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AGRICULTURAL LAND USE THEORY AND ITS APPLICATION WITH REFERENCE TO AFRICA

by

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INTRODUCTION

This paper is a follow-up on two earlier articles published in this journal which examined key geographical theories and their application to Zimbabwe, the first by Heath (1986) on central place theory and the second by Tevera (1986) on industrial location theory. In keeping with one of the objectives of the current Cambridge Higher School Certificate syllabus, the aim of this series of articles is to provide basic materials on spatial models of human behaviour and to demonstrate their assumptions, processes, implications and limitations for use by geography teachers preparing their pupils for the A-level examination. This paper examines the principle features of von Thunen's agricultural land use model and its application in developing countries, particularly in Africa. Further references from both developed and developing countries are provided for those who wish to establish a collection of empirical case studies.

Johann Heinrich von Thunen (1783-1850) was a wealthy German who farmed about 35 km from the market town of Rostock in Mecklenburg near the Baltic Sea on the north German plain. Although not trained as a geographer, he showed remarkable ability in one of the essential geographical skills, namely the ability to observe and describe the spatial arrangement of phenomena. He bought his farm in 1810 and, for the next 40 years until his death in 1850, he meticulously recorded the costs and revenues and the patterns of land use on his estate. It was these records that provided the empirical basis of his land use theory. As a result of his detailed observations nearly two hundred years ago, von Thunen is today recognised as the founding father, not just of agricultural location theory, but indeed of all modern location theory. Although agriculture has changed enormously since then, due mainly to changes in technology, von Thunen's theory retains considerable relevance to this day. The principles he put forward to explain agricultural land use have been extended to the analysis of urban land use patterns as well.

As a farmer, von Thunen had observed that, where there were two plots of land that were similar in their physical characteristics (a feature of the north German plain), but situated at different locations in relation to the market (presumably Rostock), they would be used for different agricultural purposes. He suspected that the differences in the use to which the land was put would be due to differences in the distance, and therefore cost, of transport to and from the market. He therefore set out to investigate the influence of distance on agricultural land use patterns and, more specifically, to establish laws governing the relationship between prices of agricultural commodities, distance, and land use such that farmers were able to maximise their net profits. His observations were published in Germany in 1826 in a book called *The Isolated State.*

ECONOMIC RENT

Before we discuss von Thunen's actual model, it is necessary to define the concept of economic rent which forms the pivot of his theory. The term had also been introduced almost simultaneously but independently by David Ricardo in 1817, but with a different meaning. It is von Thunen's definition of economic or locational rent that has become widely accepted in locational analysis. Whereas Ricardo's definition of economic rent was based on the quality or fertility of the land, von Thunen's was based on the cost of transporting products from the farm to a central market. He suggested that the crop grown on a particular piece of land is that which yields the highest net return per unit of land or economic rent, and that the level of economic rent from a given crop is determined by distance, and therefore the cost of transporting the product, to the market. Different crops may, therefore, be said to competitively bid for occupation of a given piece of land, with that crop which is able to offer the highest economic or locational rent winning the right to occupy that plot. (Note that economic rent is calculated per unit of land, e.g. per ha., and not per unit of weight or volume of product). Commodities that are not successful in bidding for the first piece of land are relegated to other locations farther away from the market where they in turn will be able to make the highest bids. The net return or economic rent obtained from the different land uses at varying distances from the market gradually diminishes; that is, the differences between income and expenses become smaller with increasing distance. At the spatial margins of production, income is just enough to cover expenses. Beyond that point, the land is not utilized for agricultural purposes because it is now unprofitable to do so. It is important to note that, in von Thunen's model, the only factor influencing variations in land use is distance, and therefore cost of transport, to the market, and not variations in soil fertility, farmer attributes or other variables.

The concept of economic rent may be simply illustrated with reference to a single crop such as maize. The price of maize is set at the market through the economic process of supply and demand. A farmer's income per hectare, i.e. economic rent, is therefore equivalent to the total amount received at the market for his maize produced on that hectare LESS (a) the cost of the production per hectare and (b) the cost of transporting the output from that one hectare to the market. The greater the transport costs, the smaller the locational rent. The locational or economic rent of a piece of land therefore decreases with distance from the market. The economic rent for a given commodity can be calculated using the following formula:

$$E = O(p - c - td)$$

where
- E = economic rent per unit of land (e.g $ per ha.)
- O = output per unit of land (e.g. tonnes per ha.)
- p = market price per unit of commodity (e.g. $ per tonne)
- c = production cost per unit of commodity (including farmer's own labour (e.g. $ per tonne)
- t = transport cost per unit of commodity per unit of distance (e.g, $ per tonne per km)
- d = distance to market.

ASSUMPTIONS OF THE MODEL

It has been mentioned above that, in von Thunen's model, the only factor determining variations in land use is distance from the market. In fact, von Thunen made several simplifying assumptions relating to (a) the land surface and (b) the people inhabiting that land. Assumptions relating to the land surface were that

(i) it was a broad featureless or isotropic plain – flat, unbounded and homogeneous in every respect, i.e. climate, soil fertility, relief etc;

(ii) other than distance, there were no barriers to movement, transport costs were exactly proportional to distance alone, and a single dense radial transport network was available in all directions at equal cost, converging at the central market; the horse-drawn cart was the only mode of transport available at that time:

Assumptions relating to the population were that

(iii) it was evenly distributed over the plain and was identical in every respect, i.e. incomes, tastes and consumption patterns, labour costs for a given commodity, production techniques, etc; therefore production costs for a given commodity were the same for all farmers on the plain;

(iv) conditions of perfect competition prevailed and prices of commodities at the market were determined by supply and demand; all the farmers sought to maximise profits and would automatically and instantaneously adjust their crop output to changes in prices and needs of the central market.

Other assumptions that he made were as follows:

(v) the featureless plain was dominated by a single large central town that served as the sole market to which farmers transported and sold their commodities in return for industrial products;

(vi) the area that was currently utilized for agriculture was surrounded by an unutilized, but also homogeneous, wilderness which also provided room for the future expansion of agriculture to meed growing demands; and

