologies rejecting the attribution of sacred value to other living creatures or to natural objects, e.g. religions like Judaism, Christianity and Islam historically arose in tracts dominated by nomadic pastorals in the middle east. In fact such religions often prescribed deliberate destruction of sacred trees and sacred groves.

Indeed the ritual life of nomads is quite meagre; no pantheon of gods as in peasant societies, no system of totemism as in gatherer societies. Ritual importance may be placed on livestock, almost never on natural locations or fields. Striking, too, is the relative unimportance of witchcraft. Again, in comparison with peasants and gatherers, nomadic pastorals have little need to pacify or placate nature; in the event of resource shortages they can promptly remove themselves to another more resource - abundant area - something peasants cannot do (Goldschmidt, 1979).

These broad ideologies apart, in their day to day interactions with nature nomads do have practices of deliberate restraint on resource use. These include deliberate total exclusion of grazing pressure over certain periods in fodder reserves and its limitation in other periods in terms of kind and number of animals permitted for grazing, for example, in the system of ahmias around Taif in Saudi Arabia (Draz, 1985).

Ecological impact : It is possible that nomadic pastorals contributed to a gradual overgrazing and expansion of the arid regions at their margins all through their history, as they certainly have done in some regions in modern times. They have also contributed to ecological degradation through the organization of trade and the diffusion of technology over large distances, and perhaps most importantly, by spreading the ideology of man's mastery over nature.

Settled cultivation

Technology : Human societies learnt to cultivate plants and domesticate animals around the same time; beginning some ten thousand years before present. In some regions the two developed hand-in-hand, with the traction power of animals and the manurial value of their dung being vital to agricultural operations. This for instance, was the case in the middle east from where the use of cattle and plough and the cultivation of wheat and barley gradually spread over parts of Asia, Europe and Africa. In other parts domesticated animals played a much less significant part in

cultivation, as with the paddy growing tracts of Asia, or had no role at all as in the case of maize cultivation in pre-Columbian America (Grigg, 1980).

Cultivation involves an intensification of the production of certain species of plants and the removal of this plant material, from a relatively restricted area of land. The plant parts so removed, for instance, cereal grains, are particularly rich in some elements such as nitrogen and phosphorus, and of course contain a number of micronutrients like boron and molybdenum in smaller quantities. The continuance of cultivation on a piece of land therefore depends on returning to the earth what is taken away from it; either through long periods of fallow as in shifting cultivation, or through the application of river silt, organic manure or mineral fertilizers if the same piece of land is to be tilled year after year. Shifting cultivation is of course the option followed so long as the amount of land available is large relative to the population; as this ratio declines the same piece of land has to be used more and more intensively. Almost everywhere this has called for the extensive use of organic manure derived from natural vegetation in the surrounding areas, gathered either through grazing by domestic animals or directly by human effort. This has changed radically only in recent times when fossil fuel energy began to be used to efficiently mine, transport and synthesize mineral fertilizers to augment agricultural production (Pimentel and Pimentel, 1979).

Through most of its history settled cultivation has thus depended on human muscle power, supplemented in some regions by animal muscle power. In the industrialized world, it has come to increasingly depend on fossil fuel energy. However, pre-industrial agriculture depends primarily on plant and animal based materials, along with some control of natural flowing water for irrigation. Consequently pre-industrial agricultural societies (peasant societies, properly so-called) have a fairly substantial knowledge base relating to husbanded plants and animals and view nature as subject to some human control.

Economy : In peasant societies, cereal grains can be stored and moved around, especially on animal back or in carts, over long distances. Resources can now flow over much larger distances than in gatherer societies, enabling the concentration in towns of human populations not directly involved in gathering or production of food. Changes in settlement patterns also correspond to shifts in consumption. Of course, a majority of the agrarian population consumes natural resources largely for subsistence - eg. for food, clothing, shelter, implements, fodder and manure. However, a small but powerful segment of the population is involved in the large scale consumption and use of materials not directly related to subsistence - both luxury items such as silk and wine and instruments of coercion such as the horse and elephant, metal swords and shields. Fig. 2 shows the resultant structure of material flows in such a system. There are large scale exports of materials out of intensively cultivated patches of lands to the cultivator population in the nearby

villages and to the urban centres. The volume, range of items and the distance scale of such flows steadily increases with technical improvements, especially in animal based transport. These outflows from agricultural land are balanced by inflows from the surrounding non-cultivated lands. In peasant societies there are no counterflows from urban centres back to cultivated lands. However, as fig. 3 shows, in industrial societies there are large flows back to the land of materials such as farm machinery and synthetic fertilizers.

Characterized by fairly extensive resource flows, especially food grains and livestock, peasant societies are much less subject to environmental variation in space and time. Nevertheless, the techniques of cultivation and animal husbandry, the choice of plant and animal varieties, and the way that resources of non-cultivated lands are gathered and put to use are all greatly dependent on the local environment. There is therefore a substantial degree of locality dependent adaptive variation in patterns of resource use in peasant societies. This begins to disappear only with large scale inputs into agriculture of fossil fuel energy and advanced technology in the modern world.

Social organization : Cultivation requires intensive inputs of human energy in relatively restricted areas of land - a few hectares per person in the pre-industrial stage. A small kin group rather than a large band can most effectively organize such inputs, hence the family hence becomes the basic unit of an

agricultural society. Nevertheless, family groups need to co-operate with each other in a variety of ways, including defence against usurpation of their production (apart from what is surrendered as tax to the state). Several families therefore do remain banded together in a village, a social group of a few hundred to a few thousand individuals. This social group also tends to control and manage a territory of a few square kilometers of non-cultivated land surrounding the cultivated areas, and which provides a variety of inputs such as fuelwood, fodder and leaf manure.

While cultivated plots are usually (though not always) controlled by individual households, forests and water are normally held in common by the village. Several, sometimes myriad such villages are integrated into a larger chiefdom or kingdom or empire constituting the terrain from over which the surplus of agricultural production are pooled together, and the right to do so contested with neighbouring states. The larger social entities include concentrations of non-agricultural populations in larger settlements, the towns or cities with thousands or tens of thousands of inhabitants. While the villages constitute a face-to-face social group (not necessarily kinship based) of several hundred or thousand people analogous to the bands / endogamous tribal groups of gatherers, the larger society integrated through larger scale resource flows can no longer deal with all members of the group on a personal basis.

Within the larger social group of an agricultural society there is a great deal of division of labour made possible by the fact that only a fraction of the population needs to engage directly in the gathering and production of food. Those not directly involved in food production take on other occupations : processing of materials (textiles, oilseed), transportation, interpretation of and dissemination of knowledge, both natural and cultural (by priests), and coercion (by specialized warrior groups). There is now a substantial differentiation of coercive abilities within the social group, from peasants who receive very little in return for the surplus production they yield to others, to priests and warriors who provide others little in return for the surplus they manage to get hold of (Service, 1975).

In comparison with the gatherer mode, in the peasant mode a sharp separation between cultivated and non-cultivated land emerges. This separation is significant in directing resource flows (fig. 2), but equally so with regard to differing forms of property and control. At the lowest spatial scale agricultural land may be controlled by a family. However such control may be subject to regulation by the village community which could reassign plots of lands and further, treat it as a community resource, perhaps for grazing purposes, outside the cropping season (Bloch, 1978). The non-cultivated land within village boundaries serves to supply fuel, grazing, manure, etc. for the community as a whole. These large chunks of lands, different portions of which may be used at different seasons may be most effectively controlled as community, rather than family property.

With technological advances and the concentration of powers of coercion, village communities may lose control over the cultivated lands to become tenant - cultivators, as well as access to non-cultivated lands, for instance with the enclosure of commons by powerful landlords or the state. In addition to land in the vicinity of villages, the state may lay claim to larger uninhabited tracts, constituted as princely hunting preserves or forests from which the army derives its supply of elephants (Thompson, 1975; Trautmann, 1982).

The large scale resource flows of agricultural societies are accompanied by imbalances involving net outflows from rural areas and inflows into urban centres. These imbalances become progressively more acute as technological advances in storage, transport and processing create effective demand for a larger range of produce from both cultivated and non-cultivated lands, and as the coercive power of the non-agricultural sector increases vis-a-vis the agricultural sector. The overall imbalances decrease with large scale inflows of synthetic chemicals, fertilizers and machinery to the agricultural lands in industrial societies; however, it is very likely, that given the larger inflows and outflows, imbalances pertaining to specific elements such as micronutrients or larger organic molecules like humic acids may become all the more acute (Pimentel and Pimentel 1978; Stanhill, 1984).

