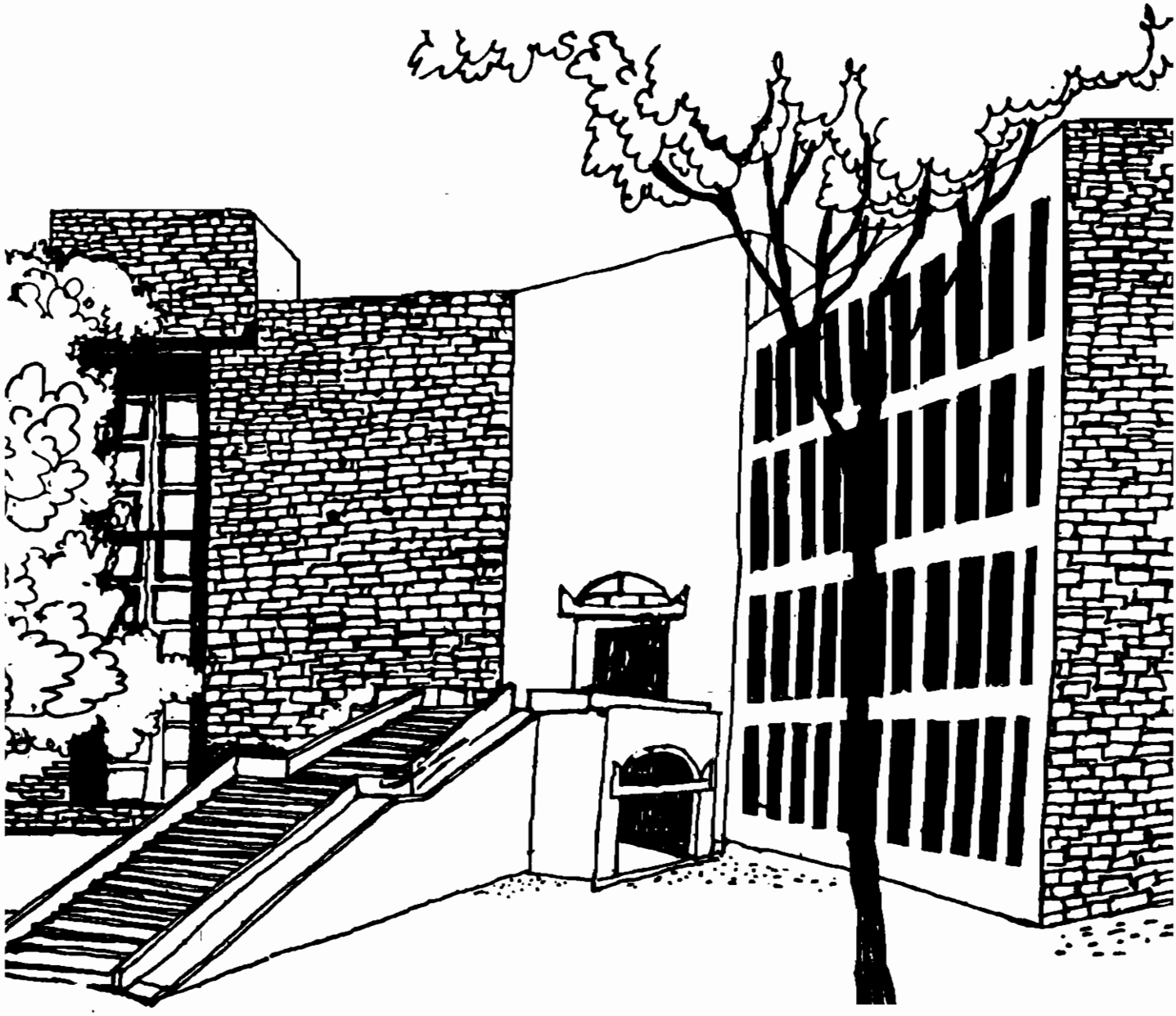
विद्याविनियोगाद्विकासः
IIM
AHMEDABAD

Working Paper

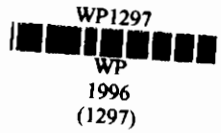


INDICATORS AS INDIGENOUS ECOLOGICAL KNOWLEDGE: 'LAMP POSTS', 'CROSSROADS' AND 'TURNING POINTS'

By

Anil K. Gupta

W P No.1297
March 1996



INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD - 380 015
INDIA

Abstract

Boundaries of most natural systems are fuzzy and thus amenable to contraction and expansion over time and space due to interaction of various natural and human variables. Fuzzy boundaries often require homeostatic indicators of threshold values so that changes conform to system properties and goals. The homeostatic indicators are kind of buffer solutions which do not tell us precise moments of change but suggest the range within which a change may take place.

Indicators are also like thumb rules which guide and regulate our relationship with nature within and outside. Nature within refers to our tendencies to internalize external shocks through various psychological, spiritual and social responses. The stresses produced by these emotions become evident through various indicators that we can experience and feel in day to day life. The nature without or outside is what we perceive through categories that we inherit as well as create or recreate. These categories also require indicators so that we can make sense of changes in these categories and accordingly deal with them.

In this paper, I deal with the theoretical as well as empirical aspects of ecological knowledge system which incorporates indicators as `lamp posts', `crossroads' and `turning points'.

Indicators as Indigenous Ecological Knowledge: `Lamp Posts', `Crossroads' and `Turning Points'[1]

Context:

Global concern for searching appropriate ecological indicators stems partly from our inability to interpret early warning signals of a major ecological change, given the complexity of ecological systems. But this concern also stems from a faith that large number of communities around the world have survived precisely through interpretation of such signals for various short term and long term adaptations. It is not my contention that local communities can always develop indicators of positive or negative change in each sub-system of a complex eco-system. I am also not suggesting that if these indicators are developed and interpreted, the appropriate social responses always result. Obviously, if this was so, we would not have seen so many natural catastrophes all around the world.

But my contention certainly is that ecological indicators embedded in local knowledge systems are certainly a very useful starting point in understanding the complexity of systems. These indicators also provide clues to the complex classification system that

---

1. This paper is considerably influenced by my participation in a brain storm meeting on indicators organised By IDRC in Ottawa last year to give rise to a Grass Roots Indicators Network (GRIN). Since I have not received the final report of the discussions, I have refrained from drawing upon the draft copy. But I recommend this report to all those who would like to partake the intensity of dialogue that took place in this meeting. Indicators have often been externally determined and literature has been quite biased in their favour. There are large number of studies that I could not review for want of time which remain to be covered in a proper discussion on indicators. I of course look forward to receiving critical suggestions from readers for improving second part of the paper in which I deal with some germs of an evolving theory.