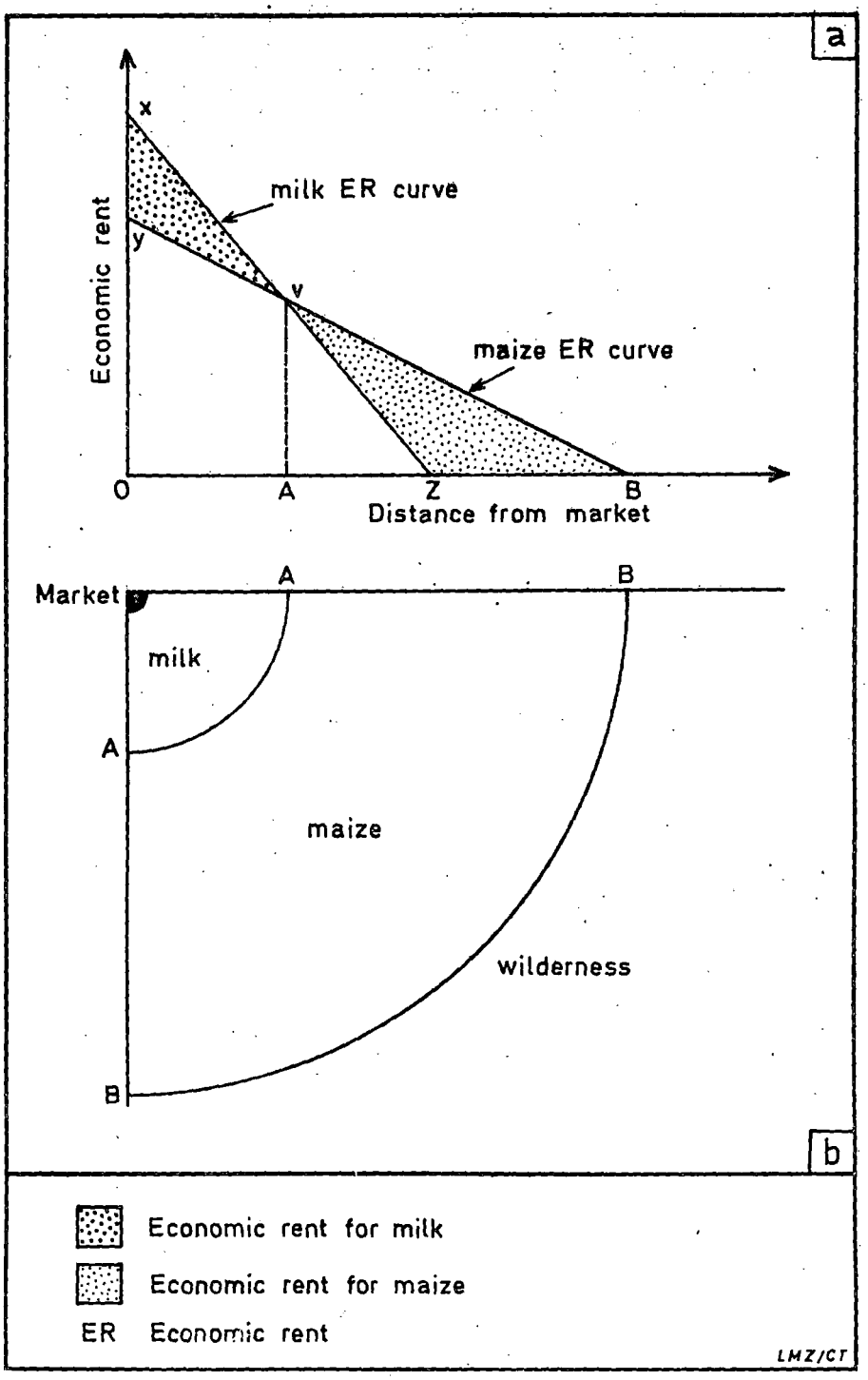
(vii) the whole region was an isolated state (the title of his book) cut off from, and therefore not trading with, the outside world.

These assumptions were clearly far removed from reality, even for the north German plain in the nineteenth century. However, such simplifying assumptions are necessary in the development of scientific models that can help us to improve our understanding of the real world and how it functions.

THE VON THUNEN MODEL

The von Thunen model of agricultural land use and the effect of spatial variations on economic rent for different crops can be illustrated by reference to a comparison of two commodities, for instance fresh milk and maize. In Figure 1a, milk yields a higher economic rent than maize within an area stretching from the market O up to point A. The difference in the economic rents from the two commodities at varying distances up to point A is shown by the shaded area YVX. From A outwards, maize yields a higher level

Figure 1: Economic Rent and Land Use Changes



a. **Economic rent and landuse change.**

b. **Spatial zonation of land use.**

(After Rhind and Hudson, 1980, p.152)

of economic rent than milk and the shaded area ZVB represents the level of economic rent from maize in relation to milk. At point B, the economic rent from maize has dropped to $0 and it is not profitable to grow the crop beyond this point. In terms of the spatial arrangement of land uses around the market, milk is going to be produced in the area between O and A (within which it yields the higher economic rent) while maize will be found between A and B. If this graph (Figure 1a) is rotated through 360° about the market town O it will describe a pattern of two concentric circles, the inner zone being allocated to fresh milk with maize on the outer zone (Figure 1b). This arrangement of land uses arises for two reasons: (a) the unit price of milk at the market is greater than that of maize and (b) transport costs rise more rapidly with distance from the market for milk than for maize. Thus, milk brings a higher return in the zone immediately adjacent to the market; however, this advantage is quickly eroded with increasing distance and additional transport costs until, from A onwards, the return from maize rises above that from milk.

From his field observations, von Thunen postulated that there would be a series of six concentric zones around the market plus an outlying wilderness, the utilized zones being characterised by decreasing intensity of land use (Figure 2 and Table 1). These land use zones, in order of increasing distance from the market were

- market gardening and dairying;
- forest;
- six-year rotational crop production without fallow;
- seven-year rotational crop production with grass fallow;
- three-field system;
- extensive livestock raising; and finally
- the wilderness.

Figure 2: Arrangement of Land Uses in von Thunen's Isolated State

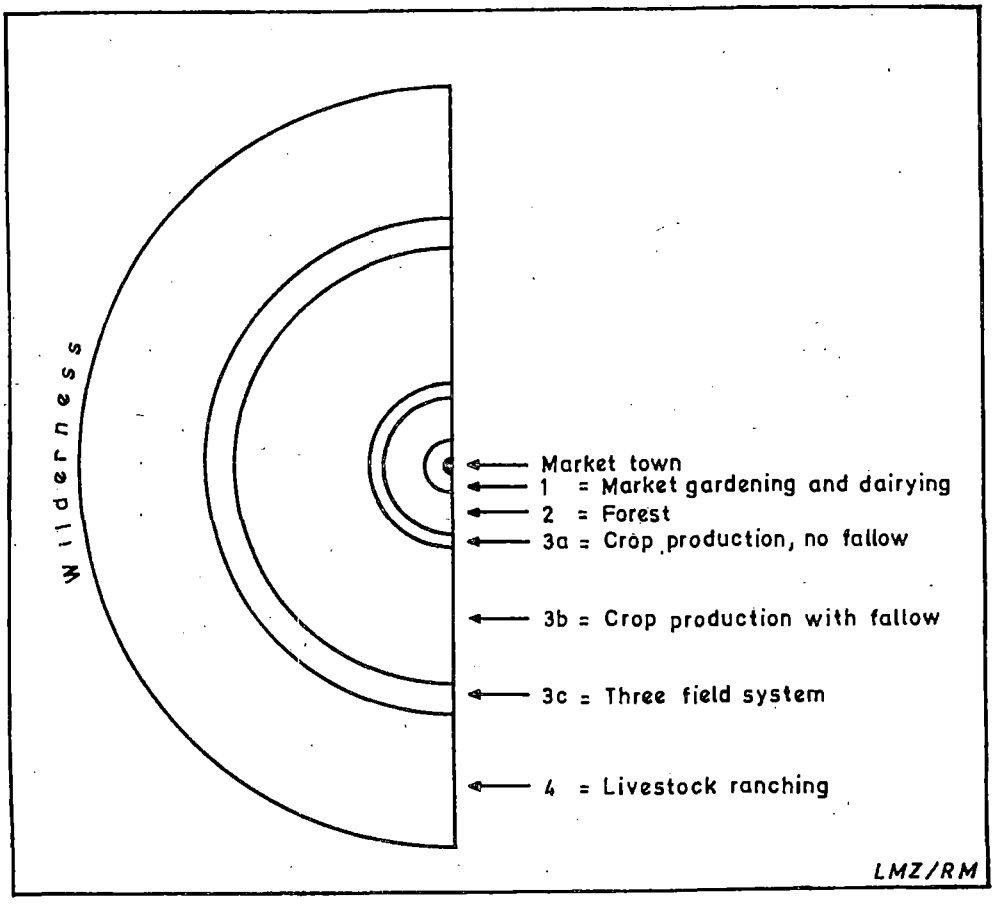


Table 1: Land Use Rings in the von Thunen 'Isolated State'