Agricultural societies might be at equilibrium with their resource base; or they might encounter either expanding or

shrinking resource bases. Agriculturists newly colonising lands earlier held by gatherer societies, or newly benefitting from a major resource input such as irrigation would find themselves with an expanding resource base. On the other hand the base may be shrinking because of an adverse climatic change, or if access is cut off from important inputs like leaf manure and fodder from forests newly taken over by the state. Their resource base may also be shrinking if agricultural productivity remains stagnant in the face of human population growth. An approximate equilibrium may be maintained if the population grows slowly, the outside demands on agricultural production remain stable and technological progress keeps pace with the need to continue increases in agricultural production in consonance with population change.

In the last case, that of approximate equilibrium, the social groups are likely to be highly viscous, with related individuals tending to stay together and tied, perhaps generation after generation, to a given locality. Under these conditions they may exhibit high levels of cooperative behaviour amongst themselves, as also behaviour favouring long term group interests. Peasant societies of India, China and Southeast Asia, in the period before European colonization, perhaps fall in this category. On the contrary, when the resource base is rapidly expanding, especially with new land being brought under cultivation, the social groups would be much more fluid and far less tied to any locality (Fig. 4). Their level of co-operative behaviour, and especially their willingness to sacrifice

individual to long term group interests would consequently be much lower. This would seem to have been the case with European pioneers in 17th and 18th century North America. Lastly, peasant cultures faced with a shrinking resource base may also lose group coherence and attachment to a particular locality as has been reported from several parts of India in recent times.

Ideology : In comparison to hunter gatherers, agricultural societies have established substantial control over natural processes; they are nevertheless still very much subject to nature's caprices, as with droughts, floods, frost and plagues of locusts. Indeed, certain life history stages of agricultural crops are themselves especially sensitive to the environment. Hence, agricultural societies continue in part to perceive man as a part of a community of beings; at the same time, the image of man as a steward of natural resources also acquires influence. Restrained use of natural resources could therefore be expected to be a part of the ideology of agricultural societies, especially when they are in near equilibrium with their resource base. On the other hand agricultural societies encountering an expanding resource base, either through new technologies, or especially while colonizing lands earlier held by gatherers, are much more likely to view man as separate from nature and with a right to exploit resources as he wishes (Cronon, 1983).

In stable peasant societies, the practices of restrained use relate to cultivation itself, linked to a philosophy of minimizing risk rather than maximising immediate profit (Scott,

The rise of individualism is also accompanied by a tremendous expansion in the role of the state in regulating individual transactions. Thus, in most spheres of social life, the personalized and flexible systems of customary law typical of agricultural societies are replaced by impersonal and relatively rigid systems of codified law. (For example, the forest codes of modern society are amazingly detailed, often running into several hundred sections and subsections (cf Guha, Ramachandra, 1983; Merriman, 1975; Linebaugh, 1976). While safeguarding private property over land and in the workplace, and taking over the ownership of what was hitherto common property, the modern industrial state completely delegitimizes community based systems of access and control.

Forest management provides a good illustration of how the industrial mode admits only the polarity of individual and state control. Thus, in the process of industrialization in Western Europe and the United States, an early phase of anarchic capitalist exploitation was followed by the assertion of state control, wherein the government stepped in to assume responsibility for forest protection and production (Hays, 1958; Heske, 1937). However, in such societies when the situation stabilizes with respect to the supply of raw material for industry, the state may withdraw control over certain forest areas handing over 'captive plantations' to private industry. Simultaneously the expansion of the market may encourage the widespread planting of commercially valued trees by individual farmers. Thus, forests in the industrial mode are primarily state

owned, supplemented in capitalist societies by a small but often growing private sector. The victim in this process, is, inevitably village based systems of community forests and pasture management, whose lands are either sequestered by the state or parcelled out among individuals.

Ideology : While radically altering the landscape of the globe, industrial societies have at the same time made systematic attempts to safeguard their own environments. These attempts were triggered off by the deforestation and consequent landslides in the Swiss Alps in 1860's and furhter strengthened when the western frontier of the United States was officially declared as closed by the 1890 census. Thus Western conservationists have gradually brought back part of the forest cover of Europe and North America, set in motion an effective programme of soil conservation and set apart wilderness areas (cf Hays, 1958 and 1987; Nash, 1982). The problems of chemical pollution that came to the fore after the 2nd World War are also being tackled with the successful cleaning of the Thames, for instance. However, newer environmental issues are coming up, such as acid rain and global warming. These require more global solutions; so that it is now appearing as if industrial societies cannot merely export environmental degradation outside their own state borders, as they have managed to do, with some success, so far (WCED, 1987).

The ideological underpinnings of industrial society involve the total rejection of the gatherer view of man as a part of a community of beings, or even of the agriculturist view of man as a steward of nature. Instead it is emphatically asserted that man

1976). The use of a whole variety of different crops and crop rotations, practices of careful community based maintenance of irrigation ponds may all be part of such an approach. This approach would also encompass the non-cultivated lands from which the villagers gather fuel, fodder, small timber, leaf manure and so on. Thus a variety of practices of restrained use of resources from these non-cultivated lands have been reported from peasant societies at equilibrium with their resource base. For example,

(i) Quantitative restriction on the amount of harvest from a given locality, eg. on the amount of wood or grass harvested by any family or their livestock from community lands.

(ii) Restrictions on the harvest in certain seasons. Thus green leaves of trees may be permitted to be lopped only after the rainy season i.e., after the trees have ceased to put on growth.

(iii) Certain species, eg. trees belonging to the genus Ficus may be totally protected.

(iv) Certain habitat patches may never be harvested. Thus in the state of Mizoram in northeastern India the community woodlots from which regulated harvests are permitted, called supply forests, are complemented by sacred groves, aptly called "safety forests", from which no harvests are permitted.

(v) Certain methods of harvest may be totally prohibited. Thus in the Aravalli hills of Rajasthan in India, there are patches of forests called oraons from which all harvest by using metal tools is prohibited, although wood may be removed by breaking

twigs by hand (Brara, 1987).

(vi) Specific age-sex classes or social groups may be banned from employing certain harvesting methods, or utilizing certain species or habitat patches.

In the peasant mode, custom and tradition provide the overarching framework within which human-nature interactions are carried out. While religion continues to permeate social life, in the realm of resource use it is supplemented to a significant degree by custom. Here, customary time honoured networks govern relationships of reciprocity within peasant society - as for example between different castes in a village, between nomadic pastorals and peasant cultivators, or between the village and the state. Clearly, such relations (with respect to resource use as elsewhere) are often asymmetrical; however, they normally fluctuate only within the limits defined by custom.

Ecological impact : The ecological impact of the peasant mode may be characterised as intermediate. With the march of agriculture a significant proportion of land begins to be converted into artificial grasslands or cropfields, which replace forests, marshes or natural grasslands. Fire, stone axes and metal axes aid in this process of conversion. Cultivation also imposes increasing demands on natural vegetation and a greater removal of forest produce, to be used as fuel, fodder, manure, building timber and implements. The discovery of iron which in many areas led to the colonization of the forest by agriculturists also facilitates the continued felling of individual trees in a

forest. In village where such felling takes place, natural regeneration is relied upon to restore tree cover. At the same time, improvements in weapon technology also enable a more flexible hunting strategy. The cumulative impact of these interventions would be a striking change in the landscape, which could become very heterogeneous with the occurrence of a variety of successional stages in a mosaic. It could also result in the local extinction of some species of plants and animals.

Of course, agricultural societies newly colonizing lands held by gatherers have had a dramatic ecological impact even in the short run, tranforming the landscape, exterminating certain species and depleting others; introducing weedy species and so on (Cronon, 1983; Crosby, 1986). This would also be the case with agricultural societies expanding their resource base through technological innovations such as large scale irrigation and the use of pesticides. On the other hand, agricultural societies in approximate equilibrium with their environment - dominated by 'local production for local use' - have only moderate levels of impact in transforming landscapes and bringing about gradual changes in the composition of biological communities.

