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THE EFFICIENCY OF RURAL SERVICES IN DISPERSED AND CONCENTRATED LAND SETTLEMENT: A COMPARISON

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Excessive distances, real or perceived, are among the major problems of rural araes, aggravated by the lack of adequate communication and the feeling of isolation. This is basically due to the "looseness" of villages composed of family farmsteads, especially where a homeplot is attached to the house of each settler. Any possible pattern of clustering the farmsteads will result in a density far below urban densities. The physical planning which determines the deployment of rural communities will aim, therefore, to reduce distances and facilitate intercommunication and access, so as to permit the provision of amenities that are beyond the reach of the individual settler or a small group of families. Agglomeration is indispensable for providing rational facilities within reasonable proximity of their users and for creating viable communities.

Because of their dispersion, agricultural settlements incur higher service costs per capita than urban communities of the same size. Moreover, when facilities are installed in rural villages, they are often out of proportion to the size of the community, especially during the initial stages of the settlement when population is sparse and employment in ancilarry services has not yet developed. Consequently, is is difficult to establish general parameters for services that will be adequate and yet economically feasible. This article deals with the problem primarily from the point of view of family-farm settlements, such as are currently being planned and executed in many developing countries.

FRAMEWORK AND STRUCTURE OF SERVICES

The term services usually covers the following categories:

— Community or Public: communication, potable water supply and sanitation, health services, public administration, roads, and other utilities.

— Production: all those affecting agricultural production, processing, storage and farm machinery and equipment.

— Social and Educational: cultural, religious, and community development aspects.

— Commercial: shops and stores of all frequency groups and other enterprises.

Not all of these services can be expressed in physical or spatial terms only. Some facilities have institutional or organizational features, e.g., agricultural extension

services, the provision of production credits, marketing functions, educational programs, etc.

What should be the level of services in each category? Services will invariably constitute an integral part of the infrastructure whenever the objective of land settlement is both social and economic development. Although social overhead capital is meted out in practice in the most economical manner, basic facilities in the "Community or Public" category (e.g. potable water supply), or "Social and Educational" amenities (e.g. primary school classes), will usually be contemplated for any planned human settlement. The services must be accessible and of a quality that will motivate people to use them, especially in the early stage of development. Ease of access is equally vital for both the settlement units and public sector in order to ensure follow-up and support.

The provision of services entails physical facilities as well as qualified personnel. Many services cannot operate adequately in small units, and require minimum user threshold to attain acceptable levels or business volumes. A school, for example, will need a given number of pupils is order to perform efficiently and to retain good teachers. Both quality and quantity are therefore decisive factors, since good facilities attract better professionals who, in turn, may generate further growth (Prion, 1968; Weitz, 1971).

Since the ability of the single village to maintain its own services is limited by its small population, it must share them, whenever possible, with other settlements. In planned land settlement this can be achieved through an optimal hierarchy in which services will be deployed in centers of distinct levels, adjusted to progressively longer population groupings.

The components of a typical service structure, often found in rural development schemes, can be described as follows:

Center "A" — A communal center within a village or community of 80—120 families for daily services, also referred to as the basic village center.

Center "B" — An intervillage center, which complements the services of several villages with a total population of 300 to 600 families.

Center "C" — A sub-regional center serving a number of village groups.

Center "D" — A regional center, usually a complex with a full range of urban facilities interrelated with other regions. Economic activities are pre-eminent at this level.

More specifically, the communal center "A" provides daily needs such as a primary school, grocery store, basic sanitary facilities, a community meeting place, and some production-related services. Small-sized villages (below 80 families) may not be able to provide all these needs economically. Several villages together may justify a center "B" which offers, in addition to the full range of basic facilities, economic, social, and cultural services at a higher standard. Besides minimizing costs, the center "B" can attract adequate professionals and staff, and serve as an initial collection and processing point for the agricultural produce delivered by the surrounding villages.

The subregional center "C" provides specialized services of a higher order, such

as secondary and vocational schools, processing plants, marketing agencies, and medical facilities. These services can also be provided by an existing village or rural town with a convenient geographical location. The intentional selection of such a center can eventually be used to revitalize an existing village by assigning it new functions (Maos, 1977).

Center "C" serves a larger number of users and is consequently better endowed. Because of its larger radius of influence (or attraction), however, such a center may be remote from some settlements and accessible mainly by mechanized transport. This lessens the importance of small (~ 5 Km) differences in distance. The following analysis concentrates therefore on the lower-level centers "A" and "B", since people generally commute between them on foot or by rudimentary transportation. A major constraint in the development of these services is distance, which depends to a large extent on the settlement pattern and layout.

A PROPOSED MODEL FOR COMPARING SERVICES EFFICIENCY

Various spatial theories have been elaborated for explaining the rationale, size, number, and distribution of centers offering services to a dispersed population (Berry, 1965). Most of these studies view hierarchy of services as a result of spatial competition between different centers. A rural structure of services, for example, resembles a Christaller-type model in form if not in substance. It has been argued that such models represent an optimal response to distinct scale requirements of various social, commercial, and administrative functions (Funnel, 1976). While several case studies have been brought forward to reconcile theory and reality in regard to central places, it seems difficult to derive clear guidelines from these evolved structures for the practical location of service points in a planned settlement scheme.

Numerous location-allocation techniques for planning a set of centers that will best serve a set of demand points have been suggested in the past (Scott, 1970; Lea, 1973). The main difficulty in using these techniques lies not only in their complexity, and the excessive amount of computer time required for their solution, but also in the sophisticated level of data input, which is often lacking in developing areas.

A different approach, which seems particularly appropriate in the case of "rural" densities, is to use a process of spatial modelling to simulate typical settlement layouts. A so-called Design Method and graphical means are employed to represent the main aspects of the system involved. The graphical presentation of a potential space has the advantage over algebraic models of conveying instantaneous meaning to the eye and brain seeking to optimize a set of preconceived criteria.

The design method, as developed herein, comprises three distinct stages: 1) Analysis: Listing all design requirements and reducing them to a set of logically related performance specifications; 2) Synthesis: Finding possible solutions for each function, and building complete designs from these with the least possible compromise; and 3) Evaluation: Comparing alternative designs with performance requirements in order to select an optimal solution (Chadwick, 1971).

The spatial models of settlement layout described in this article are examined in paired alternatives, one dispersed and the other concentrated, with land allotments

of 50, 20, 10, or 5 hectares per family. The larger land allotments represent extensive farms, common in current settlement projects, while the smaller allotments correspond to various types of intensive farming as in irrigation schemes. For the purpose of comaprison, all allotments are assumed to produce equivalent incomes, with the area only one input, along with climate, soil, or water.

Efficiency, in the context of this analysis, is defined as the aggregate effect of economy, accessibility, and structure. The first two factors are relatively easy to quantify, Economy refers to the cost of development and maintenance of the infrastructure, such as water supply, electricity, roads, etc. Accessibility is measured primarily in distances to services (the problem of distances to fields is discussed below.) Structure covers the deployment in space, or spatial organization, of service centers; it is optimal when (a) basic and higher-level services are located within adequate reach of all settlers; (b) services are distributed according to frequency of use; and (c) when services can be shared to obtain economies of scale. As will be shown, efficiency can be improved by the rational transfer of service functions from lower to higher ranking centers.

A hypothetical distribution of service centers, including the "D" regional center, is illustrated in Fig. 1. Various combinations of service structres are shown with both isolated and grouped centers, as are likely to occur in real-world situations. The actual number of service centers and satellite settlements is related, of course, to the availability of cultivable land, size of holdings per family, topography, and access. All these determine the overall density of the settlement and, consequently, the distances to services and fields.

The general notation for this structure would be

$$D + m\{C + n[B + p(A)]\} \qquad (1.0)$$

where:
D — the regional center, serves m number of
C— sub-regional centers, which in turn serve n number of
B — inter-village centers, which serve p number of
A — village centers.

If a given center is close enough to a higher order center, then some of its functions may be moved to that center, leading to more efficient service levels because of a larger clientele. Conversely, an isolated village center may have to provide diverse basic services, though in a less efficient manner than a village center serving the same number of families but better located in relation to a higher-order center. Thus, centers of equal order but varying proximity may be classified — according to their physical location — by capital letters (A, B, C,) when isloated, or by small letters (a, b, c,) when spatially associated with higher-level centers.

An optimal hierarchy in which selected lower-level service functions have been shifted upwards, can be denoted by

$$D + m\{C + n[b + p(a)]\} \qquad (1.1)$$

implying a higher efficiency due to economies of scale obtained through the sharing of services by several communities.

