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THAKURPUKUR

KOLKATA-700063

NAAC ACCREDITED 'A' GRADE

Topic: Agricultural Land use Theory after Von Thunen

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Name of the Teacher: Baishali Mukherjee

Name of the Department: Geography

Von Thunen's Agricultural Land use Theory:
The analysis of land use patterns has long been one of geography's basic concerns. At first, it might appear as if agricultural land use is little affected by relative location, once the factor of a suitable market has been acknowledged. Indeed, the farmer does adapt his land use to site conditions, climate, land forms, and soils.

However, the effects of the market situation cannot be disposed of as easily as all that. Johann Heinrich Von Thunen (1983-1850), a German economist and estate owner of the early 19th century, developed a theory of agricultural location that is still worth considering.

This model is based on an econometric analysis of his estates in Mecklenburg, near Rostock in Germany. Most of the data used in explaining his theory were obtained by him through practical experience. He attempted to construct a theoretical model of land use pattern, giving a particular arrangement of towns and villages in a situation experienced in Mecklenburg.

The main aim of von Thunen's analysis was to show how and why agricultural land use varies with the distance from a market. **He had two basic models:**
1. The intensity of production of a particular crop declines with the distance from the market. Intensity of production is a measure of the amount of inputs per unit area of land; for example, the greater the amount of money, labour and fertilisers, etc., that are used, the greater the intensity of agricultural production.

2. The type of land use will vary with the distance from the market.

The von Thunen's location theory or model states that if environmental variables are held constant, then the farm product that achieves the highest profit will outbid all other products in the competition for location.

The competitive position of a crop or livestock activity (namely, how high the bidding needs go to secure a desirable site) will depend on the level of return anticipated from producing at the particular location.

A product with a high expected return and therefore, high rent-paying ability will be able to outbid a product with a lower profit level and, therefore, a relatively modest rent-bid ceiling.

By carefully compiling economic data on different farming activities on his own large estate Tellow in north-eastern Germany, von Thunen was able to determine the relative rent-paying abilities of each major agricultural product. Of course, the technology and agricultural products he managed in the early 19th century were different from those of today.

But, there are sufficient similarities to allow the analysis to be updated for our purpose. Moreover, his explanation was truly general, allowing his explanation approach to be applied to most contemporary agricultural situations.

Following von Thunen's reasoning, the ranking of agricultural activities on the basis of rent-paying ability in the decreasing order are as follows:

	Hierarchy of agricultural crops
1.	Truck farming (fruits and vegetables)

Dairying	
3.	Mixed crop and livestock farming (corn belt agriculture)
4.	Wheat farming
5.	Ranching (yearlings often sold to feedlots of mixed crop and livestock farming)

Von Thunen's theory is based on certain **assumptions.**

These are as follows:
1. There is an 'isolated state' (as von Thunen called his model economy), consisting of 1 market city and its agricultural hinterland.

2. This city is the market for surplus products from the hinterland and receives products from no other areas.

3. The hinterland ships its surpluses to no other market except the city.

4. There is a homogeneous physical environment, including a uniform plain around the city.

5. The hinterland is inhabited by farmers who wish to maximise their profits, and who adjust automatically to the market's demands.

6. There is only one mode of transport – the horse and wagon (as this was 1826).

7. Transportation costs are directly proportional to distance, and are borne entirely by the farmers, who ship all produce in a fresh state.

Von Thunen's model examines the location of several crops in relation to the market.

The location of crops, according to him, is determined by:
(i) The market prices,

(ii) Transport costs, and

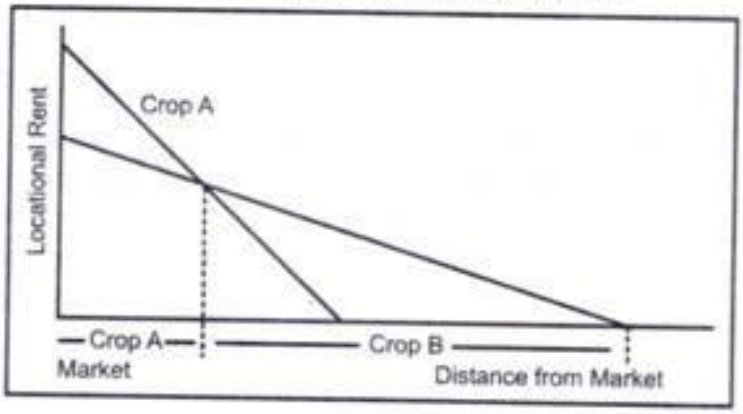
(iii) The yield per hectare.