Industrial mode

Technology : The latest mode of resource use to appear in human history, large scale industry, has been with us for just about two hundred years. This is only one fiftieth of the time that Homo sapiens has spent husbanding plants and animals, and two hundredth of the time since hunter-gatherers painted the grand hunting scenes in the caves of Lescaux and Altamira. But its ecological impacts have been profound, far surpassing those of the long generations of humans that preceded this revolution. The main reason for this lies in the quantum jump in the use of energy, with heavy demands on non-renewable sources (coal, oil) coupled with the use of entirely novel sources such as nuclear energy.

If the pattern of energy use in the gatherer mode may be characterized as passive (relying only on human muscle and wood fuel power), and that of the agricultural mode as active (augmenting human power with animal power, wood fuel and water power), in the industrial mode energy use follows an extractive path, wherein natural resources are both harnessed (hydropower) and mined (fossil fuels) for human consumption. The industrial mode has also brought into use a whole new range of man-made materials; metals, plastics, silicon chips, synthetic pesticides. Man has thus acquired the ability to bring about a wide range of transformations of materials; moreover, materials can now be preserved for use for long periods and transported for consumption elsewhere. The great improvements in transportation

mean that even bulky, heavy goods - eg. timber or even rocks can be transported with ease over large distances. "The windmill gives you the feudal lord, the steam engine the capitalist", says Marx, in distinguishing between different modes of production; distinguishing between different modes of resource use according to their technological infrastructure we may say that "the axe and bullock cart give you the peasant mode, the chain saw and locomotive the industrial mode" (Ayers, 1978).

These abilities have revolutionized the flows of resources which now have become truly global. Any desired material, be it animal, vegetable, mineral; natural or man-made can, and is now being rapidly transported from one corner of the earth to another. With this a significant fraction of humanity, albeit still very much a minority, has come to consume vast quantities of a very wide range of resources (I.I.E.D and W.R.I., 1987). Consumers in the high centres of industrial civilization can draw upon the natural resources of most parts of the globe - taking for granted the continued supply of teakwood from India, ivory from Africa and mink from the Arctic. This elite is now little affected by natural variations of resource availability in space and time; they are developing a truly global lifestyle, in the process wiping out myriad locally adapted lifestyles in different parts of the world.

Economy : Over the last centuries, industrial societies have steadily expanded their resource base. This has been achieved by growing knowledge about the working of nature - through the

hypothetico-deductive method of modern science - and the link established between scientific discoveries and their practical applications in tapping additional sources of energy, processing materials, and transporting goods faster, more economically, and over longer distances. The steady growth of scientific knowledge and its application in the intensification of resource use has led to the continual overuse and exhaustion of many resources. The typical response to such exhaustion has been to find a substitute, although initially when the resource now being substituted was abundant, the use of the substitute would have involved more effort in terms of energy, materials, and labour. In the classic case, as wood became scarce in Europe, coal came to substitute for wood charcoal in the manufacture of iron, while locomotives were invented to replace horse drawn carts even as there developed serious scarcities of fodder for horses. Industrial societies have gone on to consume resources at an ever accelerating rate, exhausting them one by one in a sequence, going from the economically most desirable resource of the moment to less and less desirable resources as the more desirable ones are exhausted. Technological innovations have meanwhile continually extracted better and better results from what were once less desired resources (Wilkinson, 1988).

Along with advancements in knowledge and technique, the expansion of the resource base of industrial societies has rested upon their access to land and natural resources earlier controlled by gatherer and peasant societies. Reeling under an energy and transportation crisis brought about by the exhaustion

of their forests, the European colonists laid claim to vast terrains the world over. Where the 'portmanteau biota' of Europeans - wheat and cattle, their weeds and diseases - could establish itself comfortably, as in north America and Argentina, South Africa, Australia and New Zealand, it created neo-Europes (Crosby, 1986). Where the ecological setting did not permit such a takeover, as in the older civilizations of middle-east and Asia, or in the humid tropical forests of Amazon, Congo and Malaysia, the Europeans nevertheless established a firm hold on the resources of these regions and organized outflows of what they most desired to their own lands and people. Thus India became an exporter of teak, cotton, jute, tea, indigo and precious metals; Burma of rice and teak; West Indies of sugar; Brazil of rubber and coffee and so on. Although colonialism has formally ended, this process very much continues, and India now exports prawns and trained manpower along with tea rather than teak or cotton; and Brazil beef and forest produce instead of rubber.

The flows are highly asymmetric, with industrial societies receiving large volumes of unprocessed resources at low prices and exporting small volumes of processed resources at much higher prices. Simultaneously, this process also implies the production of high volumes of wastes in industrial societies, which are then sought to be disposed of elsewhere, either in the global commons of the oceans and atmosphere, or through their sale to Third World societies plagued by foreign debt.

Social organization : The greatly enhanced scale of resource flows in industrial society goes together with a substantial increase in the number of humans involved in this network. Face to face contact is obviously impossible amongst such large numbers, and they tend to interact through the medium of formally codified transactions. Within such large social groups there is of course a rather elaborate division of labour. In modern industrial societies this division largely hinges upon skills in processing, transport and exchange of materials and information. Smaller social groups based on such division of labour, for instance, car mechanics or teachers and corporate groups banded together to carry out a task, for instance, car manufacture or school teaching, become important social groups amongst whom obtain relations with face to face communication equivalent to those in an hunter-gatherer band or a peasant village. Whereas kinship, locality and religion define the forms of association in the preindustrial world, in industrial societies the impersonal criteria of structural location vis-a-vis the means of production define the ways in which individuals come together for collective action. These corporate groups, based on division of labour, are extremely fluid with the membership in flux. Again, the continual expansion of the resource base, both in terms of new extractive techniques and new territories to draw upon, has enhanced the fluidity of social groupings. There is therefore a much greater stress on pursuit of individual interest in a greatly atomised society (Hawley, 1986).

(vi) Just as certain methods of harvest eg. poisoning of streams, may be traditionally forbidden, there are regulations forbidding fishing with nets of excessively small mesh size.

(vii) Just as certain habitat patches, for instance, sacred groves or sacred ponds, may be fully protected from any harvest, there are prescriptions for keeping certain forest areas totally free from human interference, either for watershed conservation or for the maintenance of biological diversity.

(viii) Just as certain species are totally immune from hunting or felling eg., monkeys or Ficus trees in Indian villages, complete protection may be extended to certain endangered species such as the California condor or the whooping crane.

In parallel, of course, there exist a whole range of supposedly scientific prescriptions for deliberately destroying certain resources. Thus, just as the entire Khandava forest near present day New Delhi was supposedly burnt in Mahabharata times as an offering to the fire God, massive forest areas in the Narmada Valley in Central India are now being destroyed to create reservoirs for hydroelectric power generation and irrigation. And one must not forget that the large scale defoliation of forests during the Vietnam war was supported by considerable inputs from the American scientific community.

The scientific prescriptions of the industrial mode thus closely parallel the traditional prescriptions based on a large, informal base of knowledge and simple rules of thumb. In part the modern prescriptions are based on a more detailed knowledge of

the behaviour of the system, and on a more explicit definition of what is sought to be achieved. Thus with many forest tree or fish populations the aim is defined as achieving maximum sustainable yield - i.e., the highest yield that would not decline in the long run.

However, deciding on a harvesting regime that would lead to maximum sustainable yields is beset with manifold difficulties (Clark, 1985; Beddington and May, 1982). Firstly, any plant or animal population being harvested would be involved in a number of interactions with other members of the community. Thus harvesting a deer population may through a change in the composition of the herb layer affect another resource such as wild cattle. Again, harvesting a plant species may result in a change in the availability of honey. In fact, some years ago, fishery biologists warned the fishing industry of the East Coast of Canada that the scallop fisheries were being overexploited and likely to crash. It so happened that just after this there was an outbreak of an epidemic disease amongst sea urchin populations that heavily prey upon the scallop. With the predation pressures reduced the scallop populations increased rather than collapsed as feared by the fishery biologists (cf Berkes, 1989). Similarly, wild life biologists concerned with enhancing the carrying capacity of the wetlands of the bird sanctuary of Bharatpur in North India recommended the banning of buffalo grazing in the sanctuary. Following the imposition of such a ban it was found that in the absence of grazing a grass, Paspalum, grew so rapidly as to choke the wetland and reduce its carrying capacity for

water fowl (Vijayan, 1987).