In the concentrated settlement pattern, where the small community is part of a bigger complex, the "a" center may be altogether devoid of services except for a

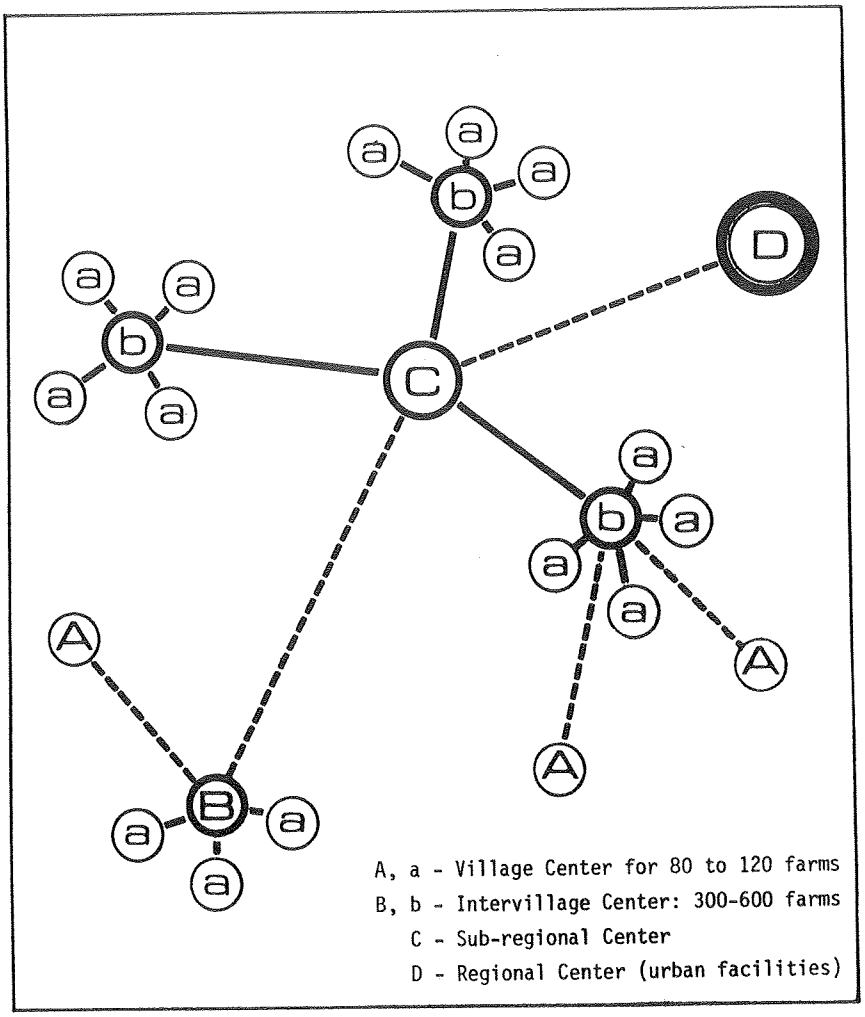

Fig. 1. Hierarchical structure of rural services from A to D levels

village green, and eventually a kindergarten of communal house. These are meant primarily to give the neighborhood an areal core (like the plaza in the Latin American village) needed to foster social leadership and to facilitate extension programs and community participation.

Figures 2 through 5 show a model, or graphical simulation, of a hypothetical land settlement area of 40 square kilometers (4,000 hectares). Each model has two possible patterns, despersed and concentrated, divided among the same number of farms.

The settlement area in fig. 2 is divided into 80 farms of 50 hectares each. In the dispersed pattern (figure 2.1) the land holdings are attached to the house as a single homeplot. In the concentrated pattern (figure 2.2), holdings are split in two parts: 25