   This being a first draft, suffers from all the limitations that one can imagine. Pew Conservation Scholar Award (1993) made possible part of the research for this paper. IDRC supported project On Indigenous Knowledge network (Global) provided the remaining support.

   Comments invited at following address: Prof Anil k Gupta, Coordinator, SRISTI, c/o IIM Ahmedabad 380015, India, email address:anilg@iimahd.ernet.in , fax 91 79 427896

local communities have evolved to deal with variability in any natural resource.

The paper provides a brief review of some studies throwing light on the indicators of ecological change along with implications that follow for further investigations in part one. I present a tentative theory of indigenous ecological knowledge system. Lastly, in part three some of the selected propositions about the role of indicators are summarized.

Part One: Review of select studies on indigenous ecological indicators:

Cultural adaptations: Nuno lived in the middle Zaire in the 19th Century on the bank of Zaire river. The diversity of the macro environments inhabited brought about diversity in the resource use patterns. Harms (1988) describes the process of drawing boundaries at the time of early settlement through various rituals. The purpose was to increase the fertility of the soil and ensure a match between cultivated and the uncultivated zones.

The combination of land and water based survival strategies enabled Nunus to evolve a combination of rituals and recipes for dealing with seasonal fluctuations in the ecological systems. They knew where the fish would be available when the water level was high and when it was low. The difference between fish farming and fish hunting or trapping was a way of evolving spatial and temporal limits of their resource extraction. They knew how the changes in one system - the rising water in the ponds and rivers - led to change in the movement of animals. The hunting points differed accordingly. The changes in the grazing pressure influenced the growth patterns after the rain which in turn gave them indication about the sites of more or less density of fish. They made small dams with holes to let water pass. The fish was collected when passing through these holes.

These systems were adapted with varying degree of success during colonial rule. The introduction of new technology by the missionaries improved the productivity but required

changes in the ethics of extraction. The dams and ponds could not be maintained. The nets with smaller holes were not sustainable. And yet, the knowledge of the environment and the indicators of change still survived. These indicators in the absence of self governing institutions, one could hypothesize, fail to evoke appropriate response.

Role of Myths: Ibrahim et al (1983), in a study of indigenous agro-veterinary knowledge system in Africa, suggested that indigenous ecological knowledge or indicators couched in mythical language accompanied with rituals had in many cases quite functional outcomes. For instance, the logic of farmers may some time be contrary to the logic of formal experimental method and thus may lead to rejection of the insight. In case of diarrhea in calves, *Adansonia digitata* was used. In the laboratory, this plant may not kill worms or bacteria. But, it is very rich in vitamin C, which was known to enhance the immunity of animals to diseases. The development of indicators and consequent responses may thus be guided by very different conceptual schemes. Validation of the indicators without understanding the cultural context of the knowledge is unlikely to lead us very far.

Formal science aspects of informal indicators: Johns and Keen (1986) provide a very interesting chemical ecological model for defining testable hypotheses regarding human interaction with plants. The indigenous classification of potato by Aymara of Bolivian altiplano was found to be very sophisticated. More than thousand names were found for this purpose. Since they also had a very detailed taxonomy of taste, the authors tried to find criteria of selection of such potatoes which had low content of solanine - the glycoalkloid which was found to be toxic to humans above 20 mg./100 g. fresh weight. The `sip and spit' method was chosen for bio-systematic analysis of the ability of people to distinguish potatoes with varying content of the tomatine and solanine - chaconine in potatoes. The statistical support was found for the ability of Aymara and other Andeans to distinguish potatoes on the basis of taste. The indicators that people used were not based on merely flavthe bitterness. People took into account the aroma or in addition to taste. Even

though glycoalkaloids were only partly responsible for the aroma, people had developed complex categories for classification. The study indicated a possibility that when indigenous classification produced confounding results as it happened in this study in certain categories of glycoalkaloid content, this could be because of higher tolerance levels associated with taste. It was not because people distinguished varieties only within certain ranges of variability. This also suggests that evaluation of local indicators of taste, acceptability and palatability of food cannot be done entirely on normative grounds. What may be an acceptable level of toxin for a particular human group may not be acceptable to another group. Variations in the acceptability may require modified hypothesis rather than rejecting improperly framed hypothesis.

Johns and Kokwaro (1990) further elaborated this issue when they observed, "unpalatability comes from allelochemicals in plants; these chemicals may also be toxic. However, toxicity is a relative concept that must be considered in relation to the context in which these plants are used". The indicators of toxicity will serve little purpose if not seen in the context of use, combination and stress. Same food may not be toxic when taken in small quantities or when processed in a particular manner. But when taken in sole condition and/or in stress period, the consequence may be different. Johns and Kubo (1988) mentioned seven methods of detoxification ranging from eating, diluting fermentation, adsorption, drying to physical processing and pH change. Many times the indicators are a response to a complex way of defining problems. For instance, a food item that can be processed and made safe may not be defined as toxic whereas the modern systems of classification may ignore use level implications. Jain (1964) had suggested a need for giving attention to precisely this issue. Even though Jain does not get referred in Johns and Kubo's excellent review, the study, however, remains an early warning to the students of indigenous knowledge system. Jain observed that many researchers did not sufficiently explain that different edible plants were not equally relished by local communities. He observed, "plants known as edible in one region are not accepted or sometimes even

known as edible in other regions".

Indicators for asserting local rights: Moles and Riker (1984) discuss the role of indigenous knowledge in the definition of their rights. One implication of their work, though not drawn by them, is that local ecological knowledge particularly the indicators signifying boundaries of systems can be used for defining and legitimizing rights of local communities over resources.

Limits of formal science: This limitation of modern scientific methods is most clearly evident in the case of germplasm categorization. The passport information for cataloguing germplasm does not include the use level information and, therefore, important indicators are ignored while drawing upon the gene pool. Gupta, Patel and Shah (1985) and Gupta (1980, 1989) argued that there is a need for re-thinking the system of classification and characterization of various natural phenomena drawing upon indigenous ecological knowledge.