Because of such complex community interactions the simultaneous harvest of more than one resource population from a given locality can have a variety of unexpected consequences. Theoretical investigations suggest that in some cases the natural tendency of a population to fluctuate might be exaggerated by the simultaneous harvest of another species and expose it to the danger of extinction (Pimm, 1986; May, 1984). However, even leaving aside such complications due to community interactions, it is difficult to understand the behaviour of the harvested populations and to assess whether it is running any risk of overharvest and extinction. For example, the Elk populations of British Columbia in Canada are being simultaneously harvested for subsistence by Amerindians, and for sport by European settlers. Wildlife biologists primarily interested in deciding on regulations for sport hunting contend that the Elk populations are declining due to subsistence hunting. On the contrary, anthropologists looking at the same population data have suggested that there is no good evidence of decline in Elk populations (Freeman, 1989). It is even more difficult to assess the fate of fish or whale populations for which the only available information is based on harvests themselves. The level of such harvests is a complex function of the number, age and sex composition of the prey population, its distribution in space and time and the extent and distribution of the harvesting effort. The parameters characterizing the prey population are also dependent on the extent of exploitation to which it has been

subjected to in the past. It is difficult to predict the responses of such populations to different levels of harvests even on the basis of sophisticated mathematical models, for our knowledge of many parameters of the model remains quite limited. Indeed the International Whaling Commission finds it difficult to arrive at any substantial consensus as to what is actually happening to many of the whale populations (May, 1984).

Given all these difficulties even today successful prescriptions of how to obtain maximum sustainable yield are possible only in very limited contexts. They work only when the community interactions as well as the population structure are drastically simplified. This is the case with single species, even aged populations of forest tree species such as pine plantations taken up in temperate latitudes. Here all other plant, insect, microbial species that may enter are sought to be eliminated. Further, intraspecific competition is regulated by permitting reproduction only through artificial regeneration, by controlling interplant distance and harvesting such individual plants as are being suppressed through intraspecific competition. It would not be incorrect to say that scientific prescriptions for obtaining maximal sustainable yield have largely failed to work except in this limited context . Even in this context it is suspected that gradual exhaustion of soil nutrients is now leading to dieback of these forests, supposed to have been managed so well over the last two centuries.

The prescriptions for giving total protection to certain species and localities, such as those embedded in the U.S. Endangered Species Act or CITES (Convention on International Trade in Endangered Species), or to certain localities as with programmes of setting apart National Parks or Biosphere Reserves also have rather uncertain scientific foundations. This is inevitable given the very limited understanding we have of the extent and distribution of biological diversity and the ecosystem processes that govern the survival of the species making up various biological communities. The heated debates on whether to aim for a few large, several small, or even plentifully patchy nature reserves, as well as the debate on minimum viable population sizes show that scientists are still far from finding definitive answers as to the appropriate ways of conserving natural populations of living organisms (Soule, 1986). Indeed one could argue that the scientific prescriptions of industrial society show little evidence of progress over simple rule of thumb prescriptions for sustainable resource use and the conservation of diversity which characterised gatherer and peasant societies. Equally the legal, codified procedures supposed to ensure that the scientific prescriptions are enforced also work little better than the earlier procedures based on religion or social convention.

Ecological impact : Industrial societies, unlike the gatherer or agricultural societies, are no longer directly dependent on the natural resources of their immediate vicinity. At first glance, this may suggest that they could effectively conserve their

resource base, whereas the societies following more primitive modes of resource use would perforce have a much more adverse impact. Indeed this seems borne out by the fact that Japan, the most industrialized of Asian countries has the best preserved forest cover, while the forests of countries like Malaysia and Indonesia with large populations dependent on primitive agriculture are being devastated. A second look however shows that Japan maintains its forest cover, in spite of enormous per capita consumption of timber only by shifting the pressure on to Malaysia and Indonesia, precisely the countries which are suffering devastation. The Japanese also exploit their coastal fisheries very conservatively while refusing to give up whaling in international waters. This discrepancy between prudence at home and profligacy abroad also characterizes the behaviour of other industrially advanced countries such as U.S.A and U.S.S.R.

If one looks at the total picture, therefore, it is obvious that it is the enormous resource demands and waste production of industrial nations, and of the industrial segments of the society in less completely industrialized nations that have the most profound impact on the world environment (cf Bahro, 1984). These impacts include radical modifications of the landscape, as with the laying down of the Alaskan pipeline or cattle ranching in Amazonian forests, gradual depletion of forests, as with acid rain in Europe or over extraction in Malaysia and Kalimantan, drastic reductions in populations or extinctions, as with the passenger pigeon and bison in the last century or the African elephant and myriad other species in the Amazonia in this

century; whole sale poisoniong of the biosphere as with wide spectrum pesticides and nuclear waste, modification of biogeochemical cycles, as with the increased production of carbon dioxide, and perhaps long term adverse modification of the climate as well (cf Richards, 1986).

In assessing the ecological impact of different modes, one is struck by two paradoxes, which we illustrate here with respect to forest use. Spatially, hunter gatherers live in the forest, agriculturists live adjacent to but within striking distance of the forest and urban-industrial men live away from the forest. Paradoxically, the more the spatial separation from the forest, the greater the impact on its ecology, and the farther removed actors are from the consequences of these impacts! The same conditions operate with regard to other resources such as water. Second, the faster the development of formal, scientific knowledge about the composition and functioning of forest types, the faster the rate of deforestation. One important reason here is undeniably higher levels of economic activity, but another though less obvious factor would be the idiom of resource use itself. While enormously enlarging our knowledge about specific physical and chemical processes, modern science has not always displayed the same understanding of the ecological consequences of the human interventions that follow the development of scientific knowledge. However, the belief that science provides an infallible guide has encouraged major interventions in natural ecosystems that have had unanticipated and unfortunate consequences. The histories of both fisheries and forest

management are replete with illustrations of the failure of "sustained yield" methods to forestall ecological collapse (McEvoy, 1988). While there no longer exist social constraints on the level of intervention, scientists are also inadequately informed of the ecological processes in operation. Ironically, therefore, religion and custom as ideologies of resource use are perhaps better adapted to deal with a situation of imperfect knowledge than is "scientific" resource management.

Conflict between and within modes

Inter modal conflict : As one mode of resource use comes into contact with another mode organized on very different social and ecological principles, we expect the occurrence of substantial social strife. In fact, the clash of two modes has invariably resulted in massive bursts of violent and sometimes genocidal conflict. One of the best documented is the clash between the indigenous hunter gatherer / shifting cultivator populations of the New World and the advance guard of European colonists practicing an altogether different system of agriculture. Historians of the victorious white race have in recent years depicted, with marked sensitivity, the ecological and cultural dimensions of a conflict that resulted in the extermination of the bulk of the native population and the traumatization of the segment which escaped annihilation (Cronon, 1983; Crosby, 1986;). Yet, as Chapter 6 of this book argues, such episodes are not exactly foreign to the histories of the Old World. For the brutal conflict between the American Indians and the English colonists

was anticipated several millenia before by the conquest of indigenous hunter gatherer populations by the invading agriculturists, a clash vividly captured in the sacred text of the conquerors, the Hindu epic Mahabharatha.

The environmental and social costs of the encounter between the agrarian and industrial modes in Europe have been ably chronicled by a long line of distinguished historians. The rise of industrial capitalism radically altered relations not merely in land and the workplace but around the utilization of nature as well. The conflicts over the enclosure of what was previously common land, and the assertion of state control over forests, while perhaps not as brutal as the clash between hunter gatherers and the neolithic vanguard, also exacted a heavy human cost (cf Agulhon, 1982). As one American forester documenting the enclosure of the forests by the state and lords in Germany, laconically put it : "All these changes from the original communal property conditions did not, of course, take place without friction, the opposition often taking place in peasants revolts; hundreds of thousands of these being killed in their attempts to preserve their commons, forests and waters free to all, to re-establish their liberty to hunt, fish and cut wood, and to abolish titles, serfdom and duties" (Fernow, 1907, p.34). In the absence of open revolt, peasants resorted to poaching and the theft of forest produce. These forest "crimes" were very widespread indeed - thus in Prussia in 1850, 265,000 wood thefts were reported as against only 35,000 cases of ordinary theft. In this class struggle over nature, between the peasants on one side

and landlords and the state on the other, the wood thieves were "defending their entire economic system - the family economy which was based on collective usage rights" (Mooser, 1986). Indeed until well into the present century, European foresters were unable to fully extinguish the customary rights of user granted as a consequence of the peasant opposition to state forest management (cf Heske, 1937).