The transport cost varies with the bulk and the perishability of the product. The crop with the highest locational rent for the unit of land will always be grown, since, it gives the greatest returns and all farmers attempt to maximise their profit. Two crops may have the same production costs and yields but difference in transport costs (per ton/kilometre) and market prices influence the decision-

making of the farmers. If commodity A is more costly to transport per ton/kilometre and it has a higher market price, A will be grown closer to the market than B (Figure 14.1). The locational rent of A decreases more rapidly than that of B, because of A's higher transport costs. As the market price of A is greater than B, the total revenue is higher at the market for A than B.

Figure 14.1

Locational rent and distance from market

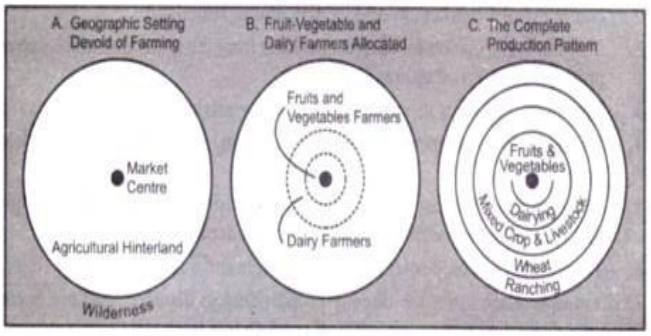


Thus, the market of the locational rent of A is greater than B, because production costs are the same and no transport costs are incurred. If the market price of B was greater than that of A, A would not be grown at all.

In his model von Thunen has explained three stages of the growth of agricultural landscape in an isolated state as shown in Figure 14.2.

Figure 14.2

Stages of formation of the agricultural landscape in von Thunen's model



The single urban centre and undifferentiated landscape of von Thunen's model landscape is portrayed in Figure 14.2. Where are the most desirable farming locations situated? For every farmer, regardless of the crop or type of livestock raised, the answer is indisputable: as close as possible to the central market. The market is the destination for agricultural goods produced throughout the region.

Next, assume that all the land in the heretofore undifferentiated landscape is placed on the auction block at the same time. The myriad of vegetable, dairy, mixed crop and livestock, wheat, and cattle-ranch land users eagerly submit their rent-bids to the landowners. All these actors prefer to purchase the right to use farmland near the market.

However, vegetable farmers have a higher relative rent-paying ability near to the market than their competitors; hence, at the auction the vegetable farmers will outbid all the others. The vegetable producers will thereby acquire the right to farm the land adjacent to the market.

Since, the undifferentiated landscape presents no advantages of being on a particular side of the market, the land users will distribute themselves circularly around the centre so as to minimise their distance to the town.

The bidding continues after vegetable farmers are accommodated. Since, dairy farmers rank next highest in rent-paying ability, they will successfully outbid the remaining contestants for locations in the next most accessible zone. Dairy farmers, too, arrange themselves in a circular fashion.

There arises a definite formation of concentric rings of different land uses circumscribing the market (Figure 14.2-B). The remaining agricultural systems can be arranged concentrically around the market centre in the same fashion, according to their competitive economic positions. The completed pattern of production rings is shown in Figure 14.2-C.

2. Von Thunen's General Theory of Land Use:

On the basis of the above-mentioned assumptions, von Thunen constructed a general land use model; having a number of concentric zones around a market town (its three stages of growth have already been mentioned).

The perishable, bulky and/or heavy products, according to this model, would be produced in the belts nearer to the town. The more distant belts would specialise in products which were less in weight and volume but fetched higher price in the market as they could afford to bear relatively higher transportation costs.

The final model was conceived as having specialised agricultural enterprises and crop-livestock combination. Each belt, according to von Thunen, specialises in the production of those agricultural commodities to which it was best suited (Figure 14.3).

It becomes clear from Figure 14.3 that the production of fresh milk (in the context of Europe) and vegetables was concentrated in the Zone I nearest to the city, because of the perishability of such products.

In this zone, the fertility of land was maintained by means of manuring and, if necessary, additional manure was brought from the city and transported to short distances to the farm.

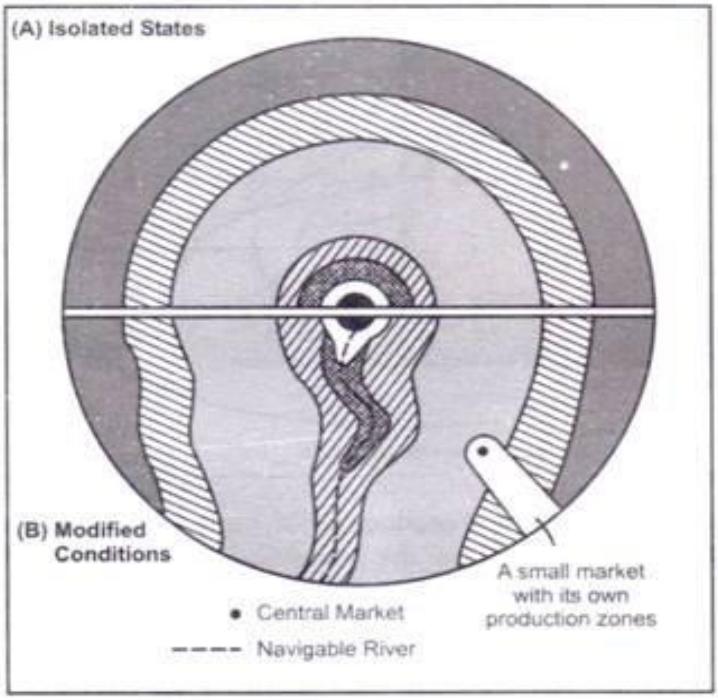
The Zone II was used for production of wood, a bulky product in great demand in the city as a fuel in the early part of the 19th century. He showed, on the basis of his empirical data, that forestry yielded a higher locational rent, since its bulkiness meant relatively higher transport cost.

The Zone III represents crop farming where rye was an important market product, followed by other farming zones with a difference of the intensity of cultivation. As the distance from the market increased, so the intensity of rye production decreased with a consequent reduction in yields. There was no fallowing and manuring to maintain soil fertility.

In the next Zone IV the farming was less intensive. Farmers used a seven-year crop rotation in which rye occupied only one-seventh of the land. There was one year of rye, one of barley, one of oats, three of pastures and one of fallow.

Figure 14.3

Agricultural zones according to the von Thunen's model

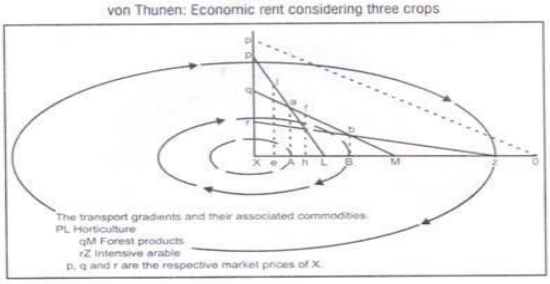


The products sent to the market were rye, butter, cheese, and occasionally, live animals to be slaughtered in the city. These products did not perish so quickly as fresh milk and vegetables and could, therefore, be produced at a considerably greater distance from the market. In the most distant of the zones supplying rye to the city Zone V, farmers followed the three-field system.

This was a rotation system whereby one-third of the land was used for field crops, another one-third for pastures and the rest was left fallow. The farthest zone of all, i.e., Zone VI was the one of livestock farming. Because of the distance to the market, rye did not produce so high a rent as the production of butter, cheese or live animals (ranching). The rye produced in this zone was solely for the farm's own consumption. Only animal produce were marketed.

Figure 14.4

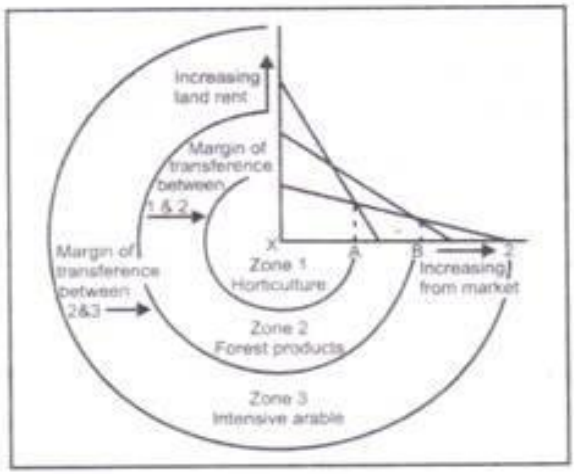
von Thunen: Economic rent considering three crops



The economic rent considering three crops (horticulture, forest products and intensive arable cereals) has been plotted in Figure 14.4, while Figure 14.5 shows a simplified model of concentric Figure 14.5 zones.