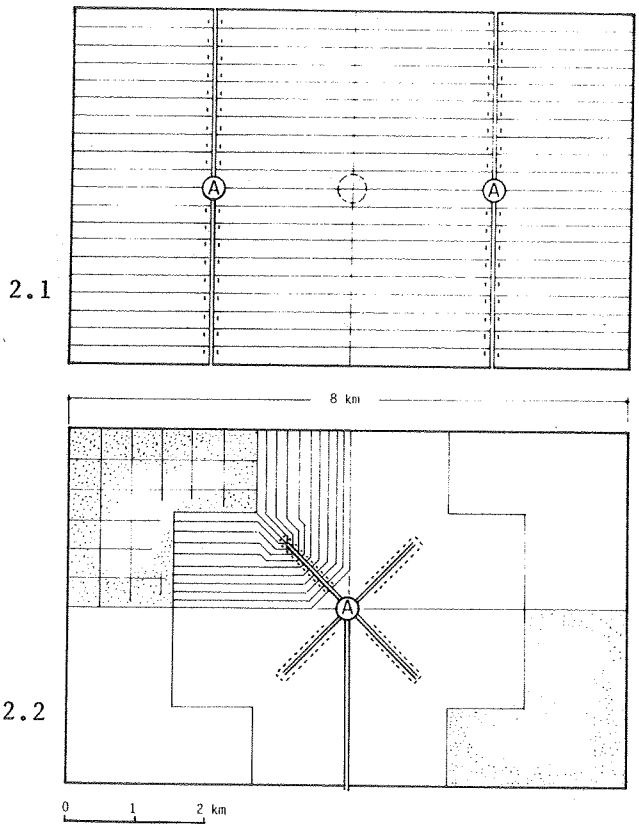

Fig. 2. Alternative settlement models of 80 farms with 50 ha holdings:

(2.1) dispersed: two "A" centers or one "A" center.

(2.2) concentrated: one "A" center.

hectares are attached to the house, while the rest is located in a separate block of land.

In the dispersed model (figure 2.1) there are two apparent distributions for service points: (1) two "A" centers, each for 40 farms within a maximum radius of over two kilometers from the remotest house; or (2) one center for all 80 farms in the gravity center of the settlement area, as shown in dotted lines. The first deployment splits the services between two weak centres, each serving a small number of consumers, while the other would put services at a prohibitive distance of up to 4.5 kilometers from the most distant user.

In the concentrated model (figure 2.2), one center serves 80 farms within a radius of 1,200 meters. In both models the centers rate as "A" centers, yet it is obvious that one center for 80 agglomerated farms will be more efficient than two separate (and more distant) centers for the same population. The relative efficiency of the services structure in the concentrated and dispersed pattern can be expressed as:

$$E[A_{80}] > E[2A_{40}]. \quad (2.0)$$

The model of the small village in figure 2 serves primarily for illustrating the relative efficiency of these basic sizes in both patterns. Given initial conditions in developing countries it is doubtful whether a community of 80 families would ordinarily be able to sustain independent facilities. On the other hand, villages of this size may occur in new land settlement projects due to the lack of contiguous areas of cultivable land, or in cases of extensive farming. Many planners consider 80-120 families with holdings of 10 to 15 hectares an optimal number for arable and mixed farming villages, as it enables keeping maximum distances to fields within 3-4 kilometers. Experience also indicates that villages of up to 100 familites are more amenable to agricultural extension services; bigger villages tend to become socially amorphous and difficult to organize as cooperative units. Although a larger community allows for more efficient services, it also means longer distances both to services and work. These conflicting constraints can be overcome by forming larger villages consisting of serveral small neighborhood units (Yalan, 1975).

Figure 3 shows the same settlement area of 40 square kilometers with 200 twenty-hectare farms. In the dispersed pattern (figure 3.1), the centers can be distributed either as two "A" centers, as shown in dotted lines, each serving 100 farms, or as four "A" centers for 50 farms each. In the latter case a "B" center can be added in the middle of the area. Both solutions have notable drawbacks, however. With two "A" centers, the maximum distance will be nearly 3.5 kilometers, while four centers would prove inefficient, serving relatively few inhabitants (50 families) within distances up to 2.5 kilometers. Moreover, the "B" center, because of its remoteness (over 5 kilometers from the farthest user), would remain poor in term of facilities, and most "A" centers would tend to develop and retain their own facilities such as an elementary school. The arrangement in the dispersed pattern can be described as (2A + B) and (4A + B), respectively. (3.0)