In the American South too, common rights of hunting and grazing on non-cultivated land withstood landlord and state pressures until the early decades of this century (Hahn, 1982). The European experience is directly comparable to the Indian one where the encounter between peasant and industrial modes, mediated partly by colonialism, has also greatly intensified social conflicts over forest resources. In colonial societies of Southeast Asia and Africa, too, the takeover of forest land for strategic and commercial purposes fuelled bitter conflict between the state and the peasantry (Scott, 1976; Grove, 1989). It is important to note that colonial methods of ecological control also intensified conflicts within the agrarian sector. Two examples come to mind. One is the clash, over forests, lands, and water in colonial and semi colonial societies between large cash crop plantations and the traditional peasantry (Womack, 1969; Pandian, 1985). The other is the restrictions placed on subsistence hunting gathering and grazing by the setting up of game reserves by white colonists (Cf Kjekshus, 1977).

While the gatherer-peasant and peasant-industrial conflicts are both vividly represented in myth and history, a third inter-

modal conflict dominated medieval Europe and medieval Asia - viz. that between the peasant and pastoral modes. The many instances of nomad-peasant symbiosis- eg. the pasturing of livestock on the fallow fields in return for manure notwithstanding, historically this relationship has been fraught with friction. Thus medieval sources in the Near East talk of nomads driving their livestock to graze on sown fields - a practice beneficial to the pastoralists, disastrous for the cultivators. Conflicts have also arisen when agriculturists shift to crops (eg. cotton) which do not give stubble during the dry season. In this conflict between two modes of resource use, that have, for the most part, overlapped in time and space, on occasion the nomads have greatly expanded their resource base - eg. as with the Mongols of Central Asia in the medieval period - while at other times their own niche has steadily shrunk - as with the reservation of forests and the expansion of irrigated agriculture in modern India (Khazanov, 1984; Gadgil and Malhotra, 1982).

Our final example of inter-modal conflict comes from the contemporary West. In recent years, a distinctively new form of ecological conflict has surfaced, between votaries of the industrial mode of resource use and a mode struggling to be born. Thus, while scientific foresters and industrial users continue to look upon the forest primarily as a resource to be harvested, in the perspective of the Western environmental movement forests are to be preserved as a haven from the workaday world and a reservoir of biological diversity. Although this conflict has by no means been as violent as those between earlier modes of

resource use, the ideological differences between the industrial mode and what environmentalists call the "post industrial" mode can hardly be minimized (Nash, 1982; Hays, 1987).

Two aspects of inter - modal conflicts may be highlighted. First, apart from massive bursts of social conflict, the encounter between different modes also signals a spurt in rates of ecological destruction. The deforestation of the Indo-Gangetic plain in the first and second millenium B.C., the draining of the fens in eighteenth century Europe and the destruction of forest cover in colonial India all testify to the enormous environmental costs associated with the advent of a new mode of resource use (of course, the emergence of a "post industrial" mode, as and when it occurs, may reverse this trend). As one mode wins out, however, there is a slow but perceptible diminution in the levels of social conflict and ecological disturbance.

Secondly, while the conflict between different modes of resource use is at the most elemental level, a struggle for control over productive resources, it is invariably accompanied by an ideological debate legitimizing the claims of the various modes. Agrarian societies have typically justified their takeover of the lands and resources of gatherer societies in terms of the latter's low productivity and "wasteful" use of nature, a distinction used by colonists in America for their conquest of Indian territories (Cronon, 1983; Prucha, 1985). Likewise, the votaries of the industrial mode have used the rhetoric of resource use in legitimizing their claims. The scientific model

of natural resource management, it is claimed, is a distinctively modern innovation, and inherently superior to the idioms of religion and custom which legitimized human interactions with nature in earlier epochs. And as the widespread disaffection with the excesses of the industrial mode finds expression in the environmental movement, it is no accident that religion and custom are upheld as being after all, more prudent in their use of nature than so-called modern scientific methods.

Intra modal conflict

The ebb and flow of social conflict within different modes of resource use, is perhaps not as visible in history and myth as the violent struggles between modes. Yet such conflict, is by no means absent. Most of the primate relatives of humans are engaged in struggles to hold on to and expand group territories, and it is highly likely that hominids too were so engaged ever since their origins. There is however little fossil evidence of violent death in the period before 30,000 b.p., when modern Homo Sapiens with the abilities of symbolic communication finally took the stage. Since that time, conflicts relating to territorial control have undoubtedly been a feature of most hunter gatherer societies, as documented by anthropologists in such far flung areas as New Guinea, New Zealand, and the Amazon (cf Rappaport, 1984; Vayda, 1974).

Such intramodal conflicts become more complex as one passes on to more advanced modes of resource use. They become especially acute when the ideal typical characteristics of a mode as

outlined earlier in this Chapter are perceived as being distorted to subserve the ends of a particular social group. When feudal lords fail to honour the customary codes of the moral economy, for example, or the workings of forest law and science are seen to be class-specific rather than class neutral, the ideological basis of the mode of production may begin to crumble. At such times, an idiom of conflict, rather than collaboration, characterizes intramodal relations.

Coming to the peasant mode, in many historical periods conflict between the peasantry and the overlord over natural resources has been endemic. In England, for example, conflict over rights in forests were especially acute in the thirteenth and fourteenth centuries, a period of rising demographic pressure and expansion of arable land. There were a growing number of prosecutions for timber theft with peasants occasionally resorting to the invasion of woodland enclosed by lords and abbots (Faith, 1984, Birrel, 1987). Conflicts over forest and pasture were an important element in one of the greatest ever anti-feudal revolts, the German Peasant War of 1525 (cf Engels, 1956). And in France from the 16th to the 18th centuries, peasants repeatedly rose in revolt against attempts by landlords to usurp forests, swamp and grazing grounds earlier held in common (Le Roy Ladurie, 1980; Bloch, 1978). Finally, resistance to the enclosure of community pastures by plantations was widspread in early twentieth century Mexico (Lewis, 1964; Womack, 1969).

Another form of intramodal conflict characteristic of mature feudalism in Europe, related to peasant rights of pasturage and timber in forests reserved exclusively for hunting by nobles (Thompson 1975; Hay et al 1975). While in normal times peasants were unable to challenge this monopoly (though they continued to breach it on the sly), when the state was vulnerable they quickly and forcefully asserted their rights. Thus in the rural revolt that accompanied the French Revolution, groups of peasants broke into the hunting preserves of the nobility and "determinedly hunted the game" (Lefebvre, 1982, p. 44, etc.). Similar invasions of forests controlled by the nobility were also reported in the wave of peasant strikes in the Russian Revolution of 1905 (Shanin, 1986).

With the shift from the peasant to the industrial mode, conflicts within the former mode intensify as one class within agrarian society is quicker to adopt to the socio-ecological orientation of the coming mode (as for example in the enclosure movement). However, the internal conflicts characteristic of the industrial mode (particularly its capitalist variant) are quite different. These are, firstly the continuing struggles of individual capitalists with each other, and against the state, for formal proprietal control of non-cultivated areas as well as the terms of disposal of living resources. Secondly, the industrialization of forest working itself creates a new class of workers, whose interests are not always in harmony with capitalists in the timber harvesting and processing sectors (Vail, 1987)

These forms of intramodal conflict, and the ways in which they are resolved shed light on the interlinkages between modes of production (defined in the Marxian sense) and their corresponding modes of resource use (as defined here). In the natural economy of hunter gatherers, of course, the mode of production is simultaneously the mode of resource use. In the peasant and industrial modes, the links are more complex. In the former case, even where relations around land are accepted (however grudgingly) as asymmetrical, peasants insist that they have full access to the "free gifts" of nature. And when enclosing landlords and hunting monarchs violate this tacit agreement by restricting the exercise of common rights, peasants resist and levels of conflict escalate. For the stable functioning of the mode of production therefore, there must exist some discrepancy between the rights of the overlord to land (and a portion of its produce) and to living resources respectively.

The stable functioning of the industrial-capitalist mode likewise requires a discrepancy between property relations in the field / factory and in the forest. While private ownership predominates in the former case, forests are, to a much greater extent, owned and controlled by the state. However, the underlying rationale of government intervention is precisely to safeguard the stability of the industrial mode, by taking the long term view available only to the state, thereby harmonizing conflicts between individual capitalists.