It may be seen from Figure 14.5 д simplified von Thunen's model that Zone 1 in which the economic rent is high is devoted to horticulture (fruits and vegetables), while Zone II was devoted to forest products (like fuel wood) as the transportation cost of fuel wood is high. The Zone III is that of intensive arable land devoted to cereal crops.

Figure 14.5
A simplified von Thunen's model



In this model, the distinctive aspects are land values, land use intensity and transportation costs. A brief explanation of these aspects is as follows:

Land Values:
For agricultural land users the locations with better access (nearer) to the central market, bids up the value of land. Land values become so high that only those producers who yield the greatest locational rents can afford it.

A distance-decay relationship and an inverted cone is revealed, with land values declining as distance from the central peak increases. The locational advantage of proximity to the market is reflected in higher land values; as accessibility declines, so do land values.

Land Use Intensity:
In direct response to the land value pattern, land use intensities also decline with increasing distance from the centre.

Producers on farmland with better access to the central market must use that land intensively to produce high enough revenues to afford to be located there. This results in high person-hour inputs per unit area of land for central farms, thereby requiring large hired-labour forces.

Farm size is another indicator as to the intensiveness of agricultural production; farm size generally increases with increasing distance from central markets. High land prices encourage farms to be comprised of fewer acres.

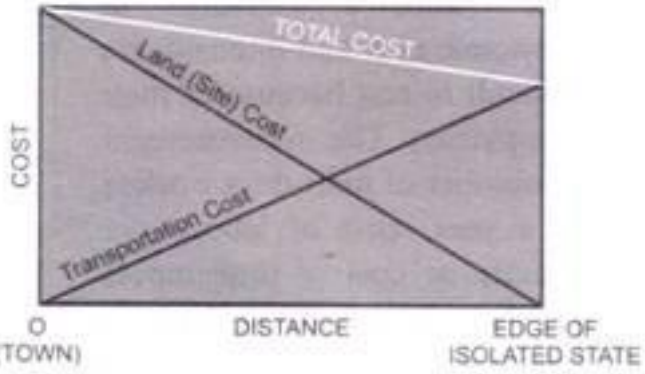
Thus, in the inner zones, financing may be difficult to obtain on a scale necessary to support large farm operations. Relatively less capital intensive land (such as chicken sheds) will therefore, substitute for relatively more expensive land.

The lower value of outer farmland permits the more lavish or extensive use of agricultural space. Because, both the cost of land and farm size change with changing accessibility to the market and aggregate locational rent per farm can be fairly constant across the landscape. For example, the aggregate locational rent for a 50 acre vegetable farm in the inner production ring can be roughly equivalent to a 1,000 acre ranch in the most peripheral zone.

Transportation Costs:
The small variation of per farm aggregate locational rent across the Thunian zones is a result of site cost decreasing at approximately the same rate as transportation costs increase (Figure 14.6).

High land values near the market are in a sense payments for savings in product-movement costs. Moreover, inner-ring farming is distinguished by the production of goods that do not easily withstand long-distance transportation. Highly perishable commodities such as fruits, vegetables, and dairy products share this low transferability.

Figure 14.6
Increasing transportation costs graphed against decreasing land costs in the isolated state



In fact, situations discussed in von Thunen's model were that of early 19th century era. The original Thunian model contained forestry (in its second ring) near to market, because heavy weight wood used for fuel and construction was expensive to transport. By the second half of the 19th century, cheaper rail transportation changed the entire pattern.

Finally, von Thunen incorporated two examples of modifying factors in his classic model. The effect can clearly be seen of a navigable river where transport was speedier and cost only one-tenth as much as on land, together with the effect of smaller city acting as a competing market centre. Even the inclusion of only two modifications produces a much more complex land use pattern.

When all the simplifying assumptions are relaxed, as in reality, a complex land use pattern would be expected. The catalytic factor in von Thunen's model was transport cost and the main assumption was the assumption of an 'isolated state'. In the modified von Thunen model, the influence of fertility, subsidiary town, information, etc., has been incorporated.
The concentric zones of the model get modified under the impact of various physical, socio-economic and cultural factors. The influence of availability of information also substantially modifies the concentric zone of agricultural land use.

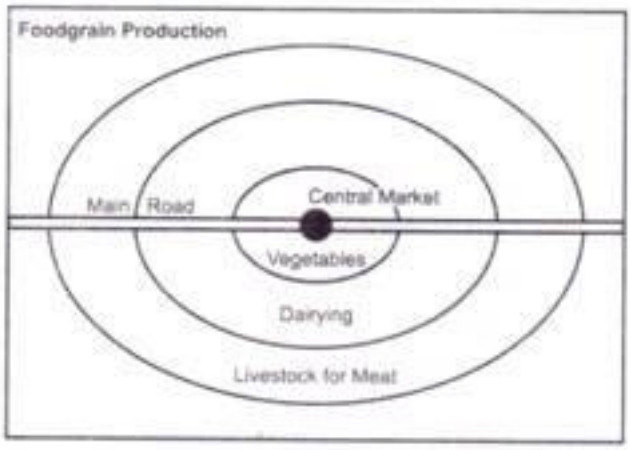
Critical Analysis:
The theory of agricultural location was presented by von Thunen in the early 19th century. Since then, several scholars including geographers have applied it in various parts of the world and have pointed out certain aspects which are not applicable in a way as pointed out by von Thunen.

Many aspects of this model have changed due to development in agricultural system, transportation system and also due to other technological developments. There are also certain regional geo-economic factors which not only direct but determine the pattern of agricultural land use.

The main points raised by scholars regarding this theory are as follows:

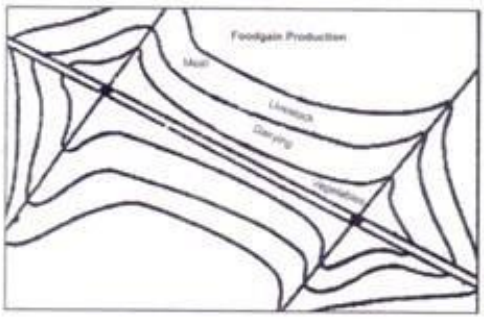
1. The conditions described in this model, i.e., in an isolated state, are hardly available in any region of the world. There are internal variations in climatic and soil conditions. The von Thunen's assumptions that there are no spatial variations in soil types and climate are rare.

Figure 14.7(a)
Pattern of land use



2. It is not necessary that all types of farming systems as described by von Thunen in his theory exist in all the regions. In many European countries location of types of farming in relation to market are no longer in existence.

Figure 14.7(b)
Pattern of land use

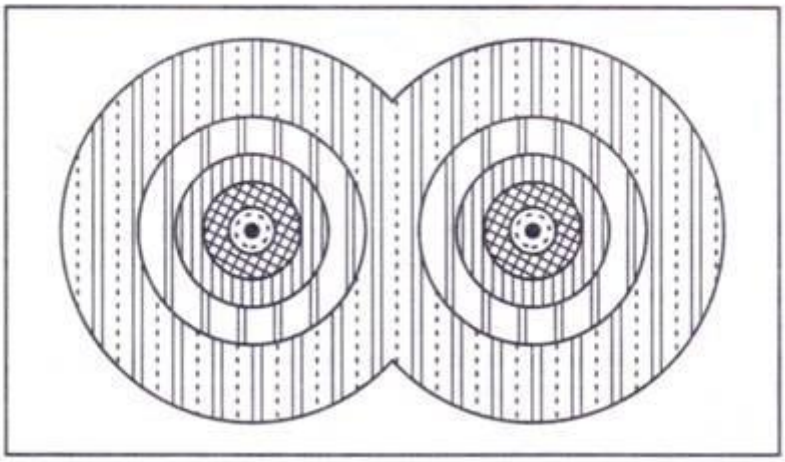


3. The Thunen's measures of economic rent and intensity are difficult to test because of their complexity. The measurement of number of man-days worked in a year, cost of labour per hectare or cost of total inputs per hectare is not uniform in intensive and extensive types of farming. Similar is the case with the measures of intensity.

4. Von Thunen himself has admitted that with the change in location of transportation or market centre the pattern of land use will also change.

Figure 14.8

Location of two market centres and general land use pattern



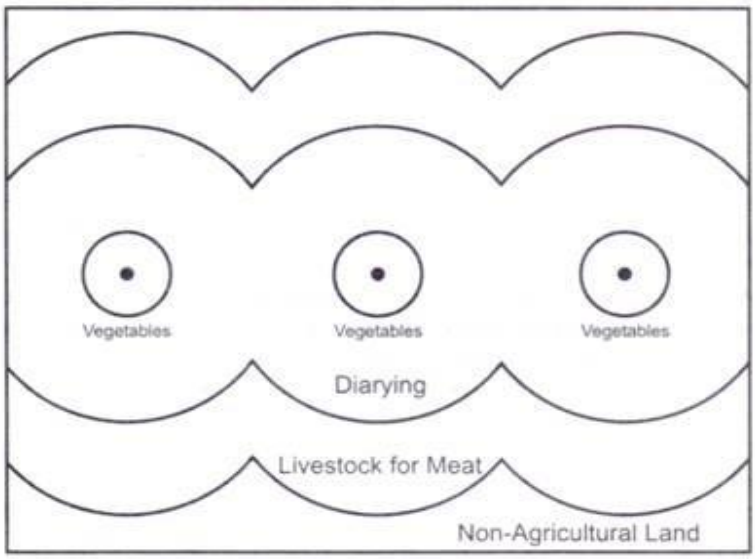
5. The location of transport link and its direction used to change the pattern of agricultural land use is depicted in Figure 14.7 (a) and (b).

