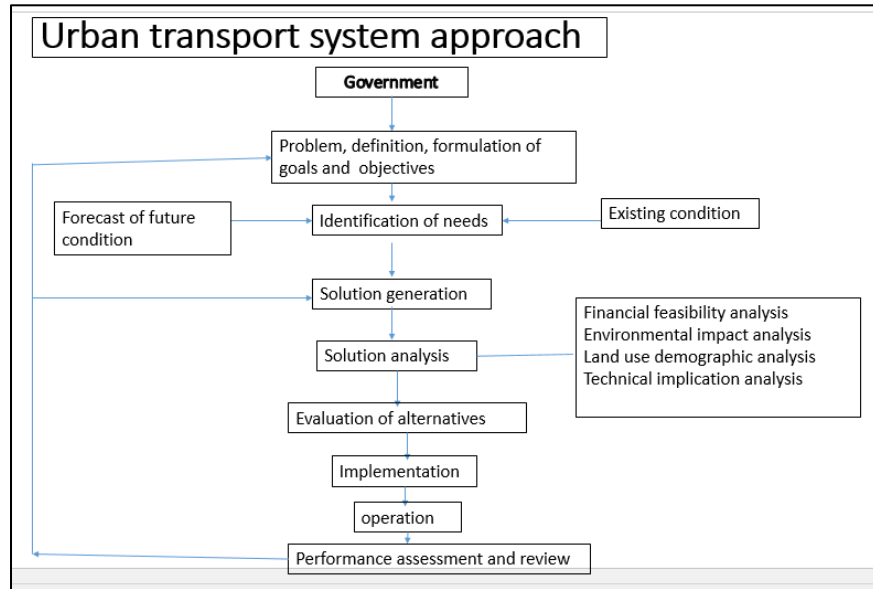# Course code 15CV751 Course Name Urban Transportation Planning

End semester question paper Sem VII 2019-20(Dec)

1.0 (a) Define system approach. Explain with flow diagram system approach to transport planning. (8 Marks)

Problem definition /objectives:

To develop a transport system that caters to all sections of society. To develop a transportation system that is primarily sustainable in nature. To minimize system costs.

For Example: Goal: Reducing travel time of people between Mysore and Bangalore

Objectives: To maximize the accessibility to activities by public transport

To improve connectivity

To improve state economy

Identification of need

To know the Inventory of existing state of system and a forecast of future condition (demand).

Solution Generation and Analysis

Based on problem definition, transportation planners have to identify various alternatives and make choice about various modes like roadway, railway, waterways or airways.The technological aspect - such as high speed train, raised monorails underground transit system, driver information system.Traffic

engineering aspect - such as changing or improving flow pattern by making certain road one way, reducing delay on arterial street by improving signalization or grade separated intersection, disallowing certain movement at intersection. Regulatory aspect - such as reserving land for only high occupancy vehicles, disallowing high polluting vehicles, imposing speed limit.

For example, to travel from Kanpur to Delhi following alternatives can be worked out.

- Facilitate train leaving Kanpur at 6:30 am and reaching Delhi at 10:30 am and again leaving Delhi at 5:30pm and reaching Kanpur at 10:30pm.

- Developing existing airport at Kanpur

- Improve the existing road facilities providing operating speed 120 kmph.

Evaluation of possible alternatives

Compare the various alternatives and select the best plan based on estimated cost and benefits.

Implementation and assessment

Once the best plan is selected and becomes operational, the performance is assessed and monitored regularly for further improvement. Based on the performance assessment it may be necessary to go back to certain stages of planning and repeat the process (see flowchart).

1 (b). List merits and demerits of mass transit system (8 Marks)

Merits of mass transit system:

➢ Generates low travel times and travel costs for people and goods
➢ Permits equal access to urban life opportunities (social services, education,
➢ Health, recreation)
➢ Provides adequate support to desired form, size, and density of the city-region
➢ contributes to the improvement of air quality and urban environment

Demerits:

➢ Mass Transit system is economically feasible only in areas that have relatively large populations.
➢ As the number of inhabitants per square mile decreases, the efficiency of a mass transportation system also decreases.
➢ Mass transit systems are also very expensive to build and to operate. This factor becomes more important when cities decide to install mass transit systems long after development has already taken place and disruption of existing structures is a serious problem.
➢ People complain about mass transportation systems also because they can be crowded, uncomfortable, dirty, and unreliable.
➢ With limited budgets, mass transit systems are seldom able to maintain equipment and schedules to the extent that riders can rightly demand.
➢ Mass transportation systems are simply not as convenient as the automobile. A person can step into her or his car and drive virtually anywhere with a minimum of inconvenience. No mass transportation system can approach this level of ease.

2a. What is mass transit system? Explain Para-transit transport and Mass and Rapid transit system. (8 Marks)

Mass Transit, also referred to as public transit, is a passenger transportation service, usually local in scope that is available to any person who pays a prescribed fare ".Mass Transit System is designed to move large numbers of people at one time.

Paratransit is normally expected to fulfill a need that neither public transport nor personal vehicles are able to fulfill. They normally cater to a category of occasional trips such as trips to airports or rail stations with excessive baggage, or emergency trips that have to be undertaken immediately and it is not possible to wait for public transport. Paratransit in US- for special transportation services for people with disabilities. Most paratransit vehicles are equipped with wheelchair lifts or ramps to facilitate access.

MRTS is Important for growth of a country's economy. Cities need and benefit from public transportation services which offer greater mobility for the entire population than people in rural areas can enjoy. Absence of well-developed MRTS leads to dependence on private transport, resulting in severe congestion and traffic jams on the roads. It also leads to severe environment degradation due to excessive emissions and noise from the traffic.

2b. Write a note on BRTS and metro rails. (8 Marks)

BRTS is reliable, convenient and faster than regular bus services.

With the right features, BRT is able to avoid the causes of delay that typically slow regular bus services, like being stuck in traffic and queuing to pay on board.

There is a separate lane exclusively dedicated to BRTS. The median and the inner most lane or the left most lane can be dedicated to the bus. BRTS is a relatively inexpensive mode and can be implemented more widely. In case of cost consideration for construction of BRTS approximately about 5-20 crores per km whereas in metro rails about 125 to 220 crores per km. Advanced Traveler Information System (ATIS) and Automatic tracking of buses In BRTS commuters can only cross at the zebra crossings. Fatality rates will come down drastically.

Salient features of BRTS are

Right of way(R/W) –strip of land on which transit vehicle operates.
Bus alignment
Off board fare collection
Intersection treatment
Platform level boarding
Clearly designated stops
Low floor and multiple door for easy access
Services offered throughout the day regularly
Movement of buses along the line, well organized and controlled by various ITS measures guaranteeing high reliability
Four lane roadways along most sections of a line.

Metro rails

Consists of large four-axle electrically powered rail vehicles that operate in trains of upto 10 cars on fully controlled A row with full signal control.
This ensures high speed, reliability, capacity, rapid boarding
In case of driver's error or inability the train stops automatically.
Some automated operation without driver
Line haul transport
Several doors on either side without fare collection delay
Requires higher investment cost than any other transit mode.

3a. What are the various surveys to be carried out in transportation planning process. Explain. (8 Marks)

1) Home interview survey
2) Commercial vehicle survey
3) Taxi surveys
4) Roadside interview surveys
5) Post card questionnaire surveys
6) Registration number surveys
7) Tag surveys
8) Public transport surveys

1) Home interview survey- Most Reliable type of survey for collection of origin and destination data.

Done to know the travel pattern of household and the general characteristics of house hold influencing trip making. The information on travel pattern includes number of trip made, purpose of trip, origin and destination. The information on Household characteristics include age, sex, vehicle ownership, number of drivers, family income, and type of dwelling unit. Based on this information it is possible to relate the amount of travel to household and zonal characteristics and develop equation for trip generation rates.

Since wide variety of data has to be collected, it involves high cost. It is necessary to standardize the survey procedure. Such procedure is done by Bureau of public road manual which set guidelines for how interviews to be conducted and information to be collected. It is impractical to interview all the residents of the study area. Since travel pattern tend to be uniform in a particular zone, it is sufficient to employ the sampling procedure.

2) Commercial vehicle survey

Roadside interview survey is one of the methods of carrying out a screen line or cordon line survey.
It can be directly done either by directly interviewing drivers of the vehicles at selected survey points or by issuing prepaid post cards containing questionnaire.
The survey points are selected along the junction of the cordon-line or screen line with roads. Cordons may be in the form of circular rings, rectangular grids or radial lines.