Recapitulation

The salient features of the four modes of resource use are reproduced in Tables 1 to 4. To recapitulate, as human societies move temporally from hunting and gathering through pastoralism, agriculture and finally into industrialization, five distinct but closely interrelated processes occur. First, there is an increasing intensity of resource use and exploitation. Second, there is a secular increase in the level of resource flows across different geographical regions and across different levels of any economic/political system. Third, there is an integration of larger and larger areas into the domain of any given political/economic system. Fourth, there is at the global level, a secular increase in population densities and in the extent of stratification and inequality with repect to access, control and use of different natural resources. Finally, there is an intensification of rates of ecological change and ecological disturbance.

Of our four modes of resource use, in the Indian context nomadic pastoralism is best treated not as a separate mode but as being integrated with the peasant mode of resource use, within whose ecological zone it occupied a special niche.

Table 1 : Features of technology and economy in a society predominantly following one of the four major modes of resource use.

	Gathering (including shifting cultivation)	Nomadic pastoralism	Settled cultivation	Industry (including fossil fuel based agriculture)
Energy resources used	Human muscle power, fuelwood	Human and animal muscle power, fuelwood	Human and animal muscle power, fuelwood;coal, water power to some extent	Fossil fuels, hydroelectricity nuclear power; fuelwood, human and animal muscle power much less important
Material resources utilized	Stone,plant and animal material	Stone, plant and animal material, some use of metals	Stone, plant and animal material, some use of metals	Extensive use of metals,and synthetic materials
Abilities to store resources	Very rudimentary	Domestic animals serve as meat supply on hooves	Grain and domestic animals make long term storage of food possible	Even highly perishable materials like fleshy fruit and meat can be stored over long time
Abilities to transport resources	Very rudimentary	Domestic animals like horses make long distance transport possible	Domestic animals make long distance transport possible	Fossil fuel based vehicles render transport over great distances easy
Abilities to transform resources	Very rudimentary	Rudimentary	Low, including metal making, weaving	Very extensive
Spatial scale of resource catchments	Small, mostly of order of a few hundred or thousand km^2	Could be quite extensive	Moderate	Global
Quantities of resources consumed	Very moderate	Moderate for most	Moderate for most, a small elite may consume large number of commodities	Large numbers consume enormous quantities

Table 2 : Features of social organization and ideology in a society predominantly following one of the four major modes of resource use.

	Gathering (including shifting cultivation)	Nomadic pastoralism	Settled cultivation	Industry (including fossil fuel based agriculture)
Size of social groups	Small, a few thousand people	Moderate, several thousand people	Moderate, several thousand people	Very large, in hundreds of thousands
Extent of kinship within social groups	Very strong	Strong	Strong, but interactions with non-kin increasing	Very weak
Extent of attachment of social groups to particular localities	Often strong	Weak	Often strong	Very weak
Division of labour	Rudimentary, sex-age based	Rudimentary, sex-age based	Considerable, based on specialized skills, knowledge	Very extensive based on specialized skills, knowledge, tools
Role of division of labour in formation of social groups	Very weak	Very weak	Weak to moderate	Strong
Idiom of social transactions	Totally informal, face to face contact based	Informal, primarily based on face to face contacts	Social conventions and codified transactions	Codified transactions with legal sanctions important
Perception of working of nature	Nature viewed as autonomous, capricious	Nature largely seen as capricious	Nature viewed as partially law-bound, controllable	Nature viewed largely as lawful, very much controllable
Idiom of man-nature relationship	Man part of community of beings	Man potentially conqueror of nature	Man a steward of nature	Man fully above and apart from nature, fully capable of controlling and dominating it

Within - group differentiation of access to resources	Weak	Weak	Considerable	Very extensive
Mechanisms governing access to resources	Community based decisions	Community based decisions	Private control of farmland, community and state control of non-cultivated lands	Private, state and corporate ownerships predominant; community control delegitimized

Table 3 : Features of social organization, ideology and ecological impact of societies in relation to changes in their resource base

	In equilibrium with resource base	Resource base expanding	Resource base shrinking
Fluidity of social groups	Low	High	Often considerable
Extent to which group interests prevail over individual interests	Group interests quite significant	Individual interests more important	Group interests may crumble, perhaps totally
Perception of man-nature relationship	Man as steward of nature	Man as conqueror of nature	Man helpless, indifferent to fate of nature
Extent to which sustainable resource use prevails	Quite often	Rarely	Rarely
Level of ecological impact	Low to moderate	High	High

Table 4 : Nature of ecological impact of societies predominantly following one of the four major modes of resource use.

	Gathering (including shifting cultivation)	Nomadic pastoralism	Settled cultivation	Industry (including fossil fuel based agriculture)
Land transformation	Little, some regression of patches of forest to successional stages or grassland	Some extension of grasslands, deserts	Forests, grasslands extensively converted to fields	Large scale deforestation, desertification built up habitats
Habitat diversity	Enhanced	Somewhat reduced	Reduced	Substantially reduced
Bio-diversity	Little affected	Some effect	Moderate effect	Considerable impact
Resource populations	Occasionally overharvested	May overgraze some grasslands and overharvest some prey populations	May overgraze some grasslands and overharvest some prey populations	Many resource populations overharvested
Substances poisonous to life	Nil	Nil	Nil	A large range of synthetic chemicals
Modification of biogeochemical cycles	Very little	Very little	Little	Substantial
Modification of climate	Highly unlikely	Highly unlikely	Unlikely	Quite likely

Note on Population

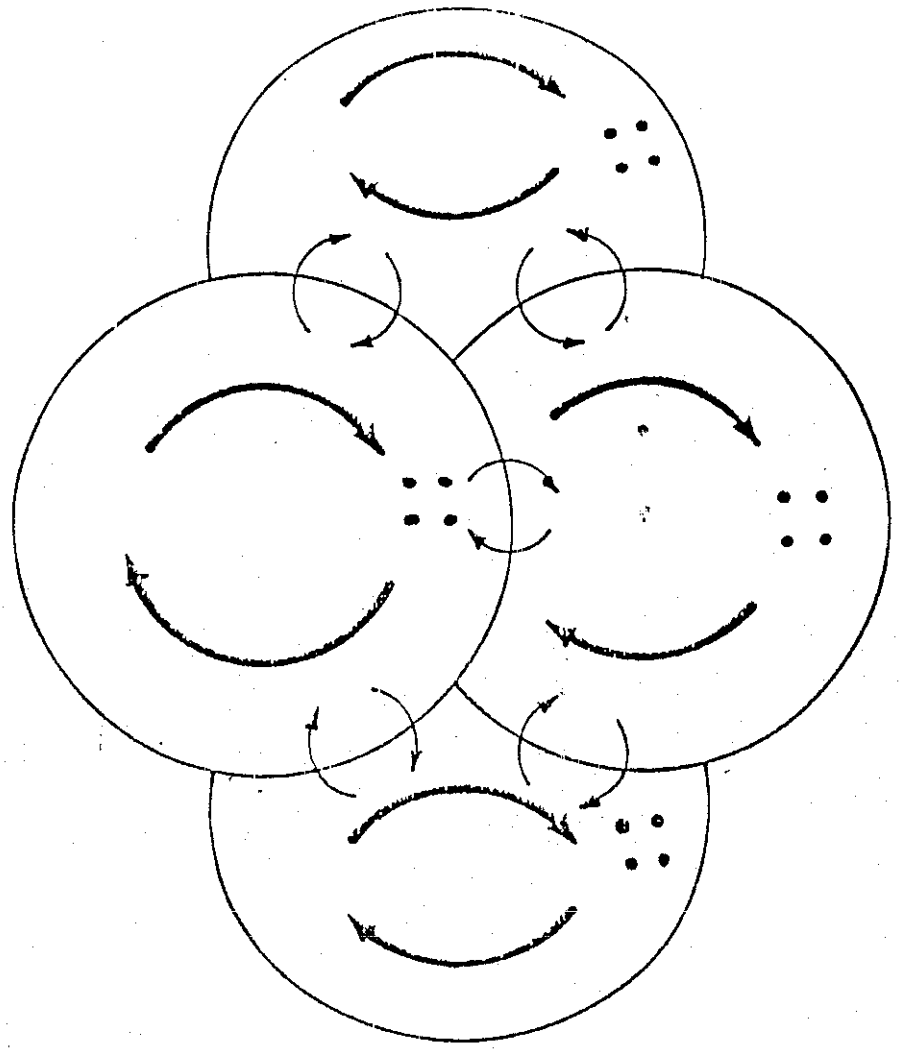
In our analysis of modes of resource use, we have classified them according to technology, pattern of resource flows, social structure, dominant ideologies, and systems of conservation. Here we deal briefly with another dimension which has an important bearing on ecological history - viz., the density of human population. The reflections which follow are prompted by the question - under what conditions will human populations regulate rates of reproduction in individual or group interests ?