6. Similarly, if there are two market centres, the pattern of land use will be according to Figure 14.8.

7. In case of three market centres the land use pattern will emerge like in Figure 14.9.

Figure 14.9

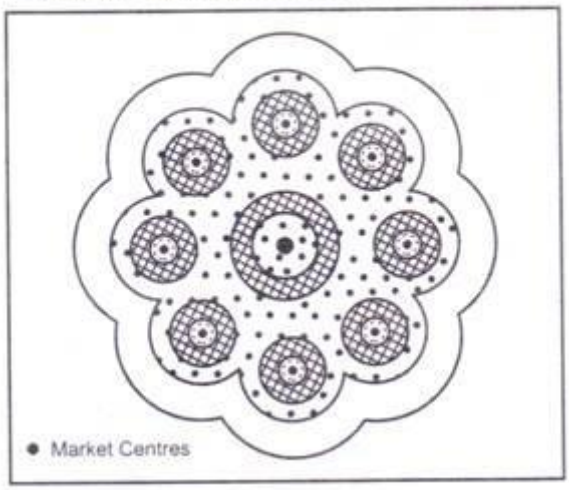
Location of three market centres and land use pattern



8. The situation will be entirely different when there are several market centres in a region (Figure 14.10).

Figure 14.10

Location of several market centres and land use pattern



9. During the past 160 years, there have been sizeable changes in agricultural land use and the economy with which it interacts. The most important of the changes have been improvements in transportation technology; these improvements now permit a space-time convergence of distant places, thereby expanding the scale of possible economic organisation.

In von Thunen's day, heavily loaded horse-drawn carts moved to market at the rate of about 1 mile an hour.

A journey from the wilderness edge to the market centre would require more than two full days, without pauses for rest. Therefore, the truest measure of economic distance in the Thunian model – the absolute mileage beyond which farming was simply too far from the market and could no longer yield locational rent — is in terms of a 50-hour time – distance.

If that 50-hour time – distance radius is constant as the Thunian farming system evolves, what would be its territorial extent today? It may be in thousands of kilometres in case of USA or Russia.

10. Environmental variables, as pointed out in connection with the physical limits model, are only a general locational constraint and play a passive role in shaping the distribution of modern commercial agriculture. In the human-technological context, the employment of artificial irrigation, chemical fertilisers, and the like, allows farmers to overcome most environmental barriers.

11 With changes in transportation conditions, the macro-Thunian system has also been modified since its emergence. A continuous process is involved that works to maximise locational utility. Demand for better access begets technological development, which results in transport innovation and culminates into change in pattern of agricultural land use.

12. Three kinds of economic empirical irregularities can be anticipated to influence the national Thunian pattern: transportation biases, distant concentrations of production that appear inconsistent with his model, and secondary markets.

13. The von Thunen model is also static and deterministic. Today, we know that economic growth and changes in demand will alter the spatial patterns of agricultural systems and land use, which in turn influence the rate of change. It might be possible to postulate a dynamic von Thunen model that could be applied to the changing conditions.

But, the model, despite these possible manipulations, is really static, since, it represents a land use system at one point in time, von Thunen was not concerned with transitional changes, since, he and most of the direct extenders of his model assumed that any change in technology, demand, or transport cost would automatically be accompanied by an adjustment in the land use system.

The Thunian model was developed in the early 19th century, since then, conditions have entirely been changed. Therefore, it is not desirable to accept this model in its original form as observed by many scholars. But this model is still considered to be significant in many ways.

3. Relevance of von Thunen Model:

Almost two hundred years ago, Johann Heinrich von Thunen demonstrated that the geographic pattern of agricultural land use was highly regular and predictable. He first described the pattern of land use within and surrounding his own large estate.