In the concentrated pattern (figure 3.2), the built-up village area contains only houses and farmyards on 0.4-hectare lots. The remaining land holdings are divided into two parts and located in large blocks. The model shows four "a" centers, with 50 families each, surrounding a "B" center within a distance of 1,100 meters. Such a relatively short distance will attract many of the services which would otherwise duplicate themselves in a weak form in the "A" centers. The notation for this arrangement would be: (B + 4a). (3.1)
The relative efficiency of the dispersed and concentrated pattern can be expressed as:

$$E(B + 4A) > E(B + 4A) + E(B + 2A) \quad (3.2)$$

A similar situation is created when the model area is divided into 400 ten-hectare farms (figure 4). In the dispersed pattern four full "A" centers are required, as shown in figure 4.1. Distances to basic services would be nearly 2.5 kilometers, while the centrally located "B" center would be at a distance of over 5 kilometers from the farthest house. With such distances each "A" center would tend to become self-sufficient in respect of basic and higher-order services, leaving little scope for the development of the "B" center. In the concentrated pattern (figure 4.2), four "a" centers, each with 100 families, surround a "B" center within 1,300 meters. Its proximity would encourage the concentration of several services in the joint "B"

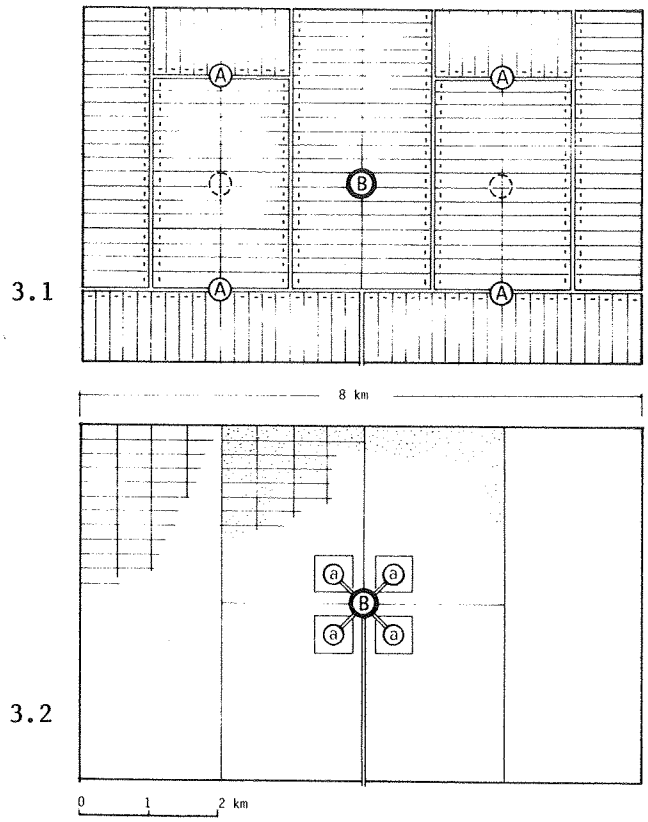

Fig. 3. Alternative settlement models of 200 farms with 20 ha holdings:

(3.1) dispersed: four or two "A" centers and one central "B" center,

(3.2) concentrated: four "a" centers surrounding a "B" center

center, preventing redundancy and producing a higher level of services for the entire settlement. In figure 4 (as in figure 3) it is possible to express the relative efficiency of the system as:

$$E[B + 4a] > E[B + 4A] \qquad (4.0)$$

Figure 5 shows the same settlement area with 800 five-hectare farms. The most obvious deployment of services from a point of view of distances consists of eight "A" centers and two "B" centers, the latter serving 400 farms each (figure 5.1). While such spatial arrangement seems necessary in the dispersed model, the concentrated model (figure 5.2), permits the introduction of a sub-regional center "C". This center, surrounded by four satellite (b + 4a) groups, serves the entire population of 800 farms. The relative efficiency of this arrangement can be

expressed as:

$$E[C + 4(b + 4a)] > E[2(B + 4A)] \qquad (5.0)$$

As in the preceding models, an improved structure is achieved in the concentrated pattern by shifting more service functions from the smaller centers to higher level centers, thus avoiding duplication while preserving accessibility. The combined effect to these factors confirms the afficiency relationship expressed above. Moreover, since the groups of 200 farms are more self-sufficient, and services in the sub-regional center "C" of a kind and quality that make longer trips worthwhile, each of the (b + 4a) complexes can be shifted to suit topographical or other conditions. The concentrated pattern thus provides a significant degree of flexibility.

