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SOME QUESTIONS OF LAND USE CHANGE

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In these days when virtually every country has development plans, and when such plans necessarily involve land as a basic factor of production, it is a continuing source of amazement that so few have ever seen fit adequately to survey land use. For if what now exists on the ground is not known, how then can what might in future be there be properly planned ? Without a system of monitoring land use change how can emerging trends be identified, how can policies be formulated and action initiated to meet such possible socially, economically and ecologically undesirable trends ?

In this context the example of the People's Republic of China is instructive. In order to meet the needs of her expanding population, the P. R. C. since Liberation developed some 33 million hectares of land, roughly one million hectares a year. Meanwhile, the building of reservoirs, railways and roads and the expansion of areas under urban and industrial uses have occupied some 29 million hectares over the same period. Given this situation and continued population growth, the man : land ratio has dropped by about 30 per cent since 1949 (Wu, 1981).

A further example is from the very different environment of New Zealand where a number of local surveys have shown that in significant areas labour inputs in agriculture are tending to fall, though capital inputs are rising in some cases. A consequence is intensification of land use (as measured in capital but not labour terms) accompanied by rural depopulation. (See Barker and Brown, 1980, for exampla).

The monitoring of land use change for national, regional and local planning is but one desirable end. The ramifications of land use change are so widespread that serious economic loss may ensue where deliberate change is not well-conceived. A case in point is the deepening and extension of drainage to intensify agricultural production on many tens of thousands of hectares potential acid sulphate soils in the Malaysian state of Johor, where further drainage has seriously threatened the existing agriculture rather than improving it as was planned. Another Malaysian example, only recently receiving scientific attention, is that of the environmental consequences of replacing forests by tree-crops such as oil-palm and rubber, where an emerging consensus would suggest that increased deposition of alluvium in the lower courses of some rivers has raised flood frequencies and will necessitate costly control measures. The change from agricultural to urban land uses are in addition, to all intents irreversible. While there have been foolish suggestions that the loss of prime agricultural land to urban and industrial uses will have dire economic consequences (see Best, 1981, P. xvii, for examples) there remains a need for a sober assessment of the amount and consequences of such change. Not least are the consequences of permitting

the expansion of Third World cities at densities comparable to those of the developed world but without the developed world's ability to pay the costs of adequately servicing such low density urban peripheral settlements.

At the more academic level there is still the need for empirical studies to back up such abstract models as those deriving from von Thunen in respect of rural land use and the various concentric zone, sector and multiple nuclei models of urban land use. The changes of land use zonation through time are also beginning to receive scholarly attention and here too there is a need for empirical data.

The current status of monitoring land use change at the international level does not give much cause for confidence. The only comprehensive estimates are those published by the F. A. O. but these suffer from several major defects. First is that the bases of the estimates are not stated, making it impossible to assess reliability, though two levels of accuracy of the statistics are stated. Second, although it seems likely that accuracy has improved with time, there is no way that the degree to which this may be so can readily be assessed. The time series statistics frequently contain unexplained changes, sometimes of great magnitude. For instance, there is a difference of about 1.1 million ha in the total land area of South America between published figures for 1966 and 1973. For Brazil, there are two sets of figures for each of the major land use categories, one for 1969-71 and another for 1970. The values given vary by nearly 60 per cent in one instance. Third, the categories of land use are very few, only five and the proportion placed in the 'dustbin' category 'Other' is so high as to be meaningless. For Central and South America it is 36 per cent ; for China it is 51 per cent. Finally, the rural bias of the data results in the total neglect of the question of urban use, a key question in many areas as cities expand whether by population growth, by lowering urban population densities or by both these processes.

International comparisons, based upon FAO data, it must regretfully be concluded, are unlikely to be sufficiently precise to be meaningful. Others may be more successful. Best (1981, pp. 168-181), using a simple classification based upon national statistics, has been able to compare the constituent countries of the European Economic Community and North America in 1961 and 1971, though even for these countries he encountered major data reliability problems. For instance, he concluded that in Britain (excluding Northern Ireland), the greater part of the so-called "loss" of farmland to non-urban and non-woodland uses (550 000 ha.) can be accounted for by reclassification (Best, 1981, p. 174). On the other hand, Fordham speaks approvingly of the agricultural land use statistics compiled by that country's Ministry of Agriculture and Fisheries. For the United States Jackson (1981, p. 6) suggested that, 'It is impossible to provide adequate statistics on land use in the United States because of differing definitions of what constitutes forest or grazing land, or even cropland'.