3) Registration number surveys

Registration number plate survey consists of noting the registration number of vehicles entering or leaving at an area at survey points located on the cordon line. By matching the registration numbers of vehicles at the points of entry and exit from the area, one is enabled to identify 2 points on the paths of the vehicle. This type of survey is mostly conducted to understand the pattern of vehicles moving from different states and RTO zones. This survey also enables to estimate the number of local vehicles plying, which becomes the input for analyzing a financial Model and to arrive at feasibility of the road project.

The results of this analysis will form inputs for forecasting tollable traffic and toll revenue, deciding tolling strategy, developing capacity augmentation proposals.

4) Taxi surveys

Large urban areas will have sizable amount of travel by taxis. Separate taxi survey is necessary. Issuing questionnaire to taxi drivers

5) Post card questionnaire

Handed over to sample of drivers, request for completing the information and return by post.

Possible to get good amount of information from this method. Avoids delay caused to drivers by direct road side interview. Response may not be good-disadvantage. Not recommended in developing countries. Simpler and cheaper method. Regarding selection of survey points, it is similar to road side interview. Good response if well planned, publicized- yield more than 50% result.

6) Tag-on survey

At each point where the roads cross the cordon line, vehicles are stopped and a tag is affixed, usually at a window screen wiper.

The tags for different survey stations have different shapes and color to identify survey station. The vehicles are stopped again at the exit points where the tags are removed. The time of entering and leaving the area may be marked to know the journey time. Sampling (every 2nd, 5th…. Vehicle) will make it easier to determine expansion factor. An observer may count the vehicles. The survey can be divided into 15 or30 min interval. Simple method. Less error. This method can be used to cover vehicles that enter the area but are parked during rest of the study period. Parking areas are surveyed at the end of the study period and tags on parked vehicles are collected.

7   Public transport survey

Number of bus passengers passing through an external cordon, the survey can be direct interview with the passengers or issuing postcard questionnaires. Direct interview result in large delays and requires large number of interviews. In order to minimize the delays, the interviewer may carry-out the interviews when vehicle is in motion. Prepaid questionnaire may result in poor response. Similarly rail survey can be done

8) Roadside

Roadside interview survey is one of the methods of carrying out a screen line or cordon line survey. It can be directly done either by directly interviewing drivers of the vehicles at selected survey points or by issuing prepaid post cards containing questionnaire.

The survey points are selected along the junction of the cordon-line or screen line with roads. Cordons may be in the form of circular rings, rectangular grids or radial lines.
For small town with less population say less than 5000 single circular cordon at the periphery of the town should be enough.

3b. List and briefly explain the types of inventory of transport facilities. (8 marks)

The inventory of present transport facilities should be undertaken to know the deficiencies in the existing system and the extent to which they need to be improved.

The inventory consists of

- ➢ Inventory of streets forming the transport network
- ➢ Traffic volume, peak and off-peak
- ➢ Studies on travel time by different modes.
- ➢ Inventory of public transport buses
- ➢ Inventory of rail transport facilities
- ➢ Parking inventory
- ➢ Accident data

Inventory of streets:

An understanding of the extent and quality of road network is important to formulate plans for future.

The following items should be covered in inventory.

- ➢ Classification of road system
- ➢ Length, cross sectional dimensions
- ➢ type and condition of road surface
- ➢ capacity
- ➢ intersections
- ➢ control devices
- ➢ street furniture

Traffic volume

Data about traffic volume is needed to check the survey data collected from home interview and cordon surveys. The variation of traffic volume over different time, different days of the week, different months is also needed.

Travel time studies

An estimate of travel time between different zones by various modes is necessary for transportation planning. Travel times are measured for peak hour and off peak hour conditions.

Inventory of public transport buses

Information about total number of buses, capacity, schedule, routes, operating speeds, terminals, number of passengers carried, economic condition of public transport system and fare structure.

Inventory of rail transport facilities

Should include

> ➢ Length, capacity
> ➢ Schedule
> ➢ Operating speeds
> ➢ Stations
> ➢ Number of passengers carried
> ➢ Fare structure
> ➢ Economic picture of rail transport undertaking

Parking inventory

Information on

> ➢ Existing on-street and off-street parking facilities
> ➢ Parking demand
> ➢ Utilization of existing facilities
> ➢ System used for charging

Accident data

Past accident data will help to understand the nature and hazards in the present system and the need to improve the situation

4a. Write a note on study area and zoning. List the factors affecting on zoning. (8 Marks)

Dividing the study area into smaller areas is known as zones. The purpose of zoning is to facilitate the quantification of land use and economic factors which influence travel pattern. The data collected from individual houses should be aggregated into zones to understand the average characteristics of individual houses. Zoning helps in geographically associating the origins and destination of travel. Zones within study area are internal zones and those outside the study area are called external zones.