Kurien (1991), in a very interesting study of traditional versus modern co-evolutionary development of marine fisheries, decries the taxonomical approach which suggests that by aggregating knowledge of individual species, we would be able to understand the total resource use system.

Cycles of Change: Kirch (1976), while reviewing the indigenous agriculture in western Polynesia, shows the linkage between ecological cycle and the cultural patterns. When the rainfall decreases and the time for yam planting starts, there are indigenous schemes of classification indicating the timing of various activities. The festivals such as liha - mua indicate the ceremony of arrival of fresh fruits. The accompanying rituals signify do's and dont's on such occasions.

Similarly, in most parts of Asia, a panchang i.e. an agro and socio-ecological calendar, specifies the period and timing of different operations according to ancient system of interpreting astronomical phenomena through astrological means. The festivals of keeping fast are provided at the time of change of season from winter to summer and vice versa. The ancient culture in the olden days must have recognized the stress caused by change of weather on human body. They would have also realized that fasting and taking certain specific foods was an efficient way of dealing with them. However, rather than leaving the coping mechanisms to individual ability to identify this stress and thus respond suitably, a cultural role was evolved.

This suggests that indicators of stress may not always be located in specific signs or symbols of change. These could be part of cultural repertoire. To that extent, these indicators may become less time and space specific. Whether the purpose of an indicator is to improve average performance vis-a-vis the individual performance may influence the location of an indicator in a fixed ritual or an occasional and flexible ritual or recipe. Thus, there are very robust indicators of one's own health compared to the health of eco-system. Even for individual health, the systematic stress periods such as monsoon in some areas and dry period in other areas. There are specific rituals or rules to deal with the stress. But these rules operate in a homeostatic manner. These take care of variations within a range. When the change is beyond the boundaries of range, some other indicators are used. Similarly, one will have to look for ecological indicators having applicability only in narrow range of conditions as distinct from wide range of conditions. The implication is that there are series of indicators providing clues to various dimensions of a phenomena. Some suggest presence or absence of a phenomena while others suggest the degree of change or extent of occurrence of that phenomena.

For instance, an ancient Indian text known as Brihat Samhita provides several indicators of above kind. In verse number 6-7 of chapter 45, it is suggested that if a tree is seen flourishing in a waterless tract, then one could expect water at the depth of about seven-and-half feet westward. Similarly, if a jamun tree is found accompanied by an ant hill, sweet water at the depth of about ten feet and at a distance of three feet southwards could be indicated. Similarly, fig, arjun, indigo, palas, pongamia, Bunyan, etc., are indicated to suggest underground water. It is also mentioned that trees which indicate water in desert will not be indicating the water in forests. Similarly, the extent of water and quality of water is suggested by some other indicators including the presence or absence of certain insects, nature of sub-soil and the temperature of the soil at different depths and on the surface. The nature of rocks, the colour and pigments on them are also used to indicate presence or absence of water. This text not only provides the indicators but also practices to operationalize them. For instance, in verse no.113, it is suggested that the ash of a particular tree when boiled along with reeds and sprinkled on rock after heating the same, it will break. Similarly, indicators exist for predicting the onset, duration or cessation of monsoon.

Indicators for cross altitude/regional coordination of resource use strategies: In Bhutan, as in many other Alpine regions, pastoralists have devised indicators for identifying not only the time for opening or closing the pastures but also for entering or withdrawing from a particular ecological niche. It is known to the pastoralists that cattle move up during the summer and the yak move down during the same period. At around 4000 feet, both these herds may meet if care is not taken. Since it is known that some diseases spread from cattle to yak, it is important that yak leave the pastures well before cattle come. This is required also to avoid over-grazing. A flower, `tseb' indicates the time for yak to go back. This happens about a month before the cattle reach at that altitude. This gives enough time for grasses to re-generate. Without modern means of communication, the pastoral-

ists coordinate their actions across altitude and long distances.

Prediction of geo-physical changes: Lowry (1982) describe various approaches based on animal behaviour, used to predict the earthquake. Some animals, it was suggested, had an extra-ordinary capacity to notice minor fluctuations in magnetic fields, smells, sounds, etc., which were associated with the onset of earthquake. Dogs are said to be much more sensitive than men to the foreshocks experience before the earthquake. Similarly, birds and some other animals can respond to the sounds at frequencies below the range of human sensitivity. It has been hypothesized that certain sounds are produced before the major earthquakes. The smell generally linked to the emission of methane or sulphur compounds are noted by snakes much earlier and at much smaller concentrations than would be the case with human beings. The abnormal behaviour of fish has also been related with occurrence of earthquake. Similarly, failure of pigeons to make a short homing flight before the quake in Napier was also indicative of earthquake.

In Brihat Samhita, Prasad (1995) points out that there are a large number of animal based indicators of earthquakes. He lists these indicators, " much tumbling of fish on to the shore line; repeated croaking of frogs, cats vigourously scratching the earth with their nails; ants shifting their eggs; snakes mating and climbing down the trees; chameleons perched on the tree tops fixing their gaze on the sky; stampede of the cows; cows look up towards the sun; domestic animals like cows and dogs, reluctant to go out of the house, shake their hoofs and ears; dogs stand on roof tops and bark or cry continuously looking at the sky; birds bathe in the water or dust; creeping worms betake to the tip of the grass blades; groups of birds twitter merrily at sun rise or sun set; flight of the glow worms at night at high elevations or altitudes".

Stocking and Abel (1981) describe many indicators such as soil colour, plant species and indicators of erosion. The soil colour has been used all over the world by the farmers as

first indicator of soil quality. The soil colour itself may depend upon the parent material, structure of clay, wetness, organic matter and particle size distribution. Even aerial photographs capture some of these differences very well. In addition to indicating soil type and particle size distribution the soil colour, authors suggest, could also indicate plasticity and volumetric activity. Similarly, the vegetation indicates certain aspects of soil climate interaction and drainage properties. The occurrence of *Parinari curatellaefolia* on the top of ridges in a watershed was considered a good indicator of the underlying fragility. Change in the land-use could be dangerous. This tree was known to flourish in zones with fluctuating water table over seasons with roots reaching the saturated soil during summer.
The changes in the soil properties particularly fertility and extent of erosion was also noticed through the ratio of edible to non-edible species in a given rangeland (Gupta, 1984). The existence of predominant non-edible species (often woody in nature) indicates that excessive grazing has taken place.

Atte (1989) reviews literature on applications of local technical knowledge in development and identifies several fields where indigenous ecological knowledge system can be very effective, such as resource inventory and mapping, environmental monitoring for floods or droughts and other natural calamities, planning of resource-use, technological change, health both human and livestock etc.

Atte (1992), drawing upon several studies, quotes Conklin (1957) that four kinds of firmness, nine kind of colours, ten basic and thirty derivative rock and mineral categories, five ways to describe topography and three to describe slopes. In Yoruba, he recalls that farmers have as many as 27 categories. By looking at the footprints on the wet soil, one could walk and divide miles of soils into sub-categories suitable for crops and crop combination. Similarly, Richards (1985) found soil and varietal association in paddy similar to the one found in most paddy growing regions. These categories when are associated with indicators of change become dynamic lexicon of environmental interpretation. It is import-

ant that one does not use these categories in static terms.

Bhandari (1974), in a very important contribution, described famine foods in Rajasthan and their importance for human survival. This information could be an indicator of the extent to which a region may be suffering silent famine.

The insect and pest incidence, occurrence and interactions with crops, weeds, etc., have also been used as indicators of productivity. Paul Richards (1985) presented detailed evidence about the taxonomy of grasshoppers and the relationship between seasonal change and the behaviour of various species of grasshopper. The insect behaviour in combination with wind velocity, direction, kind of cloud formation have also been used for predicting rainfall and consequent crop productivity. Balasubramaniam (1986) reviews various studies which show these associations. A large swarm of white butterflies was supposed to foretell flood. Similarly, a very widely held belief is that when ants gather their eggs to move to a safe place, rain is indicated. Similarly, the height at which dragon fly flies, the continuation or stoppage of rain is indicated. If it flies high, the rain will stop and vice versa.

Hill and Ramsey (1977), in a remarkable contribution provide a list of weeds used as indicators of soil conditions. They acknowledge that this was not a new concept. The great Roman scholar Pliny the Elder in 50 A.D. had observed that the land supporting wild plum, elder, oak and thimble berry was quite favourable for wheat production. During the colonization of North America, immigrants chose their land for farming on the basis of the vegetation it supported. For instance, lands having white pine or Norway pine communities were generally sandy in nature and of little value. On the other hand, forests of birch, beech, naple, hamlock, etc., indicated more fertile soils. Similarly, soils for wheat or grass production were distinguished from soils for orchards. They quote Hilgard (1906) to suggest that high alkaline soils were found unsuitable for cultivation and were character-

ized by the presence of tussock, salt grass and grease wood. They suggest six precautions before taking up weeds as indicator of soil property, (a) weeds have several ecotypes and each may have different tolerance to specific soil factor, (b) some weeds have high range of tolerance while others have narrow range, (c) same weed may be indicative of several environmental factors, (d) the perennial weeds could be better indicators than annuals, (e) the weed communities were better indicator than single specie, and (f) growth characteristics of the weed could be as revealing as their presence. The health of a soil can be monitored by the weed complexes available.

Patel (1992) reviewed various findings on indigenous knowledge from published literature and tried to ascertain their validity by interviewing the scientists. He looked at different indicators of rainfall prediction. If a particular reptile had reddish colour on the lower side of its throat and the wind was blowing from north and west direction, the rain was expected immediately. Similarly, belief from south India about fishing was that if water appeared red in the day time, fishermen were unlikely to find much catch (Singh and Prasad, 1991 quoted in Patel, 1992). In Karnataka and Kerala, the fishermen went for intensive prawn fishing when they observed mud banks or turbid ocean water.

Siar, Ortega and Babol (1992) describe the contribution of indigenous knowledge in sustainable fisheries. The variation in the wind movement are carefully monitored and a rich vocabulary has developed to explain these variations. For example, sometimes the fisherman experienced sudden change of wind direction in the deep sea while fishing far from a place called as Malalison. This phenomena is called *tampo* and is characterised by heavy rains, strong winds and storms. The wind direction close to the surface or currents underground are called *habagat*. They can come home in zero visibility by looking at *habagat* below the water surface. Similarly, there is a rich classification of waves. When big waves come in succession followed by small ones, they take it as a danger sign and have developed a collective routine to escape the danger called as *buslog*. They land their boats

on the shore to time with the smaller waves and then they draw the boat at full speed to the shore line. They jump out of the boat and carry it to the shore line as fast as they can.

Dvorak (1988) studied indigenous soil classification in south Indian villages. She found very strong analytical evidence supporting the indigenous classification of soils. The formal soil classification was found much poorer in its analytical rigour. For instance, only about one-third of the plots, farmers considered poor, were classified so by the ICRISAT scientists. She argued that targeting of research trials could be much more focused and productive based on farmers' classification rather than the formal so-called scientific classification.

In a study on matching farmers knowledge with scientific goal setting, Gupta (1985) learnt five different were ways used by the farmers to find appropriate time for the sowing of gram or chick pea crop. The five methods included (a) sighting of a particular bird called as Kunj, (b) rising of dust in the evening when animals return to the village after grazing outside, (c) barefoot walking in the field, (d) odour emanating from the soil when water falls on the ground at noon time, and (e) when one needs a sheet of cloth to cover oneself in the night due to mild cold. These indicators may be used in combination to confirm the decision. It is possible that different factors such as wind, diurnal temperature variation, humidity, etc., influence the right time for sowing gram and different indicators capture different aspects of the right time. Several other indicators were noted in other studies (Gupta, 1980, 1985a, b, c, 1988, 1989)

Indicators for holistic systems: Bhaskarbhai Save is an organic farmer in south Gujarat. He made a transition towards alternative agriculture about 20 years ago and tried a whole range of practices in orchard and annual crops. One of the indicator he uses to decide whether he needs to irrigate or not is the condition of a plant called croton. He has planted croton in different fields and when the leaves become erect and show signs of stress he

provides the irrigation. Of course, he does not believe in providing water near the roots of trees. Also his contention is that plants need moisture and not flood irrigation which may provide too much of water.