These considerations inescapably point to two conclusions. First is that it is unlikely that only very detailed world-wide classification could ever be devised, let alone used for the simple reason that even groups of scholars are not omniscient. Second, is that a general world-wide classification could be achieved if those bodies responsible for generating land use data were to be convinced of the utility

of such uniform data and of the desirability of international comparisons.

In considering the desirable properties of a land use classification a preliminary point must be raised, namely the question of whether such as classification ought to be purely formal, purely functional or a judicious mixture of both. The formal approach focusses upon the shape, the form of 'geographical individuals, on the land whether these be fields or buildings. It is a question of land cover rather of land use. The great virtue of ground cover analysis is that, potentially at least, it can be carried out largely by automated examination of remotely-sensed imagery at relatively small cost. The present problems of this approach will be discussed subsequently. The functional approach attempts to answer the question, 'what is the land used for ?' Where adequate topographical maps exist this question can be at least partly answered from map data and some analysis, for example, random or systematic sampling of maps may be partly-automated (see Fordham, 1974, for an example). But the need for extended ground survey remains and this may be prohibitively expensive. The basic problem here is that function often cannot be sufficiently consistently and reliably inferred from without ground control of some kind.

To return to the question of the desirable qualities of a classification. These may be listed briefly :

1. Classes must be mutually exclusive and unambiguous. If they are mixed, the components and proportions must be fixed. (Rhind and Hudson, 1980, p. 44, give an amusing example of overlap in a British survey where 'fried fish' and 'hot food' shops are supposed to be discrete categories).

2. The classification must be hierarchical for without this characteristic it is impossible to apply it satisfactorily at all scales. Each taxon of a higher level must be made up of taxons of a lower level, without mixing of levels. (Thus the taxon 'fried fish shop' must be one of a lower level than that of 'hot food shop' which might include 'hamburger stands' as well as 'fried fish shops').

3. The classification must meet the requirements of the primary user, who will have paid for it, as well as the needs of as many secondary users as possible.

4. It must be exhaustive, thus keeping the 'dust-bin' category 'Other' to a minimum.

5. It must be sufficiently comprehensive for both spatial and temporal comparisons to be made.

6. The classification must be easy to use and replicable, so that different workers will come up with the same results in the same area.

Finally three further technical points should be made. Land use surveys, to be effective, need to have as high a degree of simultaneity as possible—a consideration readily met by remote sensing. The 'classical' land use field surveys by Stamp (1931-1933) and Alice Coleman (1960-1968), especially the latter, have been quite properly criticised by Fordham (1974, 18) on the ground of too great a time-spread in their execution. A second, minor point is that for regions where fallowing is an integral part of the agricultural system, whether bush-fallowing in the tropics or plough-fallowing in temperate and semi-arid lands, due allowance must be made.

Third, and more important is the problem of multiple land use, a question which arises with respect to the functional approach to land use studies and a question which has not yet

received a great deal of attention. It arises in numerous contexts. In urban land use there is often considerable vertical differentiation and in some contexts this is being deliberately fostered, in Singapore for example, where in the C. B. D. lower floors may be devoted to commercial uses with residences above. In tropical agriculture, areas of simultaneous multiple cropping are by no means uncommon. Some examples are two tree-crops such as coconuts and cocoa combined, or a tree-crop such as coconut combined with an annual crop such as groundnuts. Even in many forested areas, multiple use is the rule, for commercial forestry, watershed protection and water-supply catchment and for recreation. In such areas, the problem of inferring function from displayed on aerial photographs or satelite imagery becomes formidable indeed.

The question of remote-sensing of land use change may now be considered. Here much depends upon what is regarded as an acceptable level of accuracy. If a high level of generalization is acceptable, as well it might in large areas of forest, savanna or semi-arid land, remotesensing has good prospects. On the other hand, in urban and peri-urban areas, where change is often proceeding with considerable rapidity, the limited spatial resolution of Landsat imagery and the problems of collimation between successive surveys have prevented satisfactory results from emerging. Lo's study of Hong Kong (1981) employed a manual method of analysis of land use from Landsat imagery and claimed as 'acceptable' a planimetric accuracy of ± 400 m and a semantic accuracy of 89 per cent. A computer-assisted analysis gave an accuracy of only 69 per cent. This observer would not agree that such levels are acceptable, a view which coincides with those of Allan (1980), Gordon (1980), and Jensen (1979) amongst others. Gordon describes a comparison of three sets of Landsat data, two of which were only a day apart, with ground-truthed aerial photographs. He suggested that'...we must conclude that substantial errors are associated with the use of Landsat data for land cover and change analysis'. (Gordon, 1980, p. 195). Jensen's conclusion was similar : 'Given Landsat's spatial resolution [80 m]...and the diversity of land cover in the urban-rural transition zone, results have shown that the spectral signatures for residential developments are often similar to natural vegetation and vice versa' (Jensen, 1979, p. 400). Most numeric pattern recognition classifiers use only pattern recognition and even the addition of textural analysis, in a case cited by Jensen at least, does not significantly raise the accuracy of land use categorization. For rural land use survey, Allan (1980, p. 36) has suggested that for large areas of low productivity land, where the high cost of conventional aerial photographic survey cannot be justified, the sampling of ecological zones by the transect method, employing aerial photography which is then cross-related to Landsat imagery is a cost-effective technique. The same author has pointed to the severe limitations of LACIE, the American large area crop inventory experiment. For the U. S. A. this proved 90 per cent accurate in respect of wheat production, 90 per cent of time, whereas for India, the fragmented nature of the cropping pattern made accurate area estimation impossible (Allan, 1980, p. 40). Thus the relationship between the scale of uses and the resolution of the imagery is crucial. In regions of 'coarse-grained' patterns of land use, satelite imagery is useful, but in regions of 'fine-grained' land characteristic of most of the

developing world outside arid and semi-arid areas, and in urban fringe areas, such imagery does not yet provide a satisfactory data base.

To conclude, I would like to suggest some points to which the attention of professional colleagues may profitably be directed. The major question of land use change at the settlement frontier is, of course, the concern of the Group at this meeting, which, as it proceeds will identify particular trends and concerns. Rather I would like to point to two key areas that are the subject of concern, one of which is, in a sense, contained in the other.

Over the last several decades it is clear that broad economic changes, in most countries, socialist and non-socialist alike, have been associated with two contrary processes of land use change. On one hand there has been considerable intensification of land use, not only in urban fringe areas where it is very obvious but scarcely measured in any systematic and comprenensive way, but also in the core agricultural areas which in which production has steadily risen, in some cases being accompanied by striking landscape changes—removal of hedgerows, closer subdivision and reduction of farm size, denser road, drainage and irrigation networks, to name only a few. On the other hand, in more marginal agricultural areas but also in other areas open to the influences of the urban-industrial economy, disintensification of land use has been the rule in areas as diverse as the often beautiful (and hence recreationally attractive) mountain areas of Japan or Yugoslavia, or the former rice lands of Hong Kong and the Malaysian states of Melaka and Negeri Sembilan where grazing not cultivation is now the rule. Such changes are important and widespread. How important and how widespread we simply do not adequately know, though I am hopeful that the reports presented at the Group's next meeting, in New Zealand in February 1983 will begin to answer this question.

The change to urban land uses represents a particular and permanent form of land use intensification. While this question has received some (and sometimes hysterically unscholarly) attention in the past, it remains a live issue not only in developed countries where it derives largely from falling urban population densities partly consequent upon changes in the perception of the 'good life', but more especially in developing countries still experiencing explosive urban growth. The spatial dimensions of such growth, is, I would suggest, seriously under-researched : the economic dimensions even more so.

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