Zone	Area of state %	Relative distance from centre	Land use type	Major marketed product	Production system
0	<0.1	<0.1	Urban-industrial	Manufactured goods	Urban trade centre of state; near iron and coal mines.
1	1	0.1–0,6	Intensive agriculture	Milk; vegetables	Intensive dairying and trucking heavy manuring, no fallow
2	3	0.6–3.5	Forest	Firewood; timber	Sustained-yield forestry
3a	3	3.5–4.6	Extensive agriculture	Rye; potatoes	Six-year rotation: rye (2 yrs), potatoes (1 yr), clover (1 yr), barley (1 yr), vetch (1 yr); no fallow; cattle stall-fed in winter.
3b	30	4.6–34	Extensive agriculture	Rye	Seven-year rotation: pasture (3 yrs), rye (1 yr), barley (1 yr), oats (1 yr), fallow (1 yr).
3c	25	34–44	Extensive agriculture	Rye; animal products	Three-field system: rye (1 yr), pasture (1 yr), fallow (1 yr).
4	38	44–100	Ranching	Animal products	Mainly stock-rearing; some rye for on-farm consumption.
5	–	>100	Waste	None	None.

Distance to the edge of the 'Isolated State' is assumed to be 100 units.

Sources: Haggett, *et al.* 1977, p.205; Rhind and Hudson, 1980, p.149.

The first zone was occupied by market gardening and fresh milk production which, because of their highly perishable nature, had to be as close as possible to the market. This type of agriculture gave a high return (economic rent) to the farmer but it incurred heavy transport costs with increasing distance from the market. Hence its economic rent curve dropped very steeply from the centre. Forest occupied land so close to the city because, in von Thunen's time, its woodland provided timber for both building materials and fuelwood, demands that are today met from alternative sources in most cities of the world. However, timber was a bulky commodity as a result of which it incurred heavy transport costs, thereby causing a steep drop in its locational rent curve as well.

Rings 3a, 3b and 3c were all used for crop rotation systems, the chief cash crop in each case being rye. Thus in zone 3a, rye and potatoes were sent to the market, but vetch was used both as a green fodder and to help maintain the fertility of the soil. Cattle were kept in stalls for most of the year and manure was used to maintain soil fertility. The three rings differed mainly in the intensity of land use which decreased outwards from the centre. The proportion of land that was fallow in any one year (fallow being the mechanism for restoring soil fertility in the absence of alternative techniques) increased

in the sequence of zero in zone 3a, one-seventh in zone 3b, and one-third in zone 3c. Thus, the systems became more and more extensive and therefore wasteful of land with increasing distance from the market. As the intensity of land use in the three zones decreased outwards, there was a corresponding decrease in production costs per unit area, especially for labour and manure, thereby compensating for the additional transport costs to the market. In the zone of livestock ranching, income was mainly obtained from the sale of transportable and non-perishable animal products such as meat, butter and cheese, hides and wool. Crops grown within this zone would be mostly for on-farm consumption by either people or livestock. Beyond this zone lay the wilderness which would be exploited in the future when the demand for agricultural commodities in the city warranted an outward expansion of the productive area.

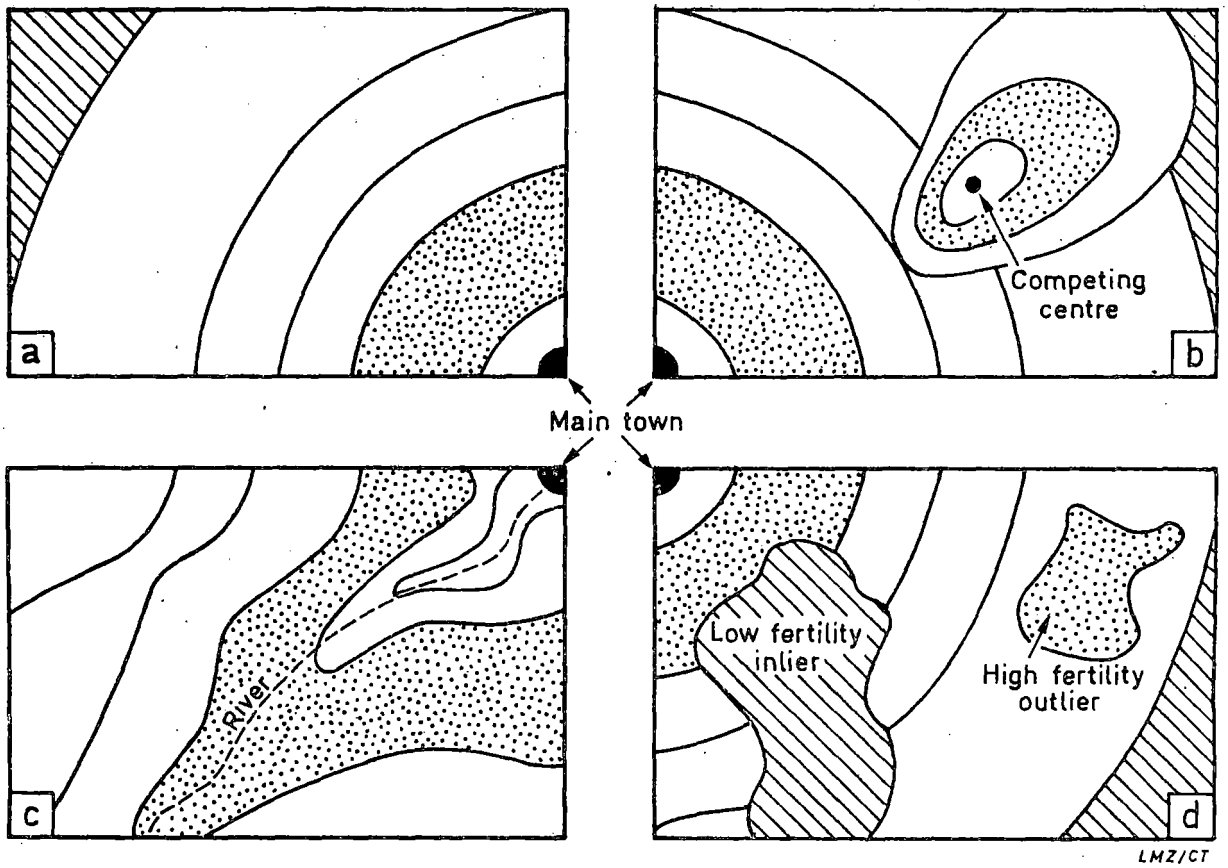
Even von Thunen himself was aware that his model and its underlying assumptions were far removed from reality. He therefore proceeded to relax some of his assumptions. First, he relaxed the assumption that movement was easy in all directions from the market centre by introducing a navigable river that provided a quicker and cheaper mode of transport in one direction (Figure 3c). (Today, instead of a navigable river, this would be a highway or railway line.) The effect of having a cheaper mode of transport was to distort the geometry of the concentric rings by elongating them on either side of the river. In other words, farmers adjacent to the river were able to grow crops a greater distance away from the market than would otherwise be possible had there been no river. The second relaxation made by von Thunen was to introduce a secondary town on the plain. This second market would develop its own competing series of concentric land use zones around it (Figure 3b). Finally, another relaxation was made concerning the nature of the land surface by introducing variations in soil fertility, relief, or climate and hence spatial variations in land productivity (Figure 3d).