Based upon these descriptions he next formulated a hypothesis to explain the geographic pattern. His hypothesis was that the higher the cost of transportation, the lower the amount a tenant farmer would be willing to pay to use the land.

He expressed his hypothesis using clear and unambiguous mathematics. He reasoned that by placing reasonable numerical values into his mathematical formulation he could closely predict actual land values and land uses.

Among his general conclusions were that land values decline with increasing distance from the market centre; and that land values and land uses change as the various costs of production, transportation, and prices of agricultural commodities change.

Today, the cost and technology of transportation has had a dramatic effect upon the agricultural land use patterns that one would expect by applying von Thunen's logic. Agricultural land use patterns that are evident surrounding market centres are thought to be historic remnants of a bygone era, or the result of administrative institutions whose existence brings about a usage to the historic patterns of land use. At the scale of the continent and the globe we now can observe von Thunen-like market forces and patterns of land use.

The von Thunen logical framework has been important in the evolution of our thinking of how land values and land uses came about in the modern city. Indeed, von Thunen's general theory of land values and land uses has been important in the evolution of thought.

Von Thunen was one of the first to adopt the 'new math's' of his era, calculus, and to apply that mathematics to a problem of the social sciences. He was a pioneer in the use of data for the verification of his normative theory, von Thunen's innovative research method was similar in composition to what we would today call computer simulation. Indeed, much of the approach to social science thought today can be traced back to von Thunen's general method of analysis as its precursor.

His contribution to modern thinking in the social sciences stands unparalleled. His general approach became diffused through its adoption by the leading scholars of the generations that followed him, and by their adoption of his general method in their own work, von Thunen's application of his general method to his own land use theory became generally accessible only in the early 1950s when Edgar S. Dunn published his interpretation in English, von Thunen is no exception among the greats whose reasoning in time is recognised to have contained an error.

The beauty of using mathematics over mere verbalisation to express concepts or hypotheses is that when an error is made it can often be corrected irrefutably. Dunn found an error in von Thunen's treatise and corrected it. It can be recalled from the discussion above that a caveat was to be presented to von Thunen's general theory: once the hierarchical ranking of farming systems was established, such as that listed in Table 14.1, those of lower ranking would always be outbid by those of higher ranking should both happen to be competing for the same land.

Instead, Dunn correctly reasoned that since locational rent changed by a different amount for each agricultural product with distance from the central market, then at some locations a lower ranking farming system could indeed outbid a higher ranking farming system, even though positive rents were bid by the higher ranking farming system.

All over the world, scholars have tested and applied the von Thunen's theory of agricultural location. The greatest importance of the theory lies in this fact that it has given a new direction of thinking, resulting into the modified way of its application.

Von Thunen himself relaxed certain assumptions of his model. First, he introduced a canal along which transportation costs were lower than by horse and wagon. The effect was to create a series of wedge-shaped land use zones along the canal. Second, he introduced a second and smaller market, around which he postulated that a series of separate zones would be created.

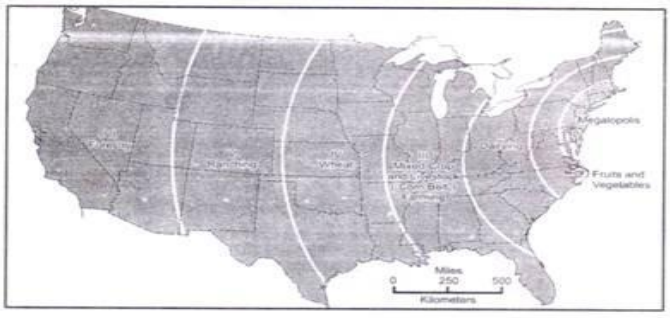
Similarly, we could relax the assumptions by introducing yet another means of transport, such as a railroad or allow variation in the physical environment.

The extent to which these relaxations affect the simple von Thunen model will depend on how they affect the simple conceptual framework put forward earlier.

Some researchers have used von Thunen's model as a general framework for interpreting the spatial framework of the economy. Others have worked on a more direct basis. Thus, von Thunen's model has been applied to the distribution of European agriculture in 1925.