For pest control, he relies on red ants and some other birds. He also monitors the soil condition by looking at the condition of mulch and soil surface. The only input he gets from outside is the soil either from a pond, an ant hill or some sand. Since he understands the entire ecological change, he looks at different indicators for monitoring the health of different sub-systems of his farm.

limitation of indicators: Farmers have to cope with sometimes unique problems created by factors beyond their control. For example, during a study in Karnataka, we learnt that when the trucks carrying grains moved on the road, small quantities of grain fell on the road. These attracted the birds. The farmers having fields on the road side had two choices, i) to grow crops which did not attract birds or ii) scare the birds away. Solutions to such problems require development of rich range of information on managing bird induced damage. Such location specific contingent solutions may defy the expected logic of location and indicators. It is possible that on the basis of soil and climate classification and interactions some other crop affected by the birds may have been more appropriate. Therefore, indicators can only provide thumb rules for action and not strict or specific guidelines.

Who knows about indicators: In hill areas, when natural streams have to be trained for taking water to long distances, the design of the irrigation system often is determined by the graziers and not the cultivators. The graziers while grazing on the higher slopes recognize the vegetative and rock indicators which help in defining the contour line and avoiding excessive water loss on the way. Without modern equipments, the streams are guided precisely to the point where water is required even though the source may be more than

20 to 30 kms. away. The implication is that the knowledge of indicators need not reside in the minds of direct users of a resource.

Part two: Towards a theory of Indigenous Ecological Indicators:

All ecological systems are inter-connected. Theory of chaos would imply a butterfly effect suggesting that a small change in one part of the world can bring about a catastrophic outcome in another part of the world. The events like El Nino no more surprise students of inter-connected system. But the inter-connections can only be studied in a limited way. If every thing is related to every thing at the same time, no causal statement can ever be made. I can call it as the principle of holistic impossibility. Reduction is necessary for making measurement possible. Local communities inhabiting a finite space do draw territorial boundaries which may divide ecological systems, disrupt flows and spur adaptations by some species while others decline. These boundaries could be fixed but the feedback effects of the systems enclosed within these boundaries can seldom be contained within. This gives rise to the concept of fuzzy boundaries. Fuzziness arises also an account of dynamic changes within the ecological systems due to long range effects. For example, because of differences in the glacial melting of snow in the Himalayas, the rivers get floods of varying intensity further influenced by the flow of different tributaries. The rivers change their course. The boundaries of riverine system get modified. The cultivated bank becomes uncultivated and regions uncultivated earlier may start getting cultivated.

Similarly, the pasture may get affected by the precipitation, grazing pressure and some other indifference (natural or manmade) which may affect the regeneration rates. Thus, the effective catchment area may change. In drought years it may expand and in normal years or good rainfall years, it may contract. The grazing routes, intensities and pastoral interactions with these settled communities may get modified.

In case of collection of gum arabica in certain African regions, the boundaries of the region from where collections are made may vary not only on ecological ground but also on economic ground. The prices of maize may influence the ability of people to hire labour and thus the number of trees to be tapped. Some other parts of the same ecological system get fluctuating supply of gum for their own life cycles.

The boundaries of the region from where a community can collect pine needles for manure purposes, hunt game, or collect fuel wood may similarly vary. There is an interesting case of how variation in ecological systems influence the rules used by social institutions to manage that system. In a semi-arid African region, there was a large tank from which water was drawn for irrigating fields by an informal collective of people. In the drought years, the water level got very low and people decided not to enforce any system of distribution. Anybody having field nearby could take the water. In the normal years, the rules of distribution were strictly enforced. The alternative cycle of chaos and order perhaps influenced the stake building of beneficiaries and losers. They cooperated to generate an optimal solution in one period and became indifferent to that in another period. When resource was too small, the community concerned might have figured out that rational distribution would not make much sense. In the process, IOUs might have been generated to bring about grater compliance in the normal years.

In all the examples mentioned above, one thing is common which is the fuzziness of the boundaries. Sometimes the feedback of fuzziness is absorbed through institutional adaptation and sometime it is through the technological or social adaptation. Two implications follow for the study of indicators: i) the boundaries may be monitored through indicators for territorial and ecological purposes and ii) the fluctuation in the boundaries may lead to development of multi-step indicators depending upon the degree of fluctuation and its effect on different sub-systems. It is assumed here that boundaries may violate the ecolog-

ical integrity of a system but the communities have drawn these boundaries always for management purposes. In some cases, during the colonial rule, artificial boundaries were drawn particularly in Africa violating the ecological and social inter-connections in a fundamental sense. Any student of ecological systems has to take these abberations as given. Although with improvements in the understanding of inter-connections, one hopes that transboundary institutional arrangements will emerge. Till then, the indicators developed by communities to define boundaries and interactions among different sub-systems can be documented and analyzed within the constraints of limited validity.

The boundaries of a system are not merely spatial. The seasonal, sectoral and social factors influence the boundaries in cultural and economic sense also. What was once a taboo may not any more be so. Similarly, scarcity of a resource may generate new economic opportunities which may dilute the institutional norms about use of that resource within sustainable limits.

The point to remember is that boundaries are defined by community use conditions and the boundaries so defined influence the choices of the communities in future. The indicators of ecological change can help in monitoring these limits.

Since fuzziness implies a range of variability, homeostatic strategies as indicators are bound to evolve. Thus, if the plots on which a crop can be sown depends upon the interaction between available soil moisture and the appropriate temperature, then this confluence may take place in some plots and not others. The students of ecological geography have noted the emergence of niches of various land-use systems affected by such interactions. Given the fact that different people have varying expectations from an investment, one finds the boundaries of niches not very precise. This is what we call as homeostatic response through indicators which reflect malleability of the resource use systems. When these limits are crossed, the disturbances in the form of disease and pest

attack, and other abiotic stresses become more important.

In cybernetics, the lead time for different signals is considered crucially depended upon a homeostatic ability of a system. For instance, if a doctor was to monitor the heart beat of a heart patient every week, not many patients will survive. Similarly, if a student of crop forecasting will monitor changes in the greenness index every day in a crop duration, so much redundant information would be generated without producing any meaningful result. Thus, different indicators have to be monitored at different frequencies to generate meaningful results.

Since indicators are by definition thumb rules, they can only guide and regulate our judgments. I argue that sustainable resource use requires not just the study of indicators which influence our relationships with nature outside but also within.

Whenever an ecological boundary given a cultural sanction has to be violated, I assume that the violator has to resolve internal dilemma at least in first few times of violation. The moral codes do get modified over time in different societies. In parts of Africa, women were not supposed to plant trees or even touch the roof in which wooden beams may have been used. Once the male emigration became widespread, this taboo had to be abandoned. Obviously, the moral sanctions may have produced guilt in the beginning but slowly and slowly, women would have realized the necessity of adaptation. Such dilemma and the consequent adaptation can be monitored by understanding and analysing the changing meanings of the myths. Sometime new myths are created to resolve this dilemma.

I have argued that `a change not monitored is a change not desired' (Gupta, 1984, 1987). It is quite possible that many communities have not realized the need for certain changes and, therefore, have not developed indicators to monitor them. In this sense, the study of

indicators also helps us in recognizing the stress points of a system. This stress could be ecological, psychological, spiritual or social. When sanctity of a resource use practice considered sacred at one time is challenged, a spiritual crisis emerges. Certain communities cope with it by generating a parallel mythology. Some other cultures generate a consensus of not asking questions about the dilemma which so arise. But in certain cases communities do go to a very great extent in evolving collective coping mechanisms.

Psychological adjustments have also been studied through the study of language and social and personal customs. Certain feelings if not expressed may not have appropriate words in the language. Thus, a linguistic analysis can provide useful clues to the study of indicators for understanding long term evolutionary adaptations of a society to the stresses in the environment. The other side of the coin is that many words may exist to capture small variation in the meanings in cases where a community is crucially dependent on a given resource. For instance, it is believed by some that Eskimos have a very large number of words for snow, just as fishermen and women may have for waves or some farmers may have for soils. The implication is that a resource on which we are dependent crucially, we may classify the variance in that resource very carefully so as to deal with the same. Indicators of this adaptability can be identified by looking at the indigenous classification system.

Analytical framework:

The eco institutional framework of blended knowledge systems is presented in figure one. The ecological context in a given region or for a given community defines the nature of environmental risks or threats. A drought, a flood, erosion of biodiversity or increase in salinity levels in coastal areas due to ingress of sea water may be different kinds of threats. The regions which have very low level of threats are preferred by markets and even state and, therefore, are advantaged in most respects. Given low transaction costs

of exchanging resources in these regions, the adaptive response of the households is fast. At the same time, in view of the prevalent value system, the social structures are also different compared to the disadvantaged regions having higher perceived risks or threats. In table 1 we have enumerated the key contrasts that characterise the advantaged (market dependent) and disadvantaged (nature dependent regions).

Table 1

	Market dominated	Nature dominated
1. Communication system	Digital	Analogical
2. Pooling of resources	Very low	Very high
3. Reliance on common properties	Low	Very high
4. Settling of books of account	Very short term	Long term
5. The proportion of women headed or managed households	Very low	Very high
6. Women participation rates	Very low	Very high
7. Reciprocities	Specific	Generalized
8. Empowerment	Material resource-based	Knowledge resource and culture-based

Source: Gupta, 1992

The nature of local community is therefore quite different though affected by similar processes of stratification as well as cultural homogenization. The access to resources may be unequal due to property rights sanctified by culture, state or sometimes just the local usurper. The stratification may also occur due to inter-generational transfer of property, bad luck in discriminating good from the bad opportunities or specific biases in public policy.

The unifying tendency could similarly be strong or weak, among different subsets of a community. Religion, caste, ethnicity, myths and rituals etc., may contribute to the centripetal forces (Gupta, 1993). Since the units which are unified may not completely overlap with the units which are stratified, they remain subsets which are fragmented. As argued earlier, most institutions of resource management have fuzzy boundaries. In each group, there are people who agree only partly with the rules and therefore play the game half-heartedly. The pluralism of this kind is a guarantee against too quick an agreement or for too long (in either case, the rules will be eventually aborted for want of periodic rejuvenation, reaffirmation or revalidation).

The perception of boundaries and changes within are influenced by the formal and informal institutions. The formal institutions imply the administrative, economic and political definition of boundaries, and formal relationships with resources, formally acknowledged entitlements and access rules. The informal institutions imply ethnic, religious, socio-cultural boundaries, norms, myths, etc., influencing our perception of nature.

This perception of nature is mediated through the stratified prisms as well as through unified lenses. The prisms refract light. The perceptions through stratified prisms thus are fragmented, fractioned and in many cases contentious. On the other hand, the perceptions through cultural or religious lenses tend to be homogenized within a cultural boundary. The contest between differentiated meanings as well as shared meanings takes place in every society. In the nature dependent society, the unifying spirit of the nature apparently provides an outer limit within which differences can be articulated. In the market dependent communities, such unifying forces, are unfortunately guided by great degree of expedience and opportunism. We are in some sense seeing the contradiction between the interest of groups with short or long time frames.

The perceptions of nature essentially requires making sense of four facets of a natural phenomena i.e. known as diversity, complexity, simultaneity and change. Once the categories are developed, their meanings remain valid within a given boundary.

The diversity indicates the ability of a natural systems to cope with different stresses through a variety of inter-connected responses. Sometimes, the inter-connection are weak and, therefore, diversity is very large. In a diverse system, selections can be exercised and opportunities can be specialized.

The complexity refers to the nature of inter-connections among different components of a diverse system. When complexity is high, the change in one sub-system may affect change in many other parts of the system and often in unpredictable ways. If complexity declincs, the systems become predictable and, therefore, are likely to breakdown.

The simultaneity is the phenomena of exchange of energy and information through different path and path ways in a natural system taking place concurrently. Unlike the sequential and liner system of analysis, simultaneity violates the assumption of cetaris paribus. And, therefore, the classical approach of modelling behaviour does not work. The change is a consequence as much as it is a precursor for nature to deal with chance and necessity.

The perception of nature mediated by formal or informal institutions are distinguished on the basis of the categories of sense making. Once certain categories become powerful in defining the boundaries of a phenomena, the system of appropriation gain legitimacy. This they do through the efficiency with which resources are extracted.

To illustrate, the crop and weed are two such categories. A plant out of its place is called weed. Obviously, in nature, there is not ever a plant which can be out of its place. And

yet, once we define the companion plants in the crop field as weeds, the next step is to find ways of eliminating them. The so called weeds may perform a whole host of functions. Some of these might attract predators of the pest, prevent certain insects from completing their life cycle, move nutrients from the lower level of soil to the surface through deep roots, fix nitrogen in the soil etc. Some of the weeds are mulched in the soil to conserve moisture, still others may have allelopathic interactions. Similarly, there are companion plants (weeds) which may compete with the crop and take away its nutrient and moisture. Most Indicators emerge through such interactions.