APPLICATION OF THE VON THUNEN MODEL

During the past half century, a number of geographers working in various parts of the world in both developed and developing countries have tested the validity of von Thunen's model by examining whether there was actual evidence of a zonal pattern of agricultural land uses. While these empirical studies have exposed some weaknesses of the model, their findings have by and large confirmed the existence of land use rings under a variety of socio-political and economic conditions. The shortcomings of the model need not detain us here. What is important to note is that, although these studies have proved that land use rings do indeed occur, the reasons for their occurrence are not always due to the influence of increasing transport costs from the market centre as postulated by von Thunen. The model assumes that production is for commercial purposes with the produce being sold at some off-farm market centre. Yet concentric zones have been found even in areas where agricultural production was for subsistence purposes by the producing household. Further, these empirical studies have confirmed the existence of land use rings at varying scales of analysis, from the international level (see Peet, 1969, for 18th and 19th century continental Europe), at the national level (e.g. Griffin, 1973, for Uruguay), regional level (e.g. Rutherford *et al.*, 1966, for New South Wales, Australia), down to the local village and farm level (e.g. Blaikie, 1971, for the village of Daiikera, India; Chisholm, 1979, for the village of Canicatti, Sicily).

The remainder of this paper will briefly outline the zonation of agricultural land uses at the local level, using some examples from studies in west and north-eastern Africa. The examples describe land use patterns around both agricultural villages as well as a capital city which also serves as the major national market. The village studies,

Figure 3: Distortions of (a) the regular concentric von Thunen Landscape by (b) a second competing centre, (c) a cheaper alternative transport route and (d) areas of varying soil productivity.



(After Haggett, *et al.*, 1977, p.74)

despite their varying socio-economic settings, have shown that inputs of both labour and manure decrease with increasing distance from the village or homestead. The critical distance beyond which the decrease begins appears to be approximately 1 km from the village; beyond about 8 km from the village, it becomes almost impossible to attend to the crops on a regular basis and such land is likely to be left uncultivated or, at most, is planted under crops that do not require regular attention and visiting. It has been shown that crops that are labour-demanding tend to be grown nearest to the village while those crops requiring less attention are grown further away. Even for a given crop, less labour-intensive methods are likely to be used on it as the distance of its field from the village increases. This is not very surprising since the effort required to use a given piece of land is going to increase with distance from the village as farmers travel to and from their fields on foot, often carrying seeds, implements, manure or produce. Thus, the concentric zones of land use found around African villages are not due to increasing transport costs to some distant market, but are determined by the amount of time spent on, and the difficulty of, movement to and from the fields that are located at varying distances away from the village. Thus, a more meaningful index for assessing the intensity of landuse under conditions of subsistence agriculture in Africa is not yield per unit of land (i.e. per ha.) as stipulated in the von Thunen model, but yield per unit of labour applied in agricultural production. It has also been suggested that concentric land use zones are more likely to occur in areas where rural population densities are low, and land is plentiful such that farmers practice either shifting cultivation or bush fallowing systems

of agriculture, rather than in areas of high population density. As population density rises and the amount of land available per farmer decreases, it appears that every available piece of land is utilized on a more or less permanent basis by the same cultivator. This will result in the disappearance of any zonal arrangement that may have existed before.

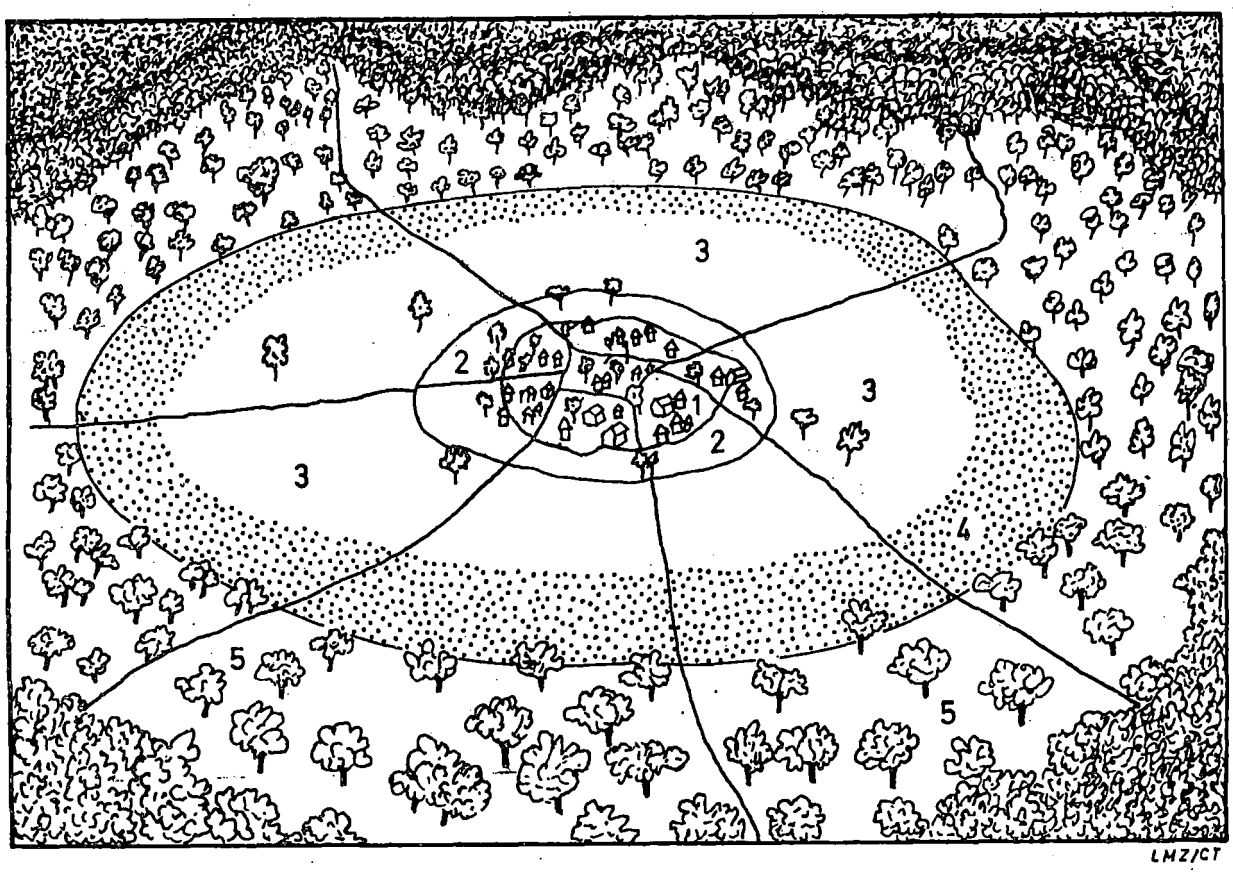
One of the first geographers to describe the zonation of agricultural land uses around an African village was Steel (1947) who had been a member of a British social survey team working among the cocoa-growing Ashanti of central Ghana during 1945-46. His detailed land use study was carried out around the village of Agogo (population: about 4500) east of Kumasi in early 1946. Steel found that the fields within a 1,6 km radius of the village were largely devoted to food crops (e.g. cocoyams, plantains, maize and cassava) grown on small plots under a system of bush fallowing, whereas the zone beyond 1,6 km up to 4 km radius was mainly under cocoa which was grown on larger, more permanent fields. This arrangement of land uses was mainly due to the fact that food farms need to be visited at frequent intervals throughout the year, either to work on them or to collect foodstuffs, and therefore have to be within easy walking distance of the village whereas cocoa, once established, needs very little attention other than the occasional weeding and harvesting of ripe cocoa pods. Also, the cocoa fields were under permanent cultivation, unlike the food plots, because to the farmer the tree crops represent a substantial investment which could not be undertaken under a bush fallowing system.