When the study area is large, it is divided into sectors. Sectors are divided into zones and zones are divided into subzones.

Coding of zones

Divide the study area into 9 sectors. The CBD is designated as 0, remaining 8 are divided into 1 to 8 in a clockwise direction. The prefix 9 is reserved for external zones.

Each sector is divided into 10 zones. 0 to 9.

Thus, a system of 3 digits denotes a subzone. For example, a sub zone bearing the number 481 belongs to sector 4,zone 8 and subzone 1.

The following points should be kept in view while dividing the area into zones.

1.Land use is the important factor while establishing zones. When the origin and destination zones reflect the land-use properly, the traffic generated within the zones can be predicted, measured and quantified accurately. Land use can be classified as : Residential, commercial, industrial, institutional, recreational and open space etc.

2. The zones should have homogenous land use to accurately reflect the trip making behavior.
3. Anticipated changes in the land use should be considered when sub dividing the study area into zones.
4. The data should not be too large to cause error in the data. At the same time it should not be too small to cause any difficulty in handling and analyzing the data.
5. The zone should have a regular geometry form for easily determining the centroid which represent origin and destination of travel.
6. Sectors should represent the catchment of trips generated on a primary route.
7. Zones should be compatible with screen lines and cordon line.
8. Zone boundaries shall be preferably be water sheds of trip making.
9. Natural or physical barriers such as canals, rivers etc. can form convenient zone boundaries.
10. In addition to external cordon lines, there may be a number of internal cordon lines arranged as concentric rings to check the accuracy of survey data.
11. Physical and natural barriers like rivers, railway lines, canals can be considered as screen lines.


4b. Define external cordon line. Explain various factors considered in selection of cordon line.(8 Marks)

Transportation planning can be at different levels- national, regional, urban level. For planning at urban level the study area should include all suburban areas-containing existing and potential built up areas of the city. The imaginary line representing boundary of study area is known as external cordon. The area inside external cordon is surveyed in detail.

The land use pattern and economic activities are studied in detail. Detailed surveys like, home interview are conducted in study area to determine the travel characteristics.

Factors to be considered during the selection of external cordon line.

> External cordon line should encompass all areas which are already built-up and areas likely to be developed during the period of study.
> The external cordon line should contain all areas of systematic daily life of the people oriented towards the city center and should in effect be the commuter shed.
> The external cordon line should be continuous and uniform so that movements cross the line only once. The line should intersect roads where it is safe and convenient to carry out traffic surveys.
> It should be compatible with previous studies of area and studies planned for future.
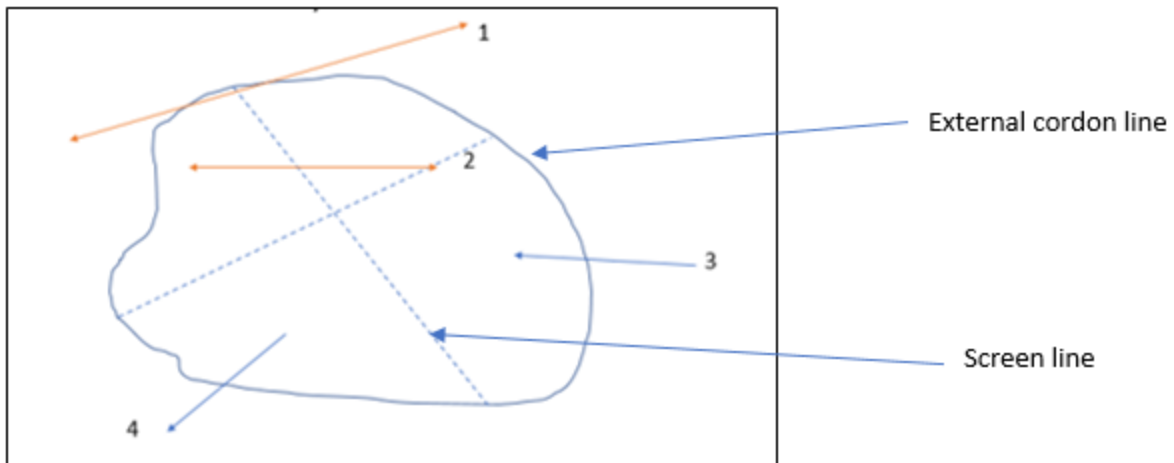
Study area showing basic movements in transportation survey

In the above figure, 1-external and external movement; 2-internal to internal; 3- external to internal

4-Internal to external

5a.What is category analysis and what are the advantages and disadvantages of category analysis?(8 Marks)

The method is based on estimating the response (e.g. the number of trip productions per household for a given purpose) as a function of household attributes.