The point is that boundary of a system in terms of crop or weed may prevent looking at certain interactions which may hold the key to sustainability. There are very few studies, which look at the positive or negative impacts of biodiversity on the field bunds, roadside or swamps etc., on the cultivated systems. What part of nature is relevant for a particular purpose is essentially decided by the categories of sense making. These in turn influence the way we define the boundary of a system.

If we take another case of soil classification, we notice similar contradictions. The soil classification based on USDA system may mask more information than it reveals. Indigenous soil classification may provide valuable clues about the micro environmental niches and the suitability of specific sites for different species and varieties. Sustainability would require precision farming i.e. an attempt for need based input use.

There are large number of other examples in which the classification of a natural resource may not provide sufficient clues for augmenting renewability of resource through various feedback loops in the ecological systems. By drawing artificial boundaries, and classification criteria we may create symbols of appropriation which allenate us from nature. To extract returns without supporting various ecological requirements of a system one needs economic calculus and an ethical position which justifies making these boundaries. Thus,

if birds are only a pest, companion plants are only weeds and biodiversity around the fields or water bodies a nuisance, the judgments have been made and categories created. Many times, in the process of doing so, we incur ecological costs which feedback in the long run and impair the viability of the systems. However, there are processes through which we may avoid these eventualities.

Systems of appropriation emerge to transfer resources from one boundary to another, from one group to another or from one time period to another. For instance, when boundaries of national parks or sanctuaries are drawn without looking at long range human ecological interactions, the categories developed by the indigenous knowledge system may lose their functional relevance. People may have defined different zones for grazing or collecting other forest products in different seasons. With the new boundaries in force, people may not be able to follow the old categories of zoning. The hope of the systems or park managers may have been that with this arrangement they will be able to transfer resources from people to wildlife over time and thus ensure the continuity of wildlife.

However, as example of Bharatpur Bird Sanctuary in north India shows, many of such assumptions prove totally invalid. The cattle graziers who used to graze in this sanctuary were prevented from entering this sanctuary after drawing a new boundary . With this restriction on grazing, the grasses in the sanctuary around the swamps started growing tall. The result was that Siberian cranes which used to come to the sanctuary stopped coming. They could no more find the insects in the tall grass. The new boundaries and new categories of sense making generated a system of appropriation which defeated the very purpose for which this was done in the first place. The crucible of creativity in which various indicators evolve can generate ecologically positive as well as negative innovations. In other words, the communities can be very efficient in degrading a resource just as they can be in augmenting it. Much depends upon how we interpret the interaction between formal and informal knowledge systems, redefine our categories of sense making and

develop new systems of appropriation which are ethically and socially fair and just.

Part three: Summing Up

Several propositions or assumptions can be put forward about the role of indicators:

These indicators in the absence of self governing institutions fail to evoke appropriate social response.

The development of indicators and consequent responses may thus be guided by very different conceptual schemes.

Validation of the indicators without understanding the cultural context of the knowledge is unlikely to lead us very far.

Many times the indicators are a response to a complex way of defining problems. For instance, a food item that can be processed and made safe may not be defined as toxic whereas the modern systems of classification may ignore use level implications.

Local ecological knowledge particularly the indicators signifying boundaries of systems can be used for defining and legitimizing rights of local communities over resources.

Indicators of stress may not always be located in specific signs or symbols of change. These could be part of cultural repertoire. To that extent, these indicators may become less time and space specific.

Whether the purpose of an indicator is to improve average performance vis-a-vis the individual performance may influence the location of an indicator in a fixed ritual or an occasional ritual or recipe.

There are series of indicators providing clues to various dimensions of a phenomena. Some suggest presence or absence of a phenomena while others suggest the degree of change or extent of occurrence of a phenomena.

Various categories of sense making when are associated with indicators of change become dynamic lexicon of environmental interpretation. It is important that one does not use these categories in static terms.

Indicators can only provide thumb rules for action and not strict or specific guidelines.

The knowledge of indicators need not reside in the minds of direct users of a resource.

Two functions of indicators in the context of boundaries of any natural resource systems are: i) the boundaries may be monitored through indicators for territorial and ecological purposes and ii) the fluctuation in the boundaries may lead to development of multi-step indicator depending upon the degree of fluctuation and its effect on different sub-systems.

Different indicators have to be monitored at different frequencies to generate meaningful results.

Indicators also help us in recognizing the stress points of a system. This stress could be ecological, psychological, spiritual or social.

A linguistic analysis can provide useful clues to the study of indicators for understanding long term evolutionary adaptations of a society to the stresses in the environment.

In this paper, I have presented evidence to show how interaction between different subsystems of local knowledge systems take place. I have suggested that indicators can provide light, as a lamp post does but along a given road. In this case, indicators do not tell us what new roads to find. These merely tells us how to move safely on a road already identified. The indicators can also be like `cross roads' where we have a choice to go in different directions. Our choice will depend upon our values, resources, technologies, institutions and cultural milieu. The indicators can also provide turning points for our future relationship with nature and these indicators are most difficult to embed in our contemporary consciousness. Because acknowledging these indicators and their validity would mean changing our lifestyles and the way business is done[2].

---

2. Henry Lickers from Akwasasne nation of Canada has amplifies this issue a great deal. He suggests that at different level of aggregation in society, there are different indicators which point out the extent to which our life styles are in tune or otherwise with the changing limits of ecological systems. He of course does not rely only on ecological indicators but also draws upon the social-psychological and institutional indicators of ecosystem health.

BIBLIOGRAPHY

Atte, David O, (1989), "Indigenous Local Knowledge as a Key to Local-level Development: Possibilities, Constraints and Planning Issues in the Context of Africa", Seminar on Reviving Local Self-reliance: Challenges for Rural/Regional Development in Eastern and Southern Africa, United nations Centre for Regional Development and Centre on Integrated Rural Development for Africa, Tanzania, 21-24 Feb, 1989.

Atte, David O, (1992), "Indigenous Knowledge and Local Level Development: The Participatory Approach", International Symposium on Indigenous Knowledge and Sustainable Development, IIRR, Philippines during 20-26 Sep, 1992 in Nigeria.