In utilizing the resources of their environment at very low intensities, gatherers also maintian low population densities. As was suggested above, in stable environments they are likely to maintain fixed territories, with high levels of conflict with neighbouring groups over territorial control. Under these conditions their interests lie in maintaining population density at a level which ensures that the territorial group does not have to face occasional resource shortages, shortages that may weaken it in a conflict with neighbouring groups. It is possible that the variety of population control mechanisms noted amongst gatherers may serve the function of maintaining their population densities in group interest. Such mechanisms may of course break down when gatherers lose control over their resource base on coming in contact with people practicing more advanced modes of resource use. Coming next to pastorals, their population densities tend to be low, inhabiting as they do the more arid and

unproductive regions. Very likely, these levels are being maintained by natural checks; it is unlikely that inhabitants of such variable environments and without fixed territories would have evolved cultural practices deliberately maintaining their populations at low levels.

Characterized by a substantial intensification of resource use agricultural societies maintain population densities far higher than those of either gatherer or nomadic pastoral societies. However, most members make rather low levels of demands on the resource base, although members of the non-agricultural elite may have high levels of demands for many non-essential commodities. Given these low levels of resource demands, and the possibilities of gradually improving yields from cultivated lands through technical change, agricultural communities are likely to be characterized by slow population growth. Further, the larger states of which they are a part would ensure that there are no serious territorial conflicts within their limits, conflicts in which overpopulation may be a serious handicap. On the contrary, the military strength of agricultural states may depend on their overall population; therefore the state apparatus would tend to encourage population growth. One therefore expects neither individual nor group level pressures to deliberately check population growth in agricultural societies; although natural checks and balances like diseases and disasters may take a periodic and heavy toll of peasant populations.

The population history of the industrial mode is captured in the phrase "demographic transition". While in the initial phase of industrialization the population of European stock, (both within Europe and in newly colonized lands) expanded rapidly, over the last century it has grown much more slowly, stabilized, and in some places even declined. This transition seems related to the fact that the attempts of each individual in enhancing his/her resource consumption limits the quantity of resources available to raise offspring. Further, the parents try to endow each offspring with a high level of ability to garner resources for themselves. The need to invest in the quality of children again implies a severe limitation on the quantity of children produced. Industrial societies have thus stabilized their populations. At the same time their per capita resource consumption remains high and on the increase.

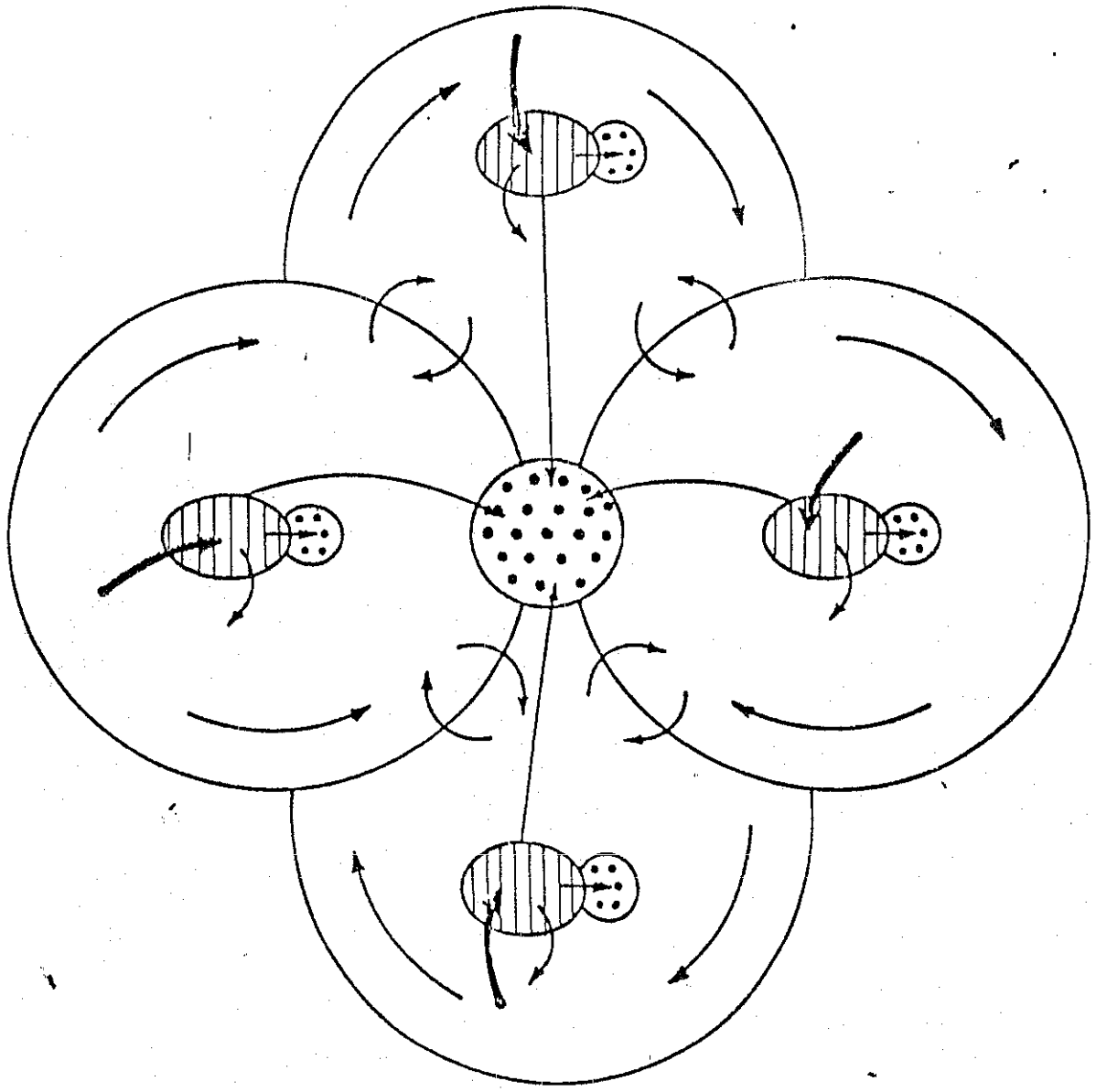


→ FLOWS OF MATERIALS ; ⁘ HUMAN HABITATION ;

□ LAND EITHER NOT CULTIVATED OR UNDER SHIFTING CULTIVATION.

In productive, stable environments, hunter-gatherer-cum-shifting cultivators maintain well defined territories. Cycles of materials in such environments are largely closed on the spatial scales of territories with flows of materials across territorial boundaries being much less significant. The thickness of an arrow indicates the intensity of the flow.