This model is based on the assumption that the number of trips generated by similar households is the same. The method finds these rates empirically and for this it needs a large amount of data

As an example of this model

Let x be a zone.

There are $P^x{}_y$ households in category y and

if Q_k is the average rate of trip generation per household in category y

then, the relation for the trip generated by zone x, T_x is given by

$$T_x = \sum P^x{}_y * Q_k$$

Advantages

i) Cross-classification groupings are independent of the zone system of the study area.

ii. No prior assumptions about the shape of the relationship are required (i.e. they do not even have to be monotonic, let alone linear.)

iii. Relationships can differ in form from class to class (e.g. The effects in changes in the household size for one or two car owning households may be different).

Disadvantages

- It is difficult to test the statistical significance of various explanatory variables.
- The technique makes use of studies in the past made elsewhere, with broad corrections.
- Large samples are needed to assign trip rate to any one category
- New variables cannot be introduced at a future date
- In the analysis it is assumed that income and car ownership increase in future. The categories of higher income and higher car ownership are however the ones which are least represented in the base year. Moreover, they are the ones most likely to be used for future estimates of trip generation.

6a.What is trip distribution. Briefly explain average factor method and mention the disadvantages of the method.

The decision to travel for a given purpose is called trip generation. These generated trips from each zone is then distributed to all other zones based on the choice of destination. This is called trip distribution which forms the second stage of travel demand modeling.

This method attempts to take into account the varying rates of growth of trip-making which can be expected in the differing zones of a survey area. The average growth factor used is that which refers to the origin end and the destination end of the trip and is obtained for each zone as in the constant factor method. Expressed mathematically, this can be stated to be

$T_{ij} = t_{ij} \{(E_j + E_i)/2\}$
Where $E_i = P_i/p_i$ and $E_j = A_j/a_j$
T_{ij} = future trips
t_{ij} = present trips
P_i = future production of zone i,
p_i = present production of zone i,
A_j = future attraction of zone j
a_j = present attraction of zone j.
At the completion of the process attractions and productions will not agree with the future estimates and the procedure must be iterated using as new values for E_i and E_j the factors P_i/p'_i and A_j/a'_j where p'_i and a'_j are the total productions and attractions of zones i and j respectively, obtained from the first distribution of trips.

The process is iterated using successive values of p'_i and a'_j until the growth factor approaches unity and the successive values of t'_{ij} and t_{ij} are within 1 to 5 percent depending upon the accuracy required in the trip distribution.

Disadvantages

The average factor method suffers from many of the disadvantages of the constant factor method, and in addition if a large number of iterations are required then the accuracy of the resulting trip matrix may be questioned.

7a) What are opportunity model? Explain the types of opportunity models.

Opportunity models are based on the statistical theory of probability

The two well-known models are:

1. The intervening opportunities models;

2. The competing opportunities model.

Intervening opportunities model,

- It is assumed that the trip interchange between and origin and a destination zone is equal to the total trips emanating from the origin zone multiplied by the probability that each trip will find and acceptable terminal at the destination.
- The probability that a destination will be acceptable is determined by two zonal characteristics: the size of the destination
- Order of closeness to origin i, upto and including j.

$$T_{i-j} = Q_i \left(e^{-LB} \cdot_{-e}{}^{-LA} \right)$$

Where,
T_{i-j} = Predicted number of trips from zone i to j
Q_i = Total number of trips originating in zone i
L = Probability density of destination acceptability at the point of consideration
A = Number of origins between i and j when arranged in order of closeness
B = Number of destinations between i and j when arranged in order of closeness

In the competing opportunities model, the adjusted probability of a trip ending in a zone is the product of two independent probabilities,, the probability of a trip being attracted to a zone and the probability of a trip finding a destination in that zone.

$$t_{ij} = O_i \left[\frac{A_j / A_x}{\sum_i A_j / A_x} \right]$$

Aj = Number of destination opportunities in zone-j.

