Altitudinal Belts in the Tropical Andes : Their Ecology and Human Utilization

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ABSTRACT
Tropical mountain environments are best understood through a three-dimensional perspective which takes into consideration the horizontal or lateral as well as the vertical dimensions of geographical space. Because tropical mountains contain varied thermic and hygric environments, many of which offer favorable conditions for human activities, the analysis of mountainous physical environments must include the assessment of how they have been transformed into "humanized landscapes;" that is, settlements, agriculture and other economic activities, and cultural environments.

"Man-habitat relations are compositions, complex orchestrations if you will, of material conditions, human labour, technology, and intelligent participation. They reflect the detail and the balance of spontaneous natural conditions, social order, and historical circumstances. These constituent elements almost never have an identical geographical shape or scope. Yet their relations are profoundly dependent upon the way the geography of their influence is patterned" (Hewitt 1983, 101-102).

In the mountains, people have to cope with the extreme variability of relief, aspect, geology, edaphic conditions and climatic patterns. In any given area, these patterns of the natural environment occur only in approximation to altitudinal belts. In addition, the variability of natural factors is further overlain by complex human factors, both contributing to a mosaic of mountain landscapes and to modification of the "assumed" vertical zonation of human activities. Although Troll (1948, 1959, 1962, 1966, 1968a,b, 1975), Lauer (1975, 1976a,b, 1981, 1982, 1983, 1984a,b, 1987a,b), Murra (1972, 1981), Brush (1973, 1976, 1977, 1982), and other scholars have attempted to describe the patterns of cultural responses to the vertical zonation of the Andes, the variability of natural and human environments has made it difficult to construct universally valid models and to arrive at generalizations.

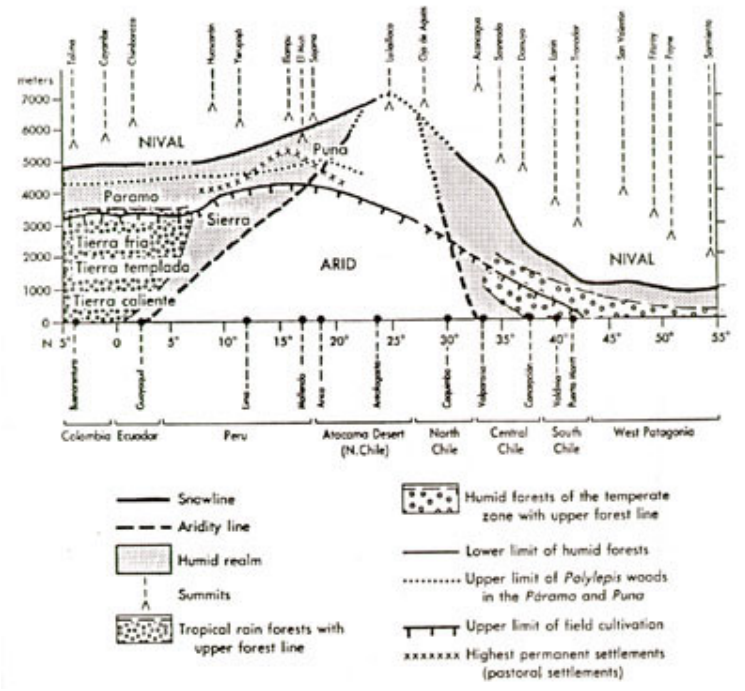
PRINCIPAL MODELS OF ECOLOGICAL AND CULTURAL ENVIRONMENTS OF THE TROPICAL ANDES

As early as 1807, von Humboldt and Bonpland (1807) established the terms ***tierra caliente, tierra templada*** and ***tierra fría*** to describe climatic zones based on vegetation types in the Chimborazo region of Ecuador. They assumed a vertically arranged ecological sequence in tropical mountains which had a certain analogy with planetary latitudinal belts extending from the tropics to the poles. However, Troll (1959, 1968a,b) in particular pointed out the essential differences between the diurnal temperature fluctuations of tropical "day-night" climates and the season-based temperature variations of polar regions which makes the analogy between the altitudinal vegetation belts of tropical mountains and the latitudinal vegetation zonation between tropical and polar regions highly questionable.

Troll and Lauer developed eco-climatological models for the tropical Andes which still form a basic framework for the discussion of ecological altitudinal belts in this mountain environment. Troll's

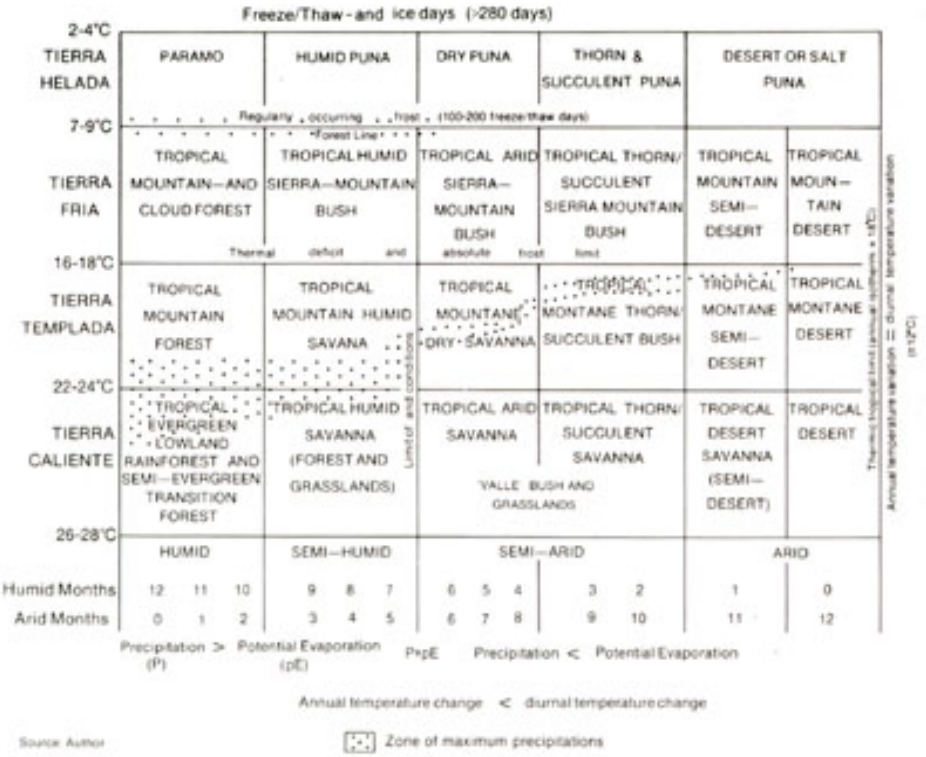
model of "ecological limits and living zones" in the Andes (Figure 1) portrays an asymmetrical ecological pattern extending along the Andes north-south running from 5ºN to 55ºS./font>

FIGURE 1 **ECOLOGICAL LIMITS AND EVALUATION OF LIVING ZONES IN THE ANDES OF SOUTH AMERICA**



For the tropical Andes, Lauer (1975) established a model in which major vegetation formations are identified for specific thermal conditions; that is, altitudinal belts (***tierra caliente, tierra templada, tierra fría, tierra helada***) as well as for hygric zones expressed by the number of humid months (Figure 2). In this model, the line of aridity (***"Trockengrenze"***) separates the humid and semi-humid tropics (7-12 humid months) from the semi-arid and arid tropics (0-6 humid months). In the zonation of altitudinal belts, the line of a "thermal deficit" (***"Wärmemangelgrenze"***) approximately coinciding with the lower limit of absolute frost occurrence, located at the approximate annual isotherm of 18C, separates the warm tropics at lower elevations from the cold tropics at higher elevations.

Fig. 2 Ecological Zonation of Tropical Andes (Lauer)



Although they made some reference to human activities at different altitudinal levels the major contributions of the geoecologists consisted of identifying biological relationships along vertical gradients; human features tended to be limited to agricultural patterns associated to the vertical life zones. Figure 3 attempts to summarize the altitudinal range of human utilization related to specific ecological zones for both the humid Andes and the semiarid and arid Andes. The major ecological and human activity zones are then presented in a latitude/altitude model for the tropical Andes (Figure 4). According to Guillet (1986), the contribution of the cultural ecology of mountains with its "emphasis on the dynamics of human cultural response to environmental constraints helps to redress the geoecological bias toward geographical determinism and stasis" (Guillet 1986, 207). He stressed further that "in mountain environments, human populations encounter altitudinal constraints on possible production strategies." Most important of these, according to Guillet, "is the interaction of altitude, climate, and soil fertility, which sets upper limits on types of crops" (Guillet 1986, 208). He summarized his findings by listing the following three elements of mountain adaptations:

1) an array of vertical production zones, each characterized by a complex interaction of variables including agricultural regime, social organization, stratification, land tenure, labour organization, and level of productivity;

2) choice by the population of an overall production strategy for the exploitation of the vertical production zones available to it, a strategy that may involve specialization in one zone or, in response to a variety of constraints, the combined exploitation of several zones; and

3) a potential for change in strategy, within the constraints of the mountain environment, under the influence of endogenous and exogenous factors (Guillet 1986, 213).

FIGURE 3 **TROPICAL ANDES. ALTITUDINAL RANGE OF AGRICULTURAL ACTIVITIES AND SETTLEMENT**

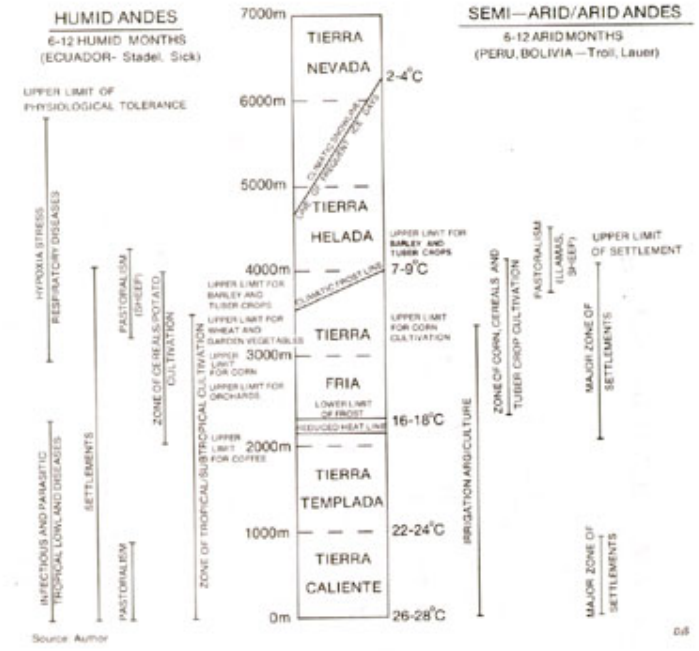
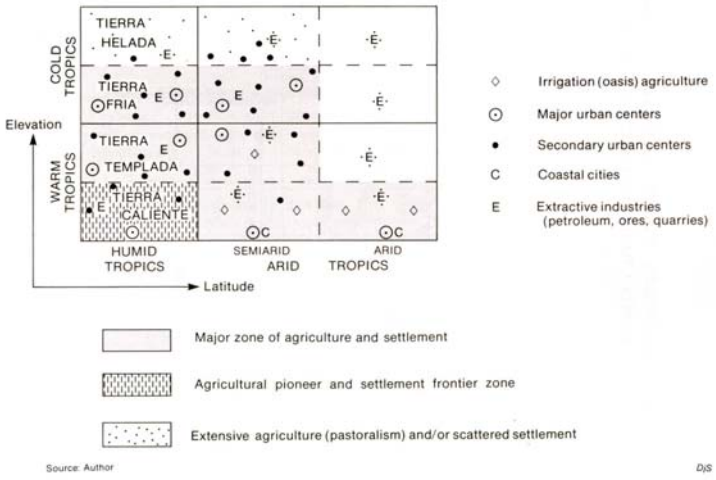


FIGURE 4 **A MODEL OF HUMAN UTILIZATION IN THE TROPICAL ANDES**



Murra (1972, 1985a, 1985b) examined the perceptions, knowledge and values of Andean people and their behavior in economic and political activities and institutions in the context of their ecological conditions. He stated that "the Andean world was conceived by its inhabitants as a totality of levels arranged 'vertically', one on top of another, forming a macro-adaptation, a system of ecological relations purely Andean." He argued further that "throughout the Andes, the village and ethnic communities had always attempted to control as many micro-climates as possible" (Murra 1972, 121, translated by Forman 1988, 134). In a later contribution, he referred to *"Archipiélagos Verticales"* and pointed out that "vertical control ('*Mitimagkuna*') of a maximum possible number of ecological zones" was an Andean ideal shared by ethnic groups that were geographically distant from each other and that were quite distinctive from each other in terms of their economic and political organization (Murra 1972, 60-61).

Drawing on a variety of examples as well as on Murra's model, Brush distinguished three types of control and integration of Andean ecological zones and resource areas for peasants. The "compact type" is the one in which different ecological zones occur in close proximity to each other and are easily accessible to the community. In the "archipelago type," the ecological zones used by a group of peasants are more distant from each other and are often separated by unused areas, thus requiring more extended travel times. This may require the establishment of a series of permanent or semipermanent colonies away from the home community in these different ecological zones as well as a system of exchanges between the home community and the "colonies" based on reciprocity and redistribution. In the case of the "extended type," each peasant group exploits a single or a few ecological zones, often specializing in certain products, and exchanges goods with other groups living in and exploiting other ecozones (Brush 1974, 292-295).

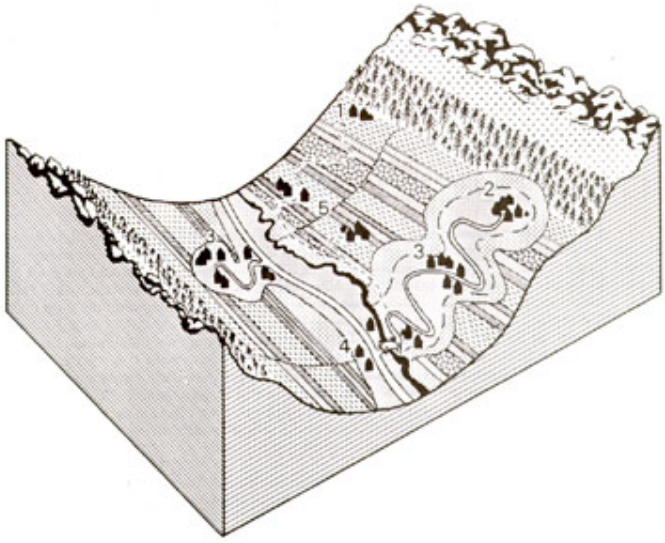
Rhoades and Thompson (1975) suggested two types of adaptive strategies of Andean communities. Their "generalized type" involves a single population which, "through agro-pastoral transhumance, directly exploits a series of microniches or ecozones at several altitudinal levels." In the "specialized type" a population "locks into a single zone and specializes in the agricultural or pastoral activities suitable to that altitude, developing elaborate trade relationships with populations in other zones which are also involved in specialized production" (Rhoades and Thompson 1975, 547). Based on research carried out in the central highlands of Ecuador, Forman stated that "at least under contemporary conditions, a mixed form of verticality is prevalent in many parts of the Andes. This mixed form involves direct access to two or more vertical ecozones by members of a peasant community, combined with indirect access to other ecozones through exchange with communities based in different ecozones or through commercial marketing" (Forman 1988, 136). Thomas, Winterhalder and McRae (1979), making reference to the multiple resource base and the behavioral flexibility of individuals and communities of the tropical Andes, distinguished the following five agricultural specific response types: rotation, regulation, co-operation, mobility and storage.

The overall applicability of conventional altitudinal zonation models for mountain land use has recently been questioned (Soffer 1982). This is particularly true for situations where levels of accessibility and lowland economic penetration are high:

"No doubt vertical patterns of difference exist in most mountains as do lateral and aspectual ones.... As 'divisions' they are a technical and sometimes useful fiction. As a ***general*** underpinning of ***human*** life in the mountains they are open to serious question. They serve to reinforce the emphasis upon physical and physiological difference and a static mapping of 'physical' resources as the paradigm of 'human use'" (Hewitt 1988, 22).

Allan (1986) proposed an accessibility model for mountain land use for situations where highways and roads are penetrating traditional mountain landscapes (Figure 5). In his paper, Allan argued that "accessibility provides avenues for the diffusion of ideas, technology, and goods into the mountains," that "roads have had a profound impact upon the area in close proximity to them," and that "this has led to a change in land use" (Allan 1986, 186).

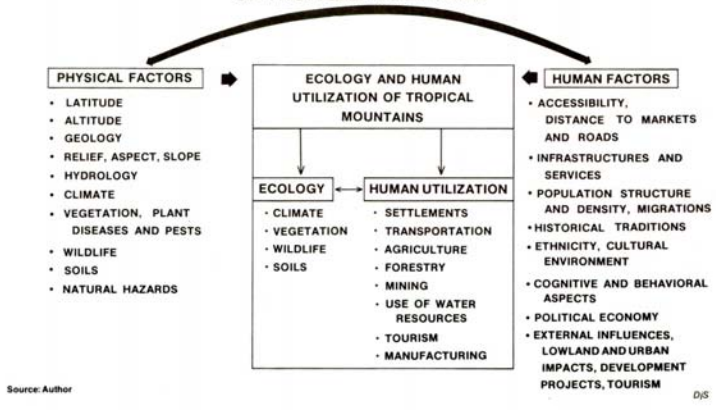
FIGURE 5 **ACCESSIBILITY MODEL OF MOUNTAIN LAND USE (Allan)**



1. Traditional, limited access, subsistence-oriented village practising [illegible]
2. Modernizing, accessible market-oriented agricultural villages with potential for tourism and recreation.
3. High-production oriented village with rapid access to urban markets and services.
4. Growing urban market and service centre.
5. Subsistence, valley-bottom village hampered by absence of bridge or road accessibility.

While a number of authors have welcomed Allan's contribution as an intriguing "challenge to the time-honoured bio-physical, or geoecological, approach to mountain research" (Ives 1986, 183), Allan had also to face considerable criticism for the sweeping statement in the abstract of his paper that "the altitudinal zonation model is no longer suitable for characterizing mountain ecosystems now that human activity is directed to new motorized transportation networks limited to a wider political economy and no longer dependent on altitude" (Allan 1986, 185). Uhlig (1986), for instance, pointed out that "regardless of all changes, the given facts of altitude zonation have not been removed from the mountains" and that "the question is rather how and why have the various altitudinal belts been changed?" Figure 6 represents an attempt to portray the array of physical factors and human factors which tend to influence the ecology and human utilization of tropical mountains.

FIGURE 6 **FACTORS INFLUENCING THE ECOLOGY AND HUMAN UTILIZATION OF TROPICAL MOUNTAINS**



LATERAL AND VERTICAL ZONATION IN THE ECUADORIAN SIERRA

Among the tropical mountain countries of Latin America, Ecuador offers a particularly rich variety

of "lateral," "vertical" and "aspectual" natural and human environments (Figure 7). In addition to the three principal regions of ***Costa, Sierra*** and ***Oriente***, the complete range of ecological and human altitudinal belts extends over a short horizontal distance from the Chimborazo (6310 meters) to the coastal and Amazon lowlands (Figure 8).

FIGURE 7 **ECUADOR - REGIONAL UNITS AND STUDY AREA**

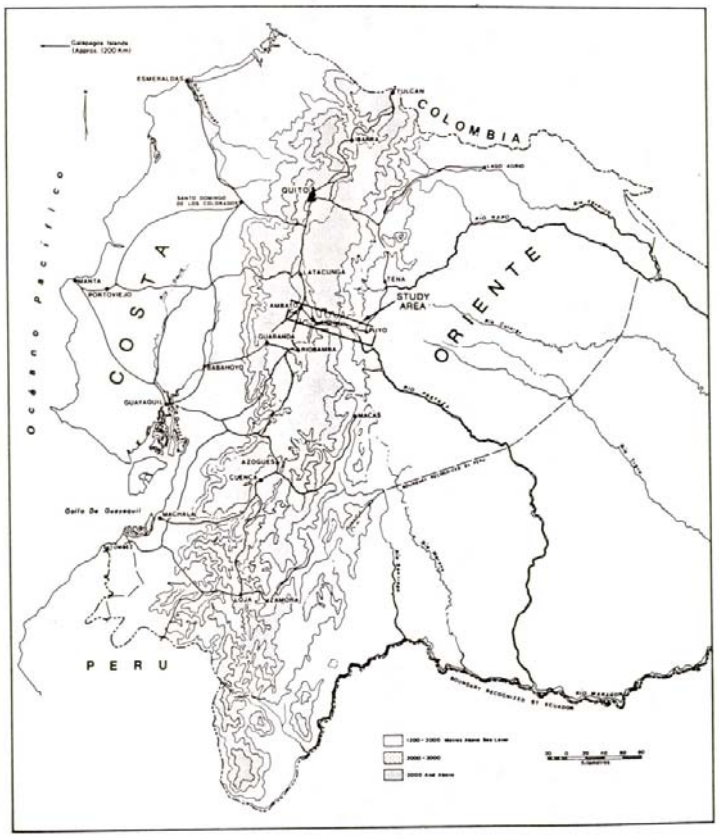
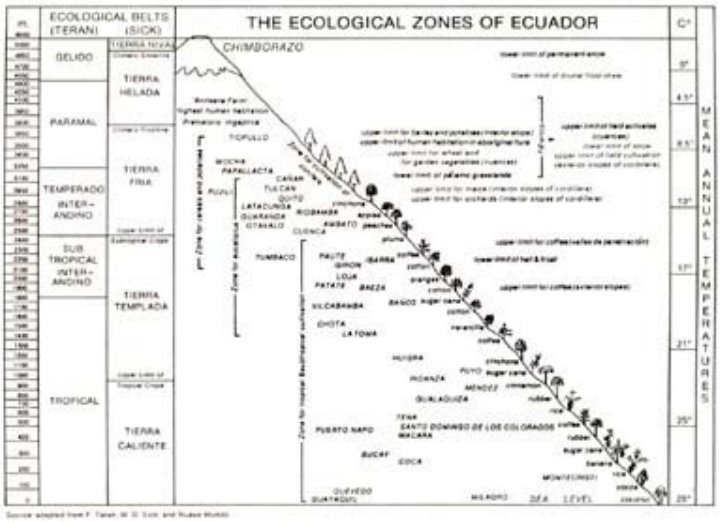


FIGURE 8



In addition to the ecological conditions, a number of human aspects should be considered in

attempting to come to an understanding of the humanized landscape. Among these, the following factors appear to be of particular significance:

1) The cultural environment, in particular the contrast between the regions with a predominant white/Mestizo population and the settlement areas of highland and lowland Indian groups, with their influence on land tenure, agricultural practices and settlement forms.

2) The age and the nature of the settlement process with its inherent imprint on the cultural landscape.

3) The relative distance to and accessibility of market centers and highways which tend to influence population densities, employment and mobility patterns, land prices and land use.

4) The provision of irrigation water, traditional water rights and new irrigation schemes which lead to significant contrasts in the intensity of land use and in the types of crops grown.

5) The nature of economic opportunities and constraints within the region itself and in neighboring regions.

6) Local and regional market conditions and the influence of local elites on economic activities.

7) The influence of local traditions, local organization, perceptions and initiatives.

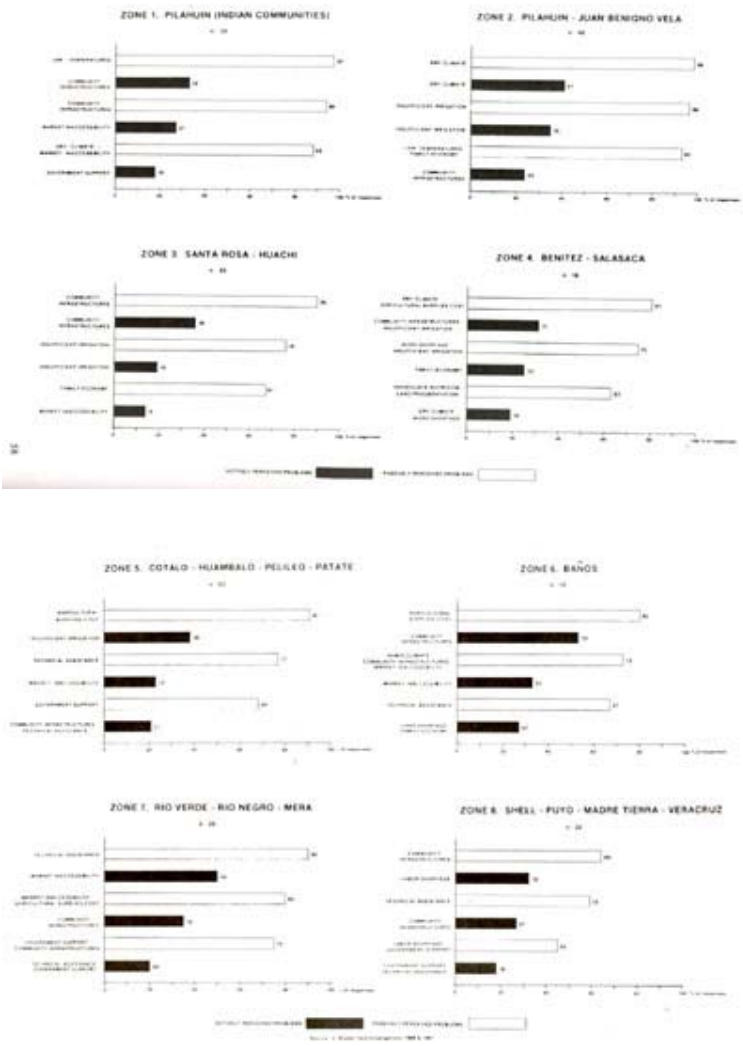
8) External influences by governmental and nongovernmental, regional, national or international agencies and organizations. This may lead to noticeable changes in agricultural practices, land use, infrastructures and services and settlement patterns.

These human factors and their profound influence on the landscape contribute to the growing recognition that human perceptions and activities in mountains can neither be solely explained by reference to altitudinal belts, nor by the notion of accessibility alone.

In a study carried out in 1985 and 1986 (Stadel 1989) I conducted field interviews of 247 *campesinos*, or peasant farmers, in Ecuador along a profile from the foot of the Chimborazo at an elevation of 4200 meters to Puyo at an elevation of about 900 meters (Figure 8). In addition to questions asked about their agricultural activities, their social and economic situation and mobility patterns, the interviews attempted to investigate the rural problems as perceived by the *campesinos*. A distinction was made between "actively perceived" rural problems; that is, problems that were spontaneously identified by the interviewed persons, and "passively perceived" rural problems that were identified as such only after the interviewees had been confronted with a set of 33 potential problems. The three most frequently mentioned actively and passively perceived problems were tabulated for eight distinct ecological or cultural regions within the study area (Figures 9a and 9b). Among those problems relating to a particular ecological zone, climatic "stress factors" were, at least in part, linked to a particular altitudinal zone; for example, the perceived stressor of cold temperature and risk of frost. On the other hand, conditions of excessive aridity or humidity were more a factor of a particular windward-leeward location than of altitude. Similarly, neither advantages or constraints of soil and hydrology conditions nor the occurrence of pests, diseases and natural hazards were directly related to specific altitudinal belts.

FIGURE 9 (A+B)

CHIMBORAZO - PUYO AXIS, ECUADOR: ACTIVE AND PASSIVE PERCEPTION OF RURAL PROBLEMS



Perceived rural problems emanating from human factors, which tend to reflect conditions of the cultural landscape, were generally either not linked at all or linked to altitudinal zones only in an indirect way. It is true that the dispersed farms at the highest areas of human utilization frequently face adverse conditions of accessibility and isolation, but the same situation may occur in the agricultural pioneer zone of the *Oriente* at low elevations. Similarly, although in the study area the highest zone of settlement is one of Indian communities with distinct cultural traditions and perceptions, other areas of Indian cultures are found in the *cuencas* (such as the Salasacas) at intermediate altitudes and in the *Oriente* at low altitudes.

Thus, although a number of perceived problems appeared to be more prominent in one or more of the eight zones of the study area, they were only partially linked to particular altitudinal levels, an observation that was further underlined by the fact that the delimitation of the zones in question was based not solely on altitudinal thresholds but on other physical and human criteria. Furthermore, a significant number of perceived rural problems; for example, deficiencies of community infrastructures, high costs of agricultural implements and supplies, and the lack of technical assistance, were found throughout the entire study area irrespective of variations of altitude and other physical factors.

CONCLUSION

Tropical mountains have been viewed often as exemplary regions for the construction of models of altitudinal zonation of ecology and human land utilization. In more recent work, the potential pitfalls of an implicit environmental determinism of a narrow interpretation of the altitudinal zonation models have been pointed out. An array of vertical or altitudinal production zones can be observed in the tropical Andes, each of which is a product of both endogeneous and exogeneous human influences as well as the physical characteristics of the region. The variety of natural and human factors thus finds its reflection in an intriguingly complex mosaic of ecological and human environments, characterized both by long-term adaptations and recent changes.

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