FIGURE - 1

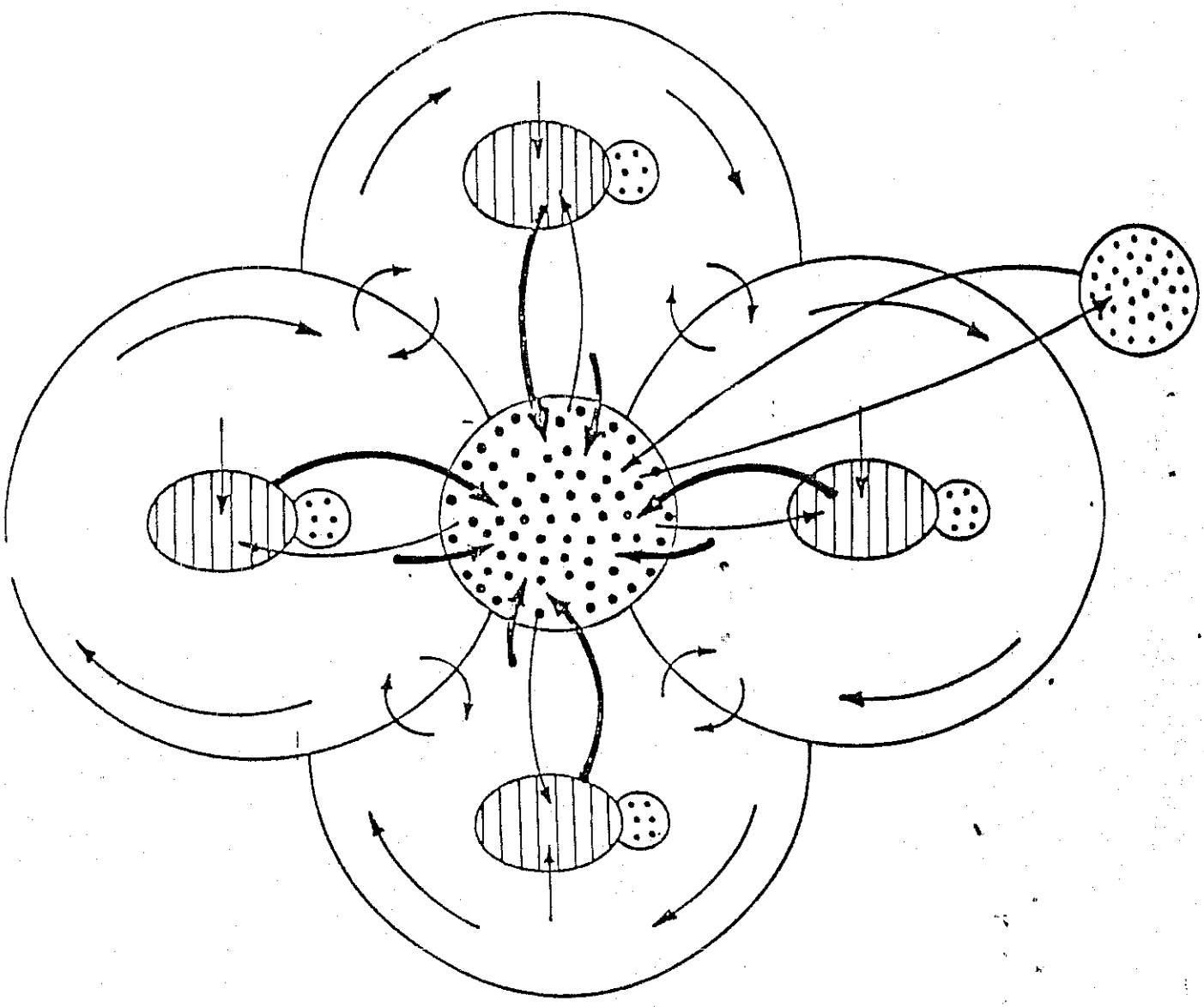


NON-CULTIVATED LANDS ; SETTLED CULTIVATION ;

HUMAN HABITATION ; ⟶ FLOWS OF MATERIALS.

Material flows in an agrarian society. Settled agriculture makes possible generation of surplus grain and livestock production which can support concentration of non-agricultural populations in town and cities. This material export from cultivated lands has to be made good by flows from surrounding non-cultivated lands. Material cycles thus become much more open in comparison with the hunter-gatherer shifting cultivator stage. Settlements adjacent to cultivated land represent villages, the larger habitation in centre, towns. The thickness of an arrow indicates the intensity of the flow.

FIGURE - 2

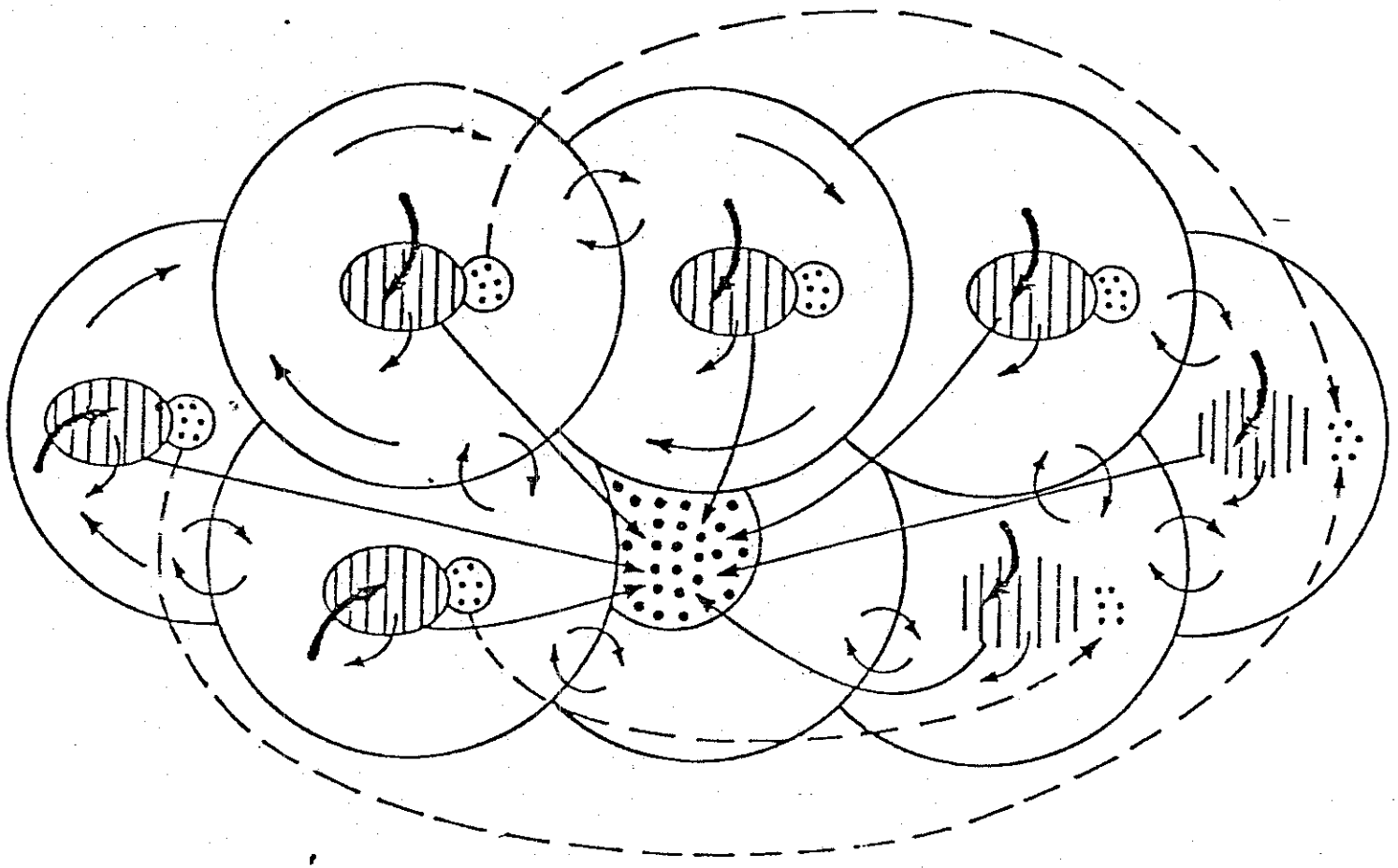


NON-CULTIVATED LANDS; SETTLED AGRICULTURE;

HUMAN HABITATION; FLOWS OF MATERIALS.

Material flows characterizing the modern Indian society. Such societies not only tap surplus of agricultural production, but also a great deal of the produce of non-cultivated lands to meet the requirements of the urban-industrial sector. Thereby the material cycles become totally open, with large outflows from rural hinterlands. These are partially compensated for by the organization of flows of materials such as fertilizers from the urban-industrial sector to the cultivated lands. The large central human habitation represents an Indian city such as Bombay; the separated habitation in the upper right hand corner, the industrialized countries. Thickness of an arrow depicts the intensity of flow.

FIGURE - 3



□ NON-CULTIVATED LANDS ; ▥ SETTLED CULTIVATION ; ⁘ HUMAN HABITATION ;

⟶ FLOWS OF MATERIALS ; - - → FLOWS OF PEOPLE.

Flows of material and people accompanying agricultural colonization. When settled agricultural populations are newly colonising river valley plains they would tend to use the cultivable lands exhaustively, without making good the losses induced by outflows of materials. As cultivated lands lose fertility, people would move on to settle new areas. Settlements adjacent to cultivated land represent villages, the larger habitation in centre, towns. The thickness of an arrow indicates the intensity of the flow.

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