In the above analysis clear priority is given to minimizing "internal"

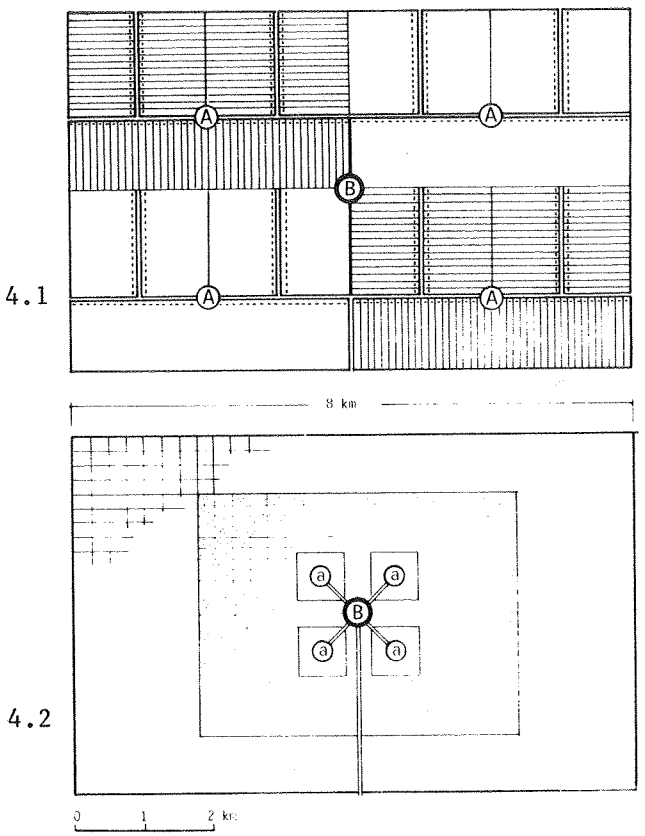

Fig. 4. Alternative settlement models of 400 farms with 10 ha holdings:

(4.1) dispersed: four "A" centers and one "B" center

(4.2) concentrated: four "a" centers grouped around a "B" center.

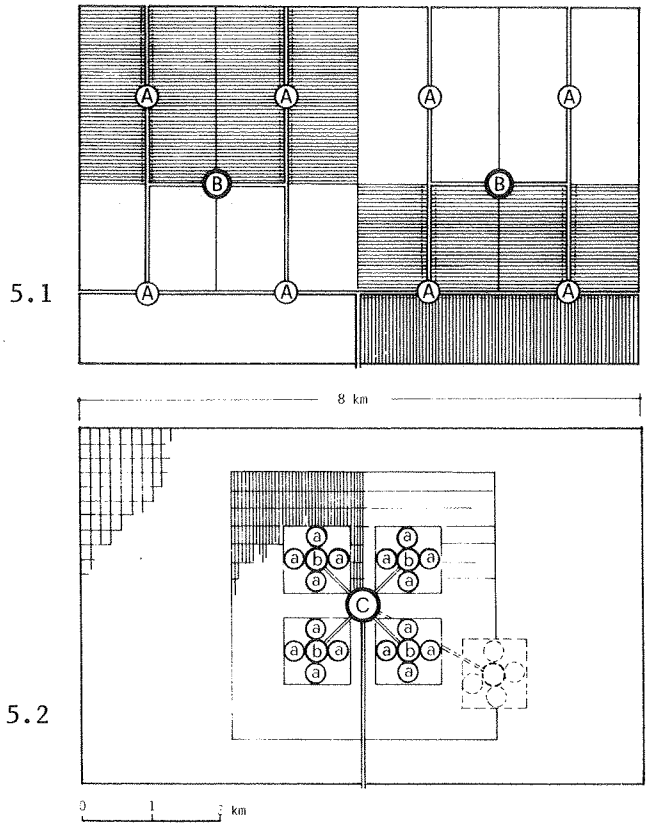

Fig. 5. Alternative settlement models of 800 farms with 5 ha holdings:

(5.1) dispersed: eight "A" centers and two "B" centers

(5.2) concentrated: four "b" centers and a "C" Center.