Muller's interpretation of a normative macro-Thunian model for the United States, anchored by a megalopolis, is shown in Figure 14.11. Its utility for explaining the national pattern of agricultural production is demonstrated as follows:

Figure 14.11
The macro-Thunian model for normative United States

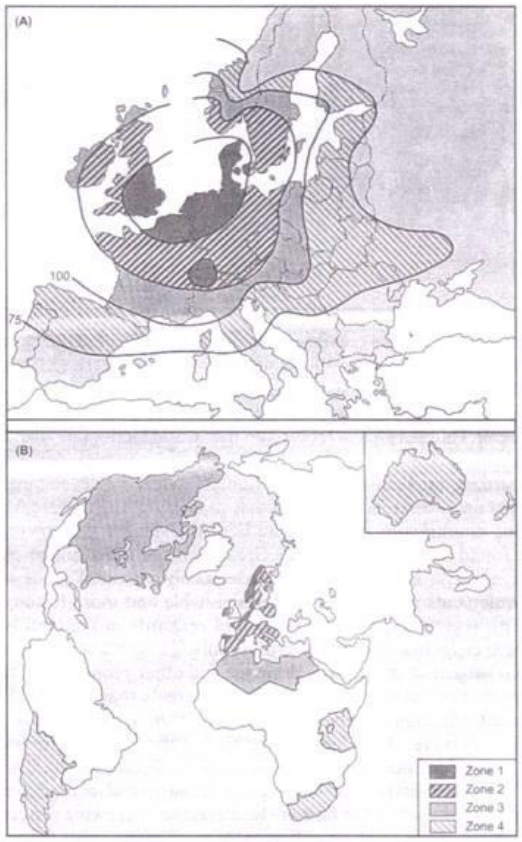


We begin again by relaxing the normative assumptions of the isolated state model, but this time with the realisation that empirical irregularities will be complex in the sophisticated economic space of the present-day continental United States.
However, because we are concerned only with the overall organisational framework of farming regions at a high level of spatial generalisation, the search is not complicated: if macro-Thunian

processes have shaped the production pattern, then empirical response to them will be easily discernible.

The main task is to set up the investigation by cataloguing physical-environmental and economic-empirical irregularities in order to derive an appropriate map of the expected real-world spatial pattern.

Figure 14.12
Large-scale Thunian system, showing macro-geographical patterns of agricultural intensity for Europe and in the world



Empirical evidence of Thunian spatial systems is also widespread beyond the United States. Figure 14.12-A shows the macro-scale pattern of agricultural intensity for the European continent, which is sharply focused on the conurbation ringing the southern margin of the North Sea, from London and Paris to Copenhagen. By combining the American and European patterns and proceeding to a yet greater level of spatial aggregation, one can even perceive (in Figure 14.12-B) a global-scale Thunian system focused on the "world metropolis" that borders the North Atlantic Ocean.

Regarding application of the Thunian model in developing countries M.H. Hussain (2010) has observed that in many of the underdeveloped and developing countries of the world, in both the villages and towns, cropping belts are found. In the villages of the Great Plains of India similar patterns can be observed.

The highly fertile and adequately manured lands around the village settlements are devoted to the perishable and more fertility requiring crops, e.g., vegetables, potatoes, oats and orchards in the land lying in the middle belt; crops like rice, wheat, barley, pulses, sugarcane, gram, maize, etc., are grown subject to the texture, drainage and other properties of the soils.

In the outer fringes fodder crops and inferior cereals (bajra, millets) are sown. Alter the introduction of tube well irrigation in the great plains of India, this pattern has, however, been largely modified as the farmers with better inputs are able to produce perishable crops even in the distant fields from the settlements.

The consolidation of holdings in India has also modified the crop intensity rings as each of the farmers is interested in growing the commodities tor his family consumption as well as some marketable crops for earning cash to clear his arrears of land revenue and irrigation charges and to purchase the articles from the market for his family consumption.

In some of the developing countries like India, Pakistan and Mexico the introduction of HYV (high yielding variety) has disturbed the application of von Thunen model.

The fast development of means of transportation has made it possible to transport the perishable goods at long distances in short period of time. Thus, the model advocated by von Thunen is no longer operative in its original form.

Thunian distance relationships can also be discerned at the national level in smaller developed countries such as Uruguay. Allowing for that nation's empirical irregularities, Ernst Griffin discovered that the expected Thunian pattern accorded nicely with the actual intensity of agricultural land use. Continuing down the level of generalisation continuum from meso scale to micro scale, Thunian influences are often observed to shape farming at the local level. Moreover, local agricultural productions in the less developed world, where technological conditions are more comparable to those of von Thunen s days, May even exhibit spatial structures reminiscent of von Thunen's landscape.

Ronald Horvath found just such a pattern for the area surrounding Addis Ababa, Ethiopia. Of particular significance was his discovery of an expanding transportation-oriented eucalyptus forestry zone in its classical inner position.