A_x = Total number of destination from origin zone-i within the time band containing the zone of destination.

7b) Define modal split. Explain in brief the factors affecting modal split.

This is the third stage in travel demand modeling.

Modal split represents a method used to determine the number of trips by mode or the share of different modes of transport and pedestrian trips in the total transport needs.

The factors may be listed under three groups:

- <u>Characteristics of the trip maker</u>

(a) car availability and/or ownership;

(b) possession of a driving license;

(c) household structure (young couple, couple with children, retired people etc.);

(d) income;

e) decisions made elsewhere, for example the need to use a car at work, take children to school, etc;

(f) Residential density.

- <u>Characteristics of the journey:</u>

(a) The trip purpose; for example, the journey to work is normally easier to undertake by public transport than other journeys because of its regularity and the adjustment possible in the long run;

(b) Time of the day when the journey is undertaken.

(c) Late trips are more diult to accommodate by public transport.

- <u>Characteristics of the transport facility</u>: both qualitative and quantitative

Quantitative factors are:

(a) relative travel time: in-vehicle, waiting and walking times by each mode;

(b) relative monetary costs (fares, fuel and direct costs);

(c) availability and cost of parking

Qualitative factors which are less easy to measure are:

(a) comfort and convenience

(b) reliability and regularity

(c) protection, security

9. What are the applications of traffic assignment?

- To determine the deficiency in the present system by assigning future trips to the existing system
- To evaluate the effect of limited improvement and additions to the existing system by assigning estimated future trips to the improved network
- To develop construction priorities by assigning estimated future trips for intermediate years to the transportation system proposed for those years
- To test alternative transportation system proposals by systematic procedure
- To provide design hour traffic volume on highway and turning movements at junctions

(5b) y = trips generated in hundreds
x = population in zone in thousands

___/___/_____

y	x	$x-\bar{x}$	$y-\bar{y}$	$(x-\bar{x})^2$	$(y-\bar{y})^2$	$(x-\bar{x})(y-\bar{y})$
12	26	-0.875	-1	0.765	1	0.875
11	28	1.125	-2	1.265	4	-2.25
17	31	4.125	4	17.01	16	16.5
15	33	6.125	+2	37.52	4	12.25
12	22	-4.875	-1	23.765	1	4.875
15	30	3.125	2	9.765	4	6.25
9	20	-6.875	-4	47.265	16	27.5
13	25	-1.875	0.	3.515	0	0
				140.87		66

$\bar{x} = 26.875$

$\bar{y} = 13$

$y = a + bx$

$a = \bar{y} - b\bar{x}$

$$b = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sum(x-\bar{x})^2}$$

$$= \frac{66}{140.87} = 0.468$$

$= 13 - 0.468 \times 26.875$

$= 0.4225$

$$\boxed{y = 0.4225 + 0.468\,x}$$

If pop is 40 (thous)

$y = 0.4225 + 0.468 \times 40$

$= 19.1$ say 19

Answer = Total trips = 1900

$y = 0.4225 + 0.468\,x$

0.4225

$y \uparrow$ $x \rightarrow$
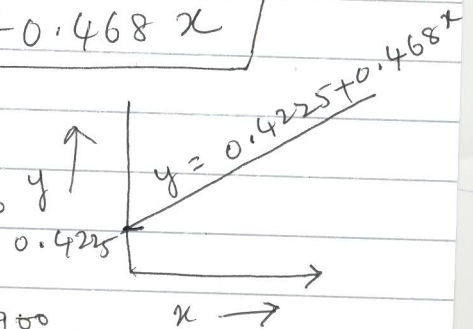
6(c)

	1	2	3	O_i
1	20	30	28	78
2	36	32	24	92
3	22	34	26	82
d_j	88	96	78	252

Solution

multiplying each cell by GF 1.3,

	1	2	3	O_i
1	26	39	36.4	101.4
2	46.8	41.6	31.2	119.6
3	28.6	44.2	33.8	106.2
D_j	101.4	124.8	101.4	327.6

uniform Growth factor method

(6) b)

O\D	1	2	3	Ti
1	60	100	200	360
2	100	20	300	1260
3	200	300	20	3120

Solution

O\D	1	2	3	t_{i-j}	T_{i-j}
1	60	100	200	360	360
2	100	20	300	420	1260
3	200	300	20	520	3120
Total				1300	4740

$$T_{i-j} = \underline{t_{i-j} \ E}$$

$$E = \frac{T_{i-j}}{t_{i-j}} = \frac{4740}{1300} = 3.646$$

$$T_{1-1} = t_{1-1} \times E = 60 \times 3.646 = 218$$

Similarly calculate other values.

O\D	1	2	3	t_{i-j}	T_{i-j}
1	218	365	729	1313	360
2	365	73	1094	1532	1260
3	729	1094	73	1896	3120
				4740	4740

(8)

A	B	C	D
1000	2250	1750	3200

No. of jobs in Industrial estate X = 3700

  " " " " " Y = 4500

Journey time in <u>min</u> from home to work

Zones	A	B	C	D
X	15	15	10	15
Y	20	10	10	20

Calculate & Tabulate interzonal trips.

$$T_{i-j} = P_i \frac{\dfrac{A_j}{(d_{i-j})^2}}{\sum \dfrac{A_i}{(d_{i-j})^2}}$$

$$T_{A-X} = \frac{1000 \times \dfrac{3700}{15^2}}{\dfrac{3700}{15^2} + \dfrac{4500}{20^2}} = 594$$

$$T_{A-Y} = \frac{1000 \times \dfrac{4500}{20^2}}{\dfrac{3700}{15^2} + \dfrac{4500}{20^2}} = 406$$

$$T_{B-X} = \frac{2250 \times \dfrac{3700}{15^2}}{\dfrac{3700}{15^2} + \dfrac{4500}{10^2}} = 602$$

$$T_{B-Y} = \cfrac{2250 \times \cfrac{4500}{10^2}}{\cfrac{3700}{15^2} + \cfrac{4500}{10^2}} = 1648$$

$$T_{C-+} = \cfrac{1750 \times \cfrac{3700}{10^2}}{\cfrac{3700}{10^2} + \cfrac{4500}{10^2}} = 790$$

$$T_{C-Y} = \cfrac{1750 \times \cfrac{4500}{10^2}}{3700/10^2 + 4500/10^2} = 960$$

$$T_{D-X} = \cfrac{3200 \times \cfrac{3700}{15^2}}{\cfrac{3700}{15^2} + \cfrac{4500}{20^2}} = 1900$$

$$T_{D-Y} = \cfrac{3200 \times \cfrac{4500}{20^2}}{3700/15^2 + 4500/20^2} = 1300$$

	X	Y	T_{i-j} for origin zone A,B,C,D Total production
A	594	406	1000
B	602	1648	2250
C	790	960	1750
D	1900	1300	3200
C_j Calculated attraction	3886	4314	8200
A_j Predicted attraction	3700	4500	8200

It is seen from the above table that the total predicted and calculated attractions don't tally.

Adjusted attraction for zone $X = \dfrac{3700 \times 3700}{3886} = 3523$

"   "   "   " $Y = \dfrac{4500 \times 4500}{4314} = 4694$

Recalculating T_{i-j}

$$T_{A-X} = \cfrac{1000 \times \dfrac{3523}{15^2}}{\dfrac{3523}{15^2} + \dfrac{4694}{20^2}} = 572$$

$$T_{AY} = \cfrac{1000 \times \dfrac{4694}{20^2}}{\dfrac{3523}{15^2} + \dfrac{4694}{20^2}} = 429$$

Similarly

$$T_{B-X} = \cfrac{2250 \times \dfrac{3523}{15^2}}{\dfrac{3523}{15^2} + \dfrac{4694}{10^2}} = 563$$

$$T_{B-Y} = \cfrac{2250 \times \dfrac{4694}{10^2}}{\dfrac{3523}{15^2} + \dfrac{4694}{10^2}} = 1687$$

$$T_{C-X} = \cfrac{1750 \times \dfrac{3523}{10^2}}{\dfrac{3523}{10^2} + \dfrac{4694}{10^2}} = 750$$

Similarly $T_{C-Y} = 999$; $T_{D-X} = 1829$; $T_{D-Y} = 1371$

The results are tabulated below

	X	Y	T_{i-j} (Total Production)
A	572	429	1000
B	563	1687	2250
C	750	999	1750
D	1829	1371	3200
Total calculated attraction C_j	3714	4486	8200
Total predicted attraction A_j	3700	4500	8200