Similar patterns of land use zoning have been described by other researchers in other parts of West and East Africa (see, for instance, Ruthenburg, 1976, pp. 73-76, 122; Dumont, 1957, pp. 65-69; Morgan, 1969, pp.301-319; Oyeleye, 1973). The example from Senegal described by Ruthenburg (1976, pp.73-74) shows that the intensity of cropping decreases through five concentric circles from the domestic kitchen-gardens in the vicinity of the huts to the widely scattered peripheral fields (Figure 4). The kitchen-gardens in the inner zone are under permanent cultivation, soil fertility on them being maintained through regular application of household refuse and livestock manure. These kitchen-gardens have fruit trees, perennial crops such as bananas and papayas, as well as food crops that require fertile soils and regular attention. The zone of kitchen-gardens is followed by a zone of permanent cultivation which, because of continuous working and inadequate application of manure, is relatively lower in soil fertility. Beyond this second zone are three other zones in which the cultivated land is under increasingly long periods of fallow and therefore decreasing intensity of land use as distance from the village increases. The longer periods of fallow also mean that these distant fields are more fertile than the permanently cultivated plots nearer to the village. The fields in these distant zones are often used for growing cash crops while the fallow land is used as pasture for livestock.

Tobacco

Another geographer, Prothero (1957), described a similar zonal arrangement around the village of Soba, 35 km east of the town of Zaria in northern Nigeria, where he identified four zones (Figure 5). The pattern of land uses around Soba (1952 population: 4100) was described as typical of much of the medium density areas of Hausa territory. The first zone was a heavily manured (from small livestock kept in the village - goats, sheep and donkeys) inner kitchen-garden zone with close interplanting, continuous and intensive cultivation of crops within the village walls. Tobacco was the most important crop, with some guinea corn, okra, sugar-cane and peppers, in that order of importance. Traditionally, tobacco was grown during the dry season in the seasonally waterlogged vlei areas or 'fadamas' along the stream passing through the village as the water table fell. Since the early 1930s, commercial production of tobacco promoted by the

Figure 4: The spatial organisation of land use in N'Gayene, Senegal

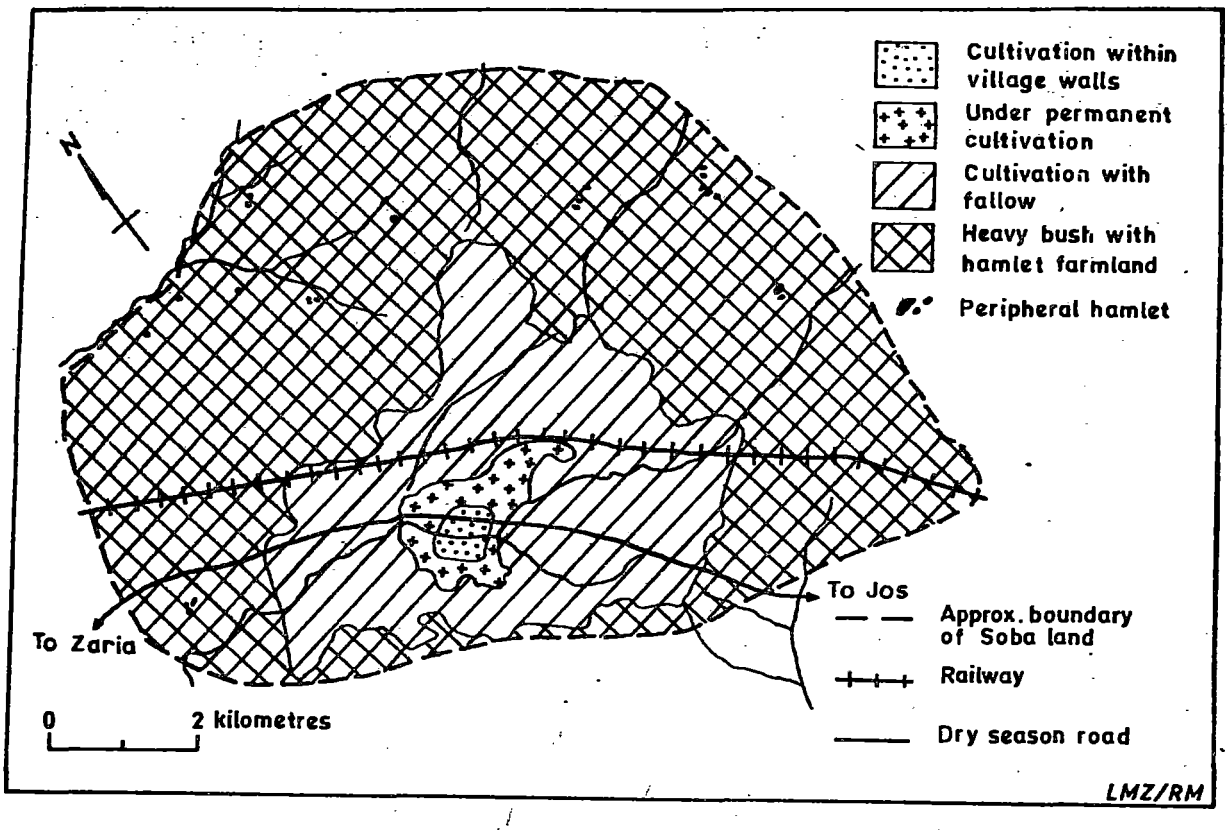


1. **House and gardens**
2. **Permanent cultivation**
3. **Intensive fallow systems**
4. **Intensive shifting cultivation**
5. **Bush and extensive shifting cultivation.**

(After Ruthenberg, 1976, p.74)

Nigerian Tobacco Company changed it to a wet season activity, but the farmers continued to grow the crop on the same manured land close to the village. Outside the village walls, the remaining three broad zones were best developed in the north, west and east where the greater part of the village land was located. The second zone, just outside the village walls and extending to a maximum of 0,8 to 1,2 km from the village walls, was also fertilized with manure from animals kept in the village and from nomadic Fulani cattle grazing on the crop residues after harvesting. The land was permanently cultivated, mainly with guinea corn and cotton as the major food and cash crops, as well as some tobacco and groundnuts. The third zone extending in radius from 0,8 to 2,4 km from the village, was cultivated without manure by a system of rotational bush fallowing. The land in this zone was cultivated for three to four years and then left to return to bush for at least five years to regain its fertility. Crops grown in this zone were similar to those in the second zone except that cotton was rather more important. The fourth or outer zone, extending another 2,4 km, except in the south where it was less than 0,8 km (i.e. 3-5 km radius of the village), was one of shifting cultivation with land being left fallow for much longer periods of time, often as much as 30 years. In this zone, cultivation was

Figure 5: Landuse zones at Soba, near Zaria, northern Nigeria



(After Prothero, 1957, p.74)

often done from temporary peripheral hamlets to reduce the amount of commuting to and from the village, each hamlet having its own small-scale zonal pattern of land uses similar to those for the village lands as a whole.

The following passage by a leading French academic describing the four-zone distribution of fields of one farmer in a village near the River Shari in Chad corroborates the evidence from other studies of rural land use in West Africa:

> The home field near the hut comprises a little over 1/4 acre, and is bounded by a fence of matted wild grass. It is heavily fertilized with animal manure ... The land is sown with maize during the rainy season, year after year ... Various 'industrial' crops are grown along the fences and the walls of huts ...
>
> A short distance away is ... a roofless enclosure for the ass and its foal. Eight goats and two kids are housed in a covered shed near the hut belonging to the head of the family and his wife ...
>
> Behind the garden with its varied produce, but still quite near the hut, is an open field belonging to what we have called the first concentric ring of cultivation. In its first year it was sown with maize, but since then it has given successive crops of early red sorghum, or 'children's millet'. This is sown at the end of May, and a very careful watch is kept on the crop, for it is harvested in August, which is a critical time of year from the point of view of food supply. The field is rarely manured, and bears an unbroken succession of crops. Sorghum, however, is a less exhausting crop than maize ...

> A second ring of crop land extends some 300 yds beyond the first and here the rotation comprises two years of mixed cultivation, with lines of red sorghum ... interspersed with groundnuts. This is followed by two or three years of fallow ...
>
> The 'bush fields' are the last, but by no means the least important area of cultivation. The fields of the whole village are grouped together in order to facilitate the watch against birds, which is kept from high observation posts ... The fields lie at some distance from the village, generally at between one and three miles, but never more than five. The villagers ... clear large sections of the savanna, and the first crop to be sown on the rich virgin land ... is sesamum, the traditional source of oil for domestic purposes. Groundnut oil is tending to replace it, however, and where this is the case the first crop is spiked millet, or 'dokhone', as it is known here. The latter ... is either grown for two or three years in succession, or, more frequently, alternated with sorghum. After this, the land remains fallow for three to five years ... (Dumont, 1957, pp.65-68)

A complicating feature of these shifting cultivation and bush fallowing systems referred to above is that while it is common for individual farmers to have fields in each land use zone or ring, not all farmers may have their plots distributed in this manner. Some farmers may have only one field in one particular zone. Further, some farmers cultivate their more distant fields during periods of peak demand for labour, not by commuting daily from the village, but from temporary shelters or hamlets erected within the outlying fields (see Figure 5). Thus, the relationship of distance to the problem of manuring, choice of crop and intensity of land use may vary quite considerably from one farmer to another within the overall zonal arrangement of land uses (Morgan, 1969, p.305). Third, evidence from other parts of West Africa has shown that, although cultivation zones may exist, the land immediately surrounding the village or homestead was often uncultivated (Jackson, 1972). In the absence of livestock for manure, this innermost land which was the earliest to be cleared for cultivation had become progressively infertile and the soil often turned into a hard laterite. These barren stretches gradually extended outwards each season in concentric circles around the village. The resulting pattern of land use was such that the most recently cleared land at the outer edge was under cultivation while the infertile innermost land was abandoned.

In those African countries where land use zonation occurs, systems of agriculture appear to have evolved from pre-colonial through to post-colonial times with minimum outside interference, other than the adoption of selected cash crops. However, in some countries in southern and eastern Africa, traditional pre-colonial systems of agriculture and land tenure have largely been altered by the impact of colonization, land alienation, as well as government policies aimed at controlling land utilization in rural areas. This is certainly the case in the communal areas of Zimbabwe where, over a long period of time, government policies and legislation have greatly changed the traditional patterns of land use. As a result, existing patterns of communal area land use at the level of the village do not bear any resemblance to the von Thunen model. However, research is needed to establish whether, at the level of the individual household, families use those portions of their fields closest to the homesteads more intensively and apply more inputs of both labour and manure onto them than they do on the more distant portions of their lands.

The present pattern of land use in the communal areas of Zimbabwe is a legacy of an American missionary-agriculturalist, D.E. Alvord, who was appointed the first

director of the newly established Department of Native Agriculture in 1926. In 1929, Alvord launched a programme that was aimed at rationalising land use in the communal areas in order to put a stop to the practice of shifting cultivation and to check soil erosion which was beginning to be a problem in these areas due to rising population densities. The effect of the rationalisation programme, or 'centralisation' as it was generally called, was to produce a pattern of linear settlements that separated large consolidated blocks of arable and grazing lands on either side, a characteristic of the communal areas to this day. The long lines of village settlements usually ran parallel to the rivers and watercourses, with the dry arable land above and the wetter grazing areas below the settlements (Figure 6a). This way, crops would be more protected from stray livestock during the growing season; in the dry season the animals were allowed to roam freely, grazing on the crop residues in the arable lands.

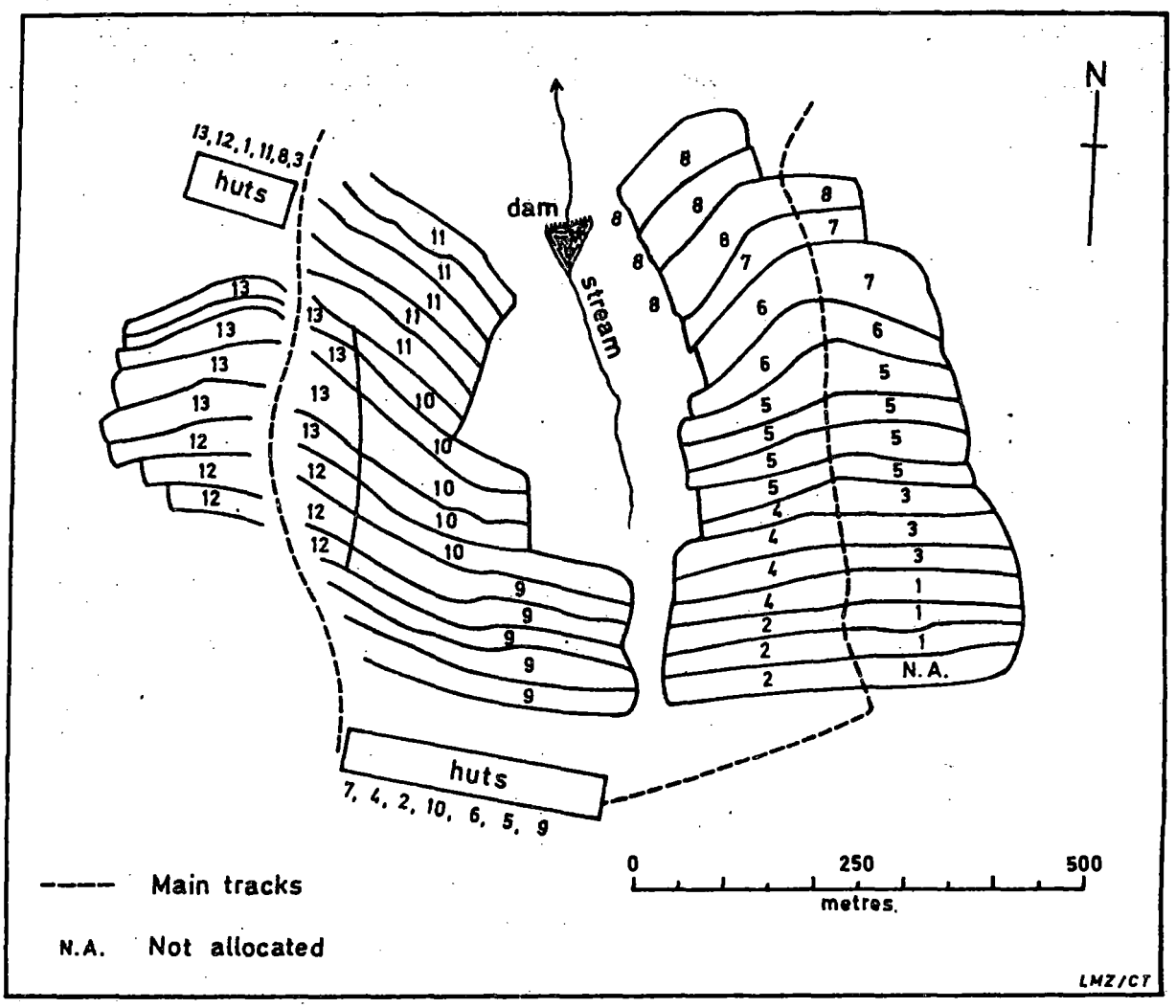
The re-organization of settlement and land use patterns along the lines started by Alvord was embodied into law with the passing of the Native Land Husbandry Act in 1951. Henceforth, land in the communal areas was to be re-allocated only to those families who were cultivating at the time of implementing the terms of the Act in any area. Each cultivation family would be allocated a small homestead plot within the linear village settlement as well as a block for cultivation within the arable zone. The arable area allocated to each family was divided into a number of narrow strips or fields which were separated by contour ridges that were designed to control water runoff and soil erosion across the fields. The amount of arable land per family varied in size from one area to another, depending on the density of population and agro-ecological conditions. The typical arable holding in medium and high rainfall areas (Natural Regions I to III) ranged from 3,24 to 5,25 ha. per family plus communal grazing for 6-10 head of cattle. Slightly larger arable holdings and grazing were allocated in the drier parts of the country. Thus, some families in a village would be within a very short distance of their fields whereas others had to walk considerable distances. Figure 7 shows the distribution of land in a village in Chinyika communal area near Goromonzi School shortly after the implementation of the Native Land Husbandry Act in the area. In this particular village, while the fields allocated to families 9 and 13 were very close to the homesteads, households 1 and 3 had to walk a considerable distance from the northwest to reach their fields in the extreme south east of the village lands. Although there have been some changes in the patterns of settlement land use in the communal areas since then, mainly as a result of increasing population pressures, the basic structure comprising linear settlements and separate blocks of arable and grazing lands is still evident today (Figure 6b) (Zinyama, 1988).

As yet, very few studies of agricultural land use around large cities in Africa have been undertaken. However, general observations of land use around the periphery of our major cities such as Harare and Bulawayo suggest that there may be some form of zonation, even though the rings may not be continuous. The large consumer market in Harare encourages the development of intensive market gardening and dairying on the outskirts, with all-year production of vegetables, fresh milk and, more recently, flowers for export to Europe being made possible by the development of irrigation from boreholes and small farm dams. In Harare, much of this output comes from relatively small farms and plots in areas such as Tynwald, Mt Hampden and north of Borrowdale. Thus, small farm size and the use of irrigation appear to produce a peri-urban zone of intensive agriculture. Farther away from the city, but within the large-scale commercial farming sector, more general types of farming seem to dominate, with crops such as maize, cotton and soyabeans as well as livestock being produced on much larger estates. However, land use intensity may be locally high where irrigation is practised, especially for winter wheat production in rotation with summer crops, as is the case in the Mazowe valley and

Figure 6: Settlement and land use patterns in a part of Save North Communal Land in (a) 1956 and (b) 1984

(After Zinyama, 1988, pp.55 and 58)

Figure 7: Distribution of arable land in Yafele village, Goromonzi, 1954-55



The numbers refer to familes in the village and the location of each household's arable land holding

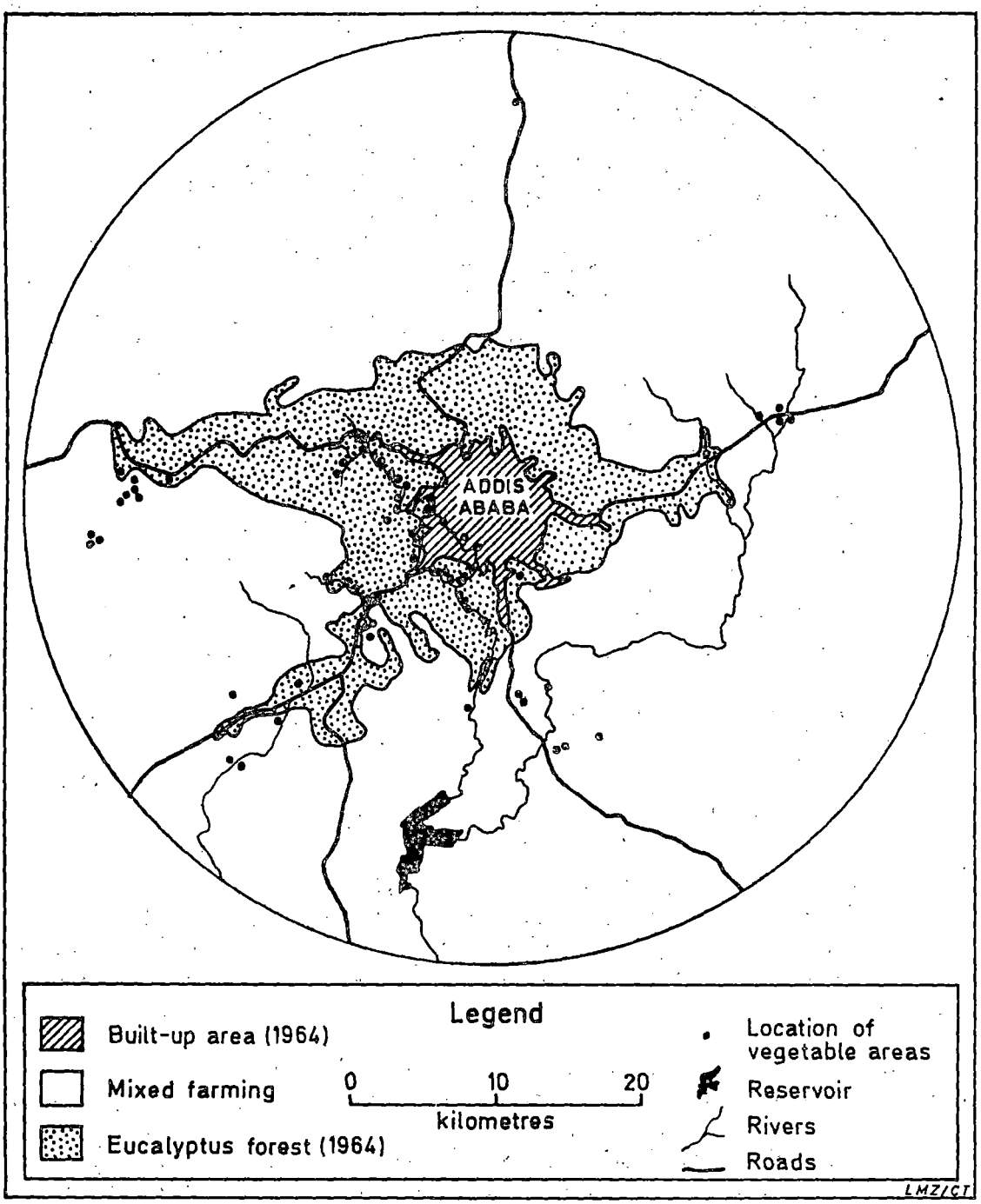
(After Beck, 1960, p.72)

the Enterprise farming area north and east of Harare respectively. But it must be emphasised that the above description is based on observations; detailed research remains to be done to establish whether or not zones of land use as postulated by von Thunen do exist around the larger urban centres of Zimbabwe and other African countries.

One such detailed study of land use around a large city was carried out in the early 1960s within a radius of 32 km of central Addis Ababa by an American geographer, R. Horvath (1969). Although the area did not conform to the theoretical assumptions of being an isolated, isotropic plain (there were variations in climate, soils and ethnic composition of the population), Horvath found several striking similarities between the Addis Ababa region and the von Thunen agricultural landscape. First, there was a 246 sq.km eucalyptus forest surrounding the city, producing firewood and building materi-

als for the urban inhabitants. The actual distribution of the forest zone offered an even more striking parallel to the theoretical pattern suggested by von Thunen as resulting from the introduction of an improved and cheaper mode of transport into the isolated state (Figure 8). The eucalyptus forest was elongated along three major all-weather roads leading into Addis Ababa from the northeast, southwest and west. Much of the wood from the inner portion of the forest was carried into the city by porters or pack animals. The wood from the more distant parts of the forest was carried along these roads by truck. The development of similar wedges along the roads to the north and south had been hindered by physical factors, namely the presence of an east-west escarpment in the north and black clayey soils that do not allow the growth of eucalyptus in the south.

Figure 8: Agricultural land use around Addis Ababa, Ethiopia, 1964



(After Horvath, 1969, p.316)

Horvath also found that vegetables were grown, particularly in the southwestern periphery of the built-up area of the city. However, vegetables did not constitute a first zone and eucalyptus trees a second zone as postulated in the theory; instead they were intermingled within the same zone, with vegetables concentrated in a linear fashion along streams that provided irrigation water during the long nine-month dry season. Again, the vegetables were transported into the city by porters. Lately, a few new vegetable areas were developing some distance away from the city on streams near to all-weather roads for easy transportation by trucks.

Beyond the eucalyptus forest was an area of peasant semi-subsistence mixed farming. The crops grown in this area were largely influenced by climatic factors. Some of the produce from the more accessible parts of this zone that were close to all-weather roads were sold to merchants from the city who visited the seventeen periodic markets in the area. From here, the produce was transported by truck to Addis Ababa. Horvath concluded that most indicators in the mixed farming area pointed to the existence of incipient zonation which coincided with the wedge-like pattern that land uses took in the theoretical isolated state following the introduction of a cheaper navigable river. The principal commodities in the mixed farming zone included wheat, barley, beans, the collection of wild products, as well as fresh milk which was brought by the farmers to local milk collection centres, each serving a radius of about 5 km. From the collection centres, the milk was then carried in special trucks to the dairy in the city for processing, bottling and distribution. The special circumstances for the displacement of fresh milk by eucalyptus forest at the edge of the city and its separation from market gardening, as well as the development of two complementary milk collecting systems (von Thunen had said farmers alone carried their produce to the market), are discussed in detail by Horvath (pp.319-321). Briefly, in the early days, milk was obtained from one's own cows or was purchased from a neighbour. Cows were grazed in open spaces within the city. But as the city grew, these grazing areas were filled in with houses and eucalyptus trees. Farmers in the surrounding areas began selling their small and sporadic surpluses in town, the milk being brought in by porter. As both the city and the zone of eucalyptus trees expanded, the amount of land devoted to milk production within walking distance shrunk (milk could not be carried more than 2 hours without spoiling), and milk supplies to Addis Ababa fell far short of demand. It was only in the late 1950s that a new programme was started to increase milk production in the mixed farming zone, but because of the greater distance to town, a two-tier marketing system had to be introduced. But instead of developing as a ring round the city, the evolving Addis Ababa milkshed was skewed northwards along a major road into the cooler mountain region where temperatures were too low for most crops. This further shows the effect of ecological factors on patterns of land use.

Horvath also found that, as postulated by the theory, each of the small towns in the study area had its own smaller zone of eucalyptus forest around it. But there was no vegetable production around these smaller centres, in part because those vegetable producing areas supplying Addis Ababa could also supply the needs of the smaller towns. Also, surpluses from the surrounding mixed farming area were sold in these small towns.

Finally, Horvath concluded that although several of von Thunen's assumptions were not completely met in the area around the Ethiopian capital, the observed agricultural patterns bore remarkable parallels to the theoretical formulations. The land use sequence was similar to that in the Isolated State, milk production excepted; much of this sequence had come about in response to the proximity of Addis Ababa as a market centre. However, Horvath also emphasised the point that agricultural land use patterns around the city cannot be explained in terms of distance and transport costs

alone; the study had shown the interplay of distance, environment, transport, and cultural factors in the development of land uses around Addis Ababa. Similar studies of agricultural land use around other African cities may reveal the inter-relatedness of these and other factors as well.

CONCLUSION

This paper began by outlining the von Thunen model of agricultural land use. It then proceeded to summarise the findings of some of the empirical studies that have been done to test the relevance of the model to patterns of agricultural land use in Africa. It is evident from these studies, as well as from those carried out in other parts of the world, that the model has considerable utility in the description of land use patterns in both developed and developing countries. However, the mere presence of zones or rings of different land uses in an area does not mean that the explanation for such zones is the same as that which is postulated in the theory of von Thunen. A diversity of factors - ecological, political, economic and social — account for the occurrence of land use zones in different parts of the world. Conversely, equally diverse physical and human factors explain the absence of land use rings in other parts of the world.

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