(village-to-services) distances over "external" (village-to-fields) distances. Although both are improtant, particularly during the initial phases of the settlement, external distances to the fields have a higher elasticity than internal distances. In the beginning the settler may possess only the simplest means of transportation or none at all, and will spend much time commuting to the fields to cultivate his parcel. The importance of this distance decreases, however, as transportation improves and farming is modernized through mechanization and expert management, all of which reduce the frequency of individual trips. Internal distances, on the other hand, are usually preceived without change over time, since household members continue to commute to central service points, mostly of foot, for their daily needs, as well as for social, cultural, or work-related purposes. Internal distances that are too long will often produce spontaneous growth of redundant and inefficient facilities, which later are liable to delay the development of more rational services (Maos, 1977).

External distances can be reduced by grouping plots of equal soil quality and crop

suitability in large blocks of land. In this manner, the nearer block may be designated for labor-intensive crops while the more distant block can be put to extensive uses. The system can be based on two or more land blocks. The resulting fragmentation of individual holdings is more than offset by the saving in total commuting time, and by the possibility of undertaking large-scale cooperative farming operations (OECD Observer, 1972). It also permits a "balancing" of the distance factor, since the holder of a far-extensive plot can be compensated with a near-intensive plot, and vice versa. Multiple field systems are well-known in history; they have been used in recent projects such as the Lakhish region in Israel, where part of the land allotment was planned for irrigation. Sometimes the far plot is part of a communal tract for fruit trees or pasture lands, as in the Taanakh Settlements in Israel, the Chontalpa project in Mexico, or the colonization project of Tingo Maria-Tocache in Peru (Nelson, 1973).

CONCLUSIONS

This study has attempted to demonstrate that the efficiency of rural services can be improved through appropriate structuring, which minimizes redundancy and maximizes the numbers of consumers per center without sacrificing accessibility. As shown, such efficiency is easier to achieve in the concentrated pattern. The analysis refers mainly to the size-range of family-farm holdings which is common in current land settlement schemes in developing regions. Table 1 summarizes the main features of each of the illustrated settlement models, indicating maximum distances to services and relative efficiency.

It is interesting to note that in the concentrated settlement pattern the location of the lower-level centers coincides with the geographical center of each settlement area, while in the dispersed pattern the services tend to fragmentation and duplication. The concentrated pattern permits expansion of services according to increases in population, or addition of new functions, without changes in location, so that investments in infrastructure are not wasted. In comparison, the long distances to services in the dispersed pattern require additional service points; yet, when more services are inserted, the number of users per center becomes too small. The graphical models demonstrate that the functional size of a settlement and its ability to sustain adequate facilities will be determined not merely by the number of farms and size of holdings, but rather by a balanced relationship between the communal center "A" and the intervillage center "B", which encourages the shifting of basic service functions to higher-order centers where economies of scale can be obtained.

REFERENCES

Berry, B.J.L. and A. Pred, (1965), *Central Place Studies: a Bibliography of Theory and Applications,* Philadelphia, Regional Science Research Institute, Bibliographic Series No. 1.

Chadwhick, G. (1971), *A Systems View of Planning,* Oxford—New York, Pergamon Press.

Funnel, D.C. (1976), "The Role of Small Service Centers in Regional and Rural Development: With Special Reference to Eastern Africa," in A. Gilbert, (ed.), *Development Planning and Spatial Structures,* London, John Wiley & Sons, pp. 84—111.

Lea, A.C. (1973), "Location-Allocation Systems," Discussion paper No. 13, Dept. of

Geography, University of Toronto.

Maos, J.O. (1977), *The Spatial Organization of New Land Settlement,* Rehovot, Settlement Study Centre.

Nelson, M. (1973), *The Development of Tropical Lands: Policy Issues in Latin America,* Baltimore, Md., The Johns Hopkins University Press.

OECD Observer (1972) no. 56, "Group Farming: A New Experiment in Cooperation Between Farmers", pp. 31—32.

Prion, I. (1968), *Development Trends of Spatial Rural Cooperation in Israel,* Rehovot, settlement Study Centre.

Scott, A. J. (1970) "Location-Allocation Systems: A Review", *Geographical Analysis,* (2), pp. 95—119.

Weitz, R. (1971), *From Peasandt to Farmer,* New York, Columbia University Press.

Yalan, E. (1975), *The Design of Agricultural Settlements: Technological Aspects of Rural Community Development,* Jerusalem, The Jewish Agency for Israel, Rural Settlement Department.