Bhandari, M.M. (1974), "Famine Foods in the Rajasthan Desert", Economic Botany, Vol.28, pp.73-81, Jan-Mar, 1974.

Balasubramanian, A.V. (1986), "Tamil Folk Sayings on Agriculture", Reprinted from PPST Bulletin No.9 (Dec.1986), pp.60-89.

Conklin, H.C., (1957), "Hanunoo Agriculture in the Philippines", FAO Paper No.2, FAO, Rome.

Dvorak, Karen Ann (1988). "Indigenous Soil Classification in Semi Arid Tropical India", RMP, Economics Group Report - 84, Patancheru :ICRISAT.

Gupta, Anil K., (1980), "Communicating with Farmers - Cases in Agricultural Communication and Institutional Support Measures",IIPA, New Delhi, 92 p.

----------, (1985a), "Socio Ecology of Natural Stress, Technological Changes & Human Resources in Bhutan", CMA, IIM, Ahmedabad.

----------,(1985b) Socio-Ecological Paradigm for Analyzing Problems of Poor in Dry Regions, Ecodevelopment News, (Paris) No.32-33, March 1985,pp 68-74.

----------, (1985c), "Notes based on the discussion with farmers of Village Kirtan and subsequently with scientists and Farm Manager of the University" IIM Ahmedabad, mimeo

----------, 1987, Why Poor don't Cooperate: Lessons from Traditional Organizations with Implication for Modern Organizations, in Clare G. Wanger (ed.), Research Relationship Politics and Practice of Social Research, George Allen and Unwin, London,1987, pp.111-127.

----------, 1988, "Survival Under Stress: Socio Ecological Perspective on Farmers' Innovation and Risk Adjustments", W.P. No. 738, 1988, International Congress on Plant Physiology, New Delhi,1988., revised version published in Capitalism, Nature and Socialism,5,1990, 79-96.

----------, 1987, " Scientific Perception of Farmers Innovations in Dry Regions: Barriers to the Scientific Curiosity", September 1987, IIM working Paper No.699, presented at International Conference on Farmer Participatory Research at IDS, Sussex, July,1987.

----------, 1989, "Managing Ecological Diversity, Simultaneity, Complexity and Change: An Ecological Perspective". W.P. no 825. IIM Ahmedabad. P 115, Third survey on Public Administration, Indian Council of Social Science Research, New Delhi.

(With Karma Ura) , (1990) Blending Cultural Values, Indigenous Technology and Environment: The Experience of Bhutan. IIM, Ahmedabad W.P. no-883. 1990, P 42. Presented at International Conference on Sustainable Development of Mountain Regions, ICIMOD, Sept.1990. Published in Sustainable Mountain Agriculture, entitled "Indigenous Farming Technologies and Environment: Experiences in Bhutan" (Eds. N.S.Jodha, M.Banskota and Tej Partap), Oxford & IBH Publishing Co Pvt.Ltd., New Delhi. pp. 540 - 568., 1992.

----------, (1993) Secular Basis of Sustainable Spirit: Understanding Roots of Creativity and Innovations at Grassroots Level, SRISTI/IIMA Discussion Paper No.2, November 1993

Gupta, Anil K., Patel and Shah, (1985) "Matching Farmers' Concern with Technologists' Objectives in Dry Regions: A Study of Scientific Goal Setting: IIM, Ahmedabad, mimeo.

Harms, Robert. (1988), "Science, diffusion of technical knowledge and system of local knowledge", presented at VII World Congress for Rural Sociology.

Hilgard, E.W., 1906. Soils: Their Formation, Properties, Composition, and Relation to Climate and Plant Growth in the Humid and Arid Regions, N.Y. : MacMillan.

Hill, B.Stuart and Ramsay, Jennifer (1977), "Weeds as Indicators of Soil Condition", The Macdonald Journal, pp 8-12,

Ibrahim, M.A., Nwude, N., Aliu, Y.O. and Ogunsusi, R.A., (1983), "Traditional Concepts of Animal Disease and Treatment Among Fulani Herdsmen in Kaduna State, Nigeria", Pastoral Development Work, ODI July, 1983.

Jain, S.K., (1964), "Wild Plant - Foods of the Tribal of Bastar (M.P)", Proceedings of the National Institute of Sciences of India, Vol.30, B, No.2, pp. 55-80.

Johns, Timothy and Keen Susan L, (1986) "Taste Evaluation of Potato Glcoalkaloids by the Aymara: A Case Study in Human Chemical Ecology", Human Ecology, Vol.14, No.4, 1986, pp.437-452.

Johns, Timothy, John, Kokwaro O, and Kimanani, (1990), "Herbal Remedies of the Luo of Siaya District, Kenya: Establishing Quantitative Criteria for Consensus", Economic Botony, 44(3), 1990, pp.369-381.

Kirch, Patrick V, (1978), "Indigenous Agriculture on Uvea (Western Polynesia)", Economic Botony, 32 (2), 157-181.

Kurien, John, (1991), "Traditional Versus Modern and Co-Evolutionary Development Potential: The Case of Marine Fisheries in India", published in Social Action Jan-March, 1991, pp.29-41.

Lowry, M.A. (1982), "Can Animals Help Earthquake Predictors", Newzealand Veterinary Journal, May, 1982, Vol.31, 35-39.

Moles, Jerry.A., and Riker, James.V. (1988), "Hope, Ideas and Our only Alternative - Ourselves and Our Values: National Heritage and the Future of Sri Lanka Agriculture".

Patel, B.B., 1992. Traditional Wisdom of Farmers, Junagadh: Gujarat Agricultural University.

Richards, Paul (1985), "Indigenous Agricultural Revolution", London; Hutchinson Press.

Siar, Susana V., Ortega, Rolando.S., Babol, Alessandro S. (1992), "Learning from Fishers: Indigenous Knowledge and SEAFDEC's Pilot Seafarming and Searanching Project", presented at the International Symposium on Indigenous Knowledge and Sustainable Development, 20-26, September, 1992, International Institute of Rural Reconstruction, Silang, Cavite, Philippines.

Singh, S.P. and C. Prasad, 1991. Technologies for Minimising Risk in Rainfed Agriculture, ISEE, ICAR, New Delhi.

Stocking, Michael, and Abel, Nick (1981), "Ecological and Environmental Indicators for the Rapid Appraisal of Natural Resources", Agricultural Administration, 8 (1981), pp.473-484.