Identification of transportation movement patterns based on the home base approach: A case study of Lembang District, West Bandung Regency

T Judiantono¹ and M I P Susanto¹

¹Department of Urban and Regional Planning, Universitas Islam Bandung, Jl. Tamansari No. 1, Bandung, Indonesia.

Corresponding author’s email: tjudiantono@yahoo.com

Abstract. Transportation planning generally uses a traffic model approach. The disadvantage of the traffic model is that it does not consider the movements to and from an area by the community. Therefore, this study uses a home base approach to study the real movement patterns in Lembang District, West Bandung Regency, West Java Province. Lembang District is a geographically strategic region and a center of agriculture and tourism in West Java Province. It is also located adjacent to Bandung City. These characteristics potentially cause a high frequency of transportation movements in the district of Lembang. The study found that the home base approach can accurately show the real movement patterns that the traffic model approach might not uncover. Moreover, the transportation movements of the community of Lembang District are mostly directed to Lembang Village and Bandung City. Furthermore, the findings of this study might differ if the home base approach would use proportional sampling.

1. Introduction

The four-step transportation model is widely used by transportation planners. This model is based on various methodologies that have its own advantages and disadvantages. The data for trip generation is at the core of transportation planning. As such, planners must use the right methodology to create a good database that can support sustainable transportation planning. The home base approach is one of the methodologies in transportation planning that looks at the disaggregate attributes to uncover the real transportation movement patterns of local communities. This study applies the home base approach to a case study of Lembang District, West Bandung Regency.

Lembang District is a vast district that consists of sixteen villages. It is of major significance for the economy of West Java and this economic significance affects the movements of people in and out of this district. Lembang District has been a major local and international tourist destination, and for the past years, it has been a key agronomical area. The district is the main agricultural area in West Java and its land use is dominated by agriculture and plantations. These characteristics affect the overall pattern of movements in the region. Septian [1] stated that the agriculture sector involves the large-scale distribution of several commodities. Thus, agricultural movements will certainly contribute to the overall pattern of community movements.

Lembang District also functions as a major tourist area because of its variety of tourist destinations. Annesya [2] conducted a seizure analysis in 2017 and found that the highest rate of trip generation
towards the tourist destinations in Lembang originated from the Bodebekkarpur (Bogor-Depok-Bekasi-Karawang-Purwakarta) region. This indicates that Lembang District has the potential to attract large-scale transportation movements originating outside its area. Consequently, this inflow of tourists has the potential to impact the internal movements in Lembang District. Considering these dynamics, the linkages among agricultural movements, tourism, and the daily movements of the local community need to be assessed more closely. Therefore, this paper studies the daily movements of the community, as a continuation of the two studies mentioned earlier [1, 2]. This paper aims to provide an understanding of the local movements by the local communities, despite Lembang’s status as a center of agriculture and tourism.

2. Theory
This section will discuss the theory that forms the foundation of the analysis. It addresses the transportation concepts of trip generation, trip distribution, origin and destination matrix, and zone.

2.1. Trip generation
Trip generation is a stage of modeling that estimates the number of movements originating from a zone or land use and the number of movements towards the land use or zone. Traffic movement is a function of land use that produces traffic movements. The output of this calculation is in the form of the number of vehicles, people, or transportation of goods per unit of time, for example, vehicles/hours. We can easily count the number of people or vehicles entering or exiting a certain area in one day (or one hour) to get data on the traffic movements that occur [3].

2.2. Trip distribution
Trip Distribution is closely related to the relationship between land use, transportation networks, and traffic flows. The spatial pattern of traffic flows is a function of land use and transportation network systems [3].

Figure 1. The desire lines in Bandung City.

Figure 1 shows the spatial pattern of vehicle movements in the city of Bandung. The line thickness indicates the number of vehicle flows and the line length indicates the distance between the connected zones. Figure 1 describes the desire line because it shows the direction of the traffic flows but it does not indicate the actual routes that are used.
2.3. Origin and Destination Matrix (ODM)

The ODM is a two-dimensional matrix that contains information about the magnitude of movement between locations (zones) in an area. The row denotes the origin zone and the column contains the destination zone. As such, the matrix cell expresses the amount of flow from the origin zone to the destination zone. Table 1 shows the general form of the ODM. Here, T[|id|] states the number of movements of a vehicle, passenger, or item that moves from the zone of origin [i] to the destination zone[d] during a certain time interval. Movement patterns can be generated if an ODM is applied to a transportation network system. By studying the movement patterns that occur, one can identify problems that arise to come up with immediate solutions. The ODM can provide a detailed indication of the need for movement so that ODMs play a very important role in various transportation planning and management studies.

Table 1. General form of the origin and destination matrix.

| Zone | 1   | 2   | 3   | ... | N   | O_i |
|------|-----|-----|-----|-----|-----|-----|
| 1    | T_{11}| T_{12}| T_{13}| ... | T_{1N}| O_1 |
| 2    | T_{21}| T_{22}| T_{23}| ... | T_{2N}| O_2 |
| 3    | T_{31}| T_{32}| T_{33}| ... | T_{3N}| O_3 |
| N    | T_{N1}| T_{N2}| T_{N3}| ... | T_{NN}| O_N|
| Dd   | D_1  | D_2  | D_3  | ... | D_N  | T   |

2.4. Zone

The zone is the smallest unit of movement so that all the movement characteristics are averages or representations of all parts of the zone. Variability in movements is often an obstacle in transportation planning that cannot be anticipated in the zone [3].

Figure 2. A representation of the zone system.
3. Methodology
3.1. Origin and destination analysis
This paper follows a conventional approach in conducting the origin-destination method; it uses the direct method of household interviews (home interview surveys) [6, 7]. Household interviews reveal household information on the socio-economic background characteristics of movements, namely family members, age, gender, occupation, income, vehicle ownership, and the intensity of movements per day by family members [7]. Household interview surveys can also inquire about movement characteristics such as the type of land use (zone of origin and destination), time of departure and arrival, the destination of movement, and mode of transportation [8, 9]. To carry out the household interview survey process, a questionnaire is needed to collect all information during the interviews.

3.2. Sampling method
This study took interview samples from sixteen villages in Lembang District. The sample size was determined using Slovin's formula:

\[ S = \frac{N}{1 + Ne^2} \]

To obtain information on community movements, the Simple Random Sampling Method is used [4, 10]. This study applied the random sampling method based on the following stages:

First, the study determined the number of samples using the Slovin method. Slovin’s formula resulted in a sample size of 400 on a total population of 196,690 (significance level of 0.05). The formula for determining the number of samples in Lembang District based on Slovin is as follows:

\[ S = \frac{196.690}{1 + 196.690 \times 0.05^2} = 400 \]

Then, the number of samples was divided by the number of zones. Thus, the total sample size of 400 people was divided by the number of villages (sixteen), resulting in twenty-five people for each village.

\[ S \text{ Zone} = \frac{400}{16} = 25 \]

In the sampling process, this study used the mean of the population to simplify the field survey process. Therefore, the calculated standard deviation is 7.61.

4. Regional scope
Lembang District is the easternmost part of West Bandung Regency. It has an area of 95.56 km² and borders the following administrative regions:

- North: Subang Regency.
- East: Subang Regency and Bandung Regency.
- West: Parongpong District.
- South: Bandung City

Lembang District is a region with fertile land and rivers that provide water for agricultural activities. Lembang’s sixteen villages are located in hilly areas. The following Table 2 provides more details about the administrative area of Lembang District.
Table 2. The administrative structure of Lembang District.

| Zone | Village            | Abv. | Size (Hectare) | Zone | Village            | Abv. | Size (Hectare) |
|------|--------------------|------|----------------|------|--------------------|------|----------------|
| 1    | Gudangkahuripan    | [GKH]| 254.74         | 9    | Sukajaya           | [SKJ]| 319.00         |
| 2    | Wangunsari         | [WSI]| 379.28         | 10   | Jayagiri           | [JRI]| 974.07         |
| 3    | Pagerwangi         | [PWI]| 415.53         | 11   | Cibogo             | [CBO]| 486.20         |
| 4    | Mekarwangi         | [MWI]| 523.82         | 12   | Cikole             | [CLE]| 342.99         |
| 5    | Langensari         | [LRI]| 469.12         | 13   | Cikidang           | [CDG]| 532.86         |
| 6    | Kayuambon          | [KBO]| 180.12         | 14   | Wangunharja        | [WJA]| 377.77         |
| 7    | Lembang            | [DLB]| 320.67         | 15   | Cibodas            | [CDS]| 1,273.44       |
| 8    | Cikahuripan        | [CKH]| 747.25         | 16   | Suntenjaya         | [SNJ]| 1,457.00       |

Lembang District [LEM] 9,053.87

4.1. Land use
Lembang has a variety of land use; it has three main land uses: built-up land, rice fields, and forests. The built-up land is located in the center of the district, namely in Lembang Village (zone 7), which is the district’s center for trade and services. Rice fields are spread across the center of the district, and forests are found in the northern part of Lembang.

Figure 3. The land use in Lembang District.
4.2. Population
Lembang District has a fairly large population size of 196,690 inhabitants. Lembang has the largest population among all districts in West Bandung Regency. The following Table 3 presents more details about the population of Lembang District.

Table 3. The population of Lembang District.

| Zone | Village       | Abv. | Population (2018) |
|------|---------------|------|-------------------|
| 1    | Gudangkahuripan | GKH  | 15,260            |
| 2    | Wangunsari     | WSI  | 12,374            |
| 3    | Pagerwangi     | PWI  | 10,859            |
| 4    | Mekarwangi     | MWI  | 5,644             |
| 5    | Langensari     | LRI  | 14,488            |
| 6    | Kayuambon      | KBO  | 9,288             |
| 7    | Lembang        | DLB  | 15,880            |
| 8    | Cikahuripan    | CKH  | 15,260            |
| 9    | Sukajaya       | SKJ  | 12,831            |
| 10   | Jayagiri       | JRI  | 21,151            |
| 11   | Cibogo         | CBO  | 12,878            |
| 12   | Cikole         | CLE  | 14,598            |
| 13   | Cikidang       | CDG  | 7,843             |
| 14   | Wangunharja    | WJA  | 9,444             |
| 15   | Cibodas        | CDS  | 12,535            |
| 16   | Suntenjaya     | SNJ  | 8,403             |

Lembang District [LEM] 198,756

5. Analysis
The movement patterns that were obtained from the survey paint a picture of the origin and destination movements in Lembang District. These movements are presented in the Origin-Destination Matrix (ODM). The ODM is based on household interviews with twenty-five respondents from each zone who represent the entire population of their zone.

The resulting ODM shows that there are many zones that are not a destination for movement by the respondents. Therefore, each zone that is not a destination zone or has "0" movements is assumed to be one person-trip destination movement [5]. Table 1 shows the ODM results based on these assumptions.

Table 4. Origin-Destination matrix based on household interview surveys.

| Zone | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [8] | [9] | [10] | [11] | [12] | [13] | [14] | [15] | [16] | [17] | [18] | [19] | [20] | [21] |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|------|------|
| [1]  | 2   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 2    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 0    | 2    | 1    | 1    |
| [2]  | 1   | 5   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 4    | 1    | 1    | 1    | 1    |
| [3]  | 1   | 1   | 9   | 1   | 1   | 1   | 1   | 1   | 1   | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 36   |
| [4]  | 1   | 1   | 1   | 6   | 1   | 1   | 1   | 1   | 1   | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 6    | 1    | 1    | 1    | 1    | 40   |
| [5]  | 1   | 1   | 1   | 1   | 10  | 1   | 1   | 1   | 1   | 2    | 1    | 1    | 1    | 1    | 1    | 1    | 2    | 1    | 1    | 1    | 1    | 40   |
| [6]  | 1   | 1   | 1   | 1   | 2   | 4   | 7   | 1   | 1   | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 36   |
| [7]  | 1   | 1   | 1   | 1   | 1   | 2   | 15  | 1   | 1   | 2    | 1    | 1    | 1    | 1    | 1    | 1    | 4    | 1    | 2    | 1    | 1    | 42   |
| [8]  | 1   | 1   | 1   | 1   | 1   | 4   | 7   | 1   | 1   | 1    | 1    | 2    | 1    | 1    | 1    | 1    | 2    | 3    | 2    | 2    | 3    | 37   |
| [9]  | 1   | 1   | 1   | 1   | 1   | 1   | 5   | 1   | 1   | 1    | 2    | 1    | 1    | 1    | 1    | 2    | 1    | 4    | 1    | 1    | 1    | 39   |
| [10] | 1   | 1   | 1   | 1   | 1   | 1   | 9   | 1   | 1   | 3    | 2    | 2    | 2    | 1    | 1    | 1    | 5    | 1    | 1    | 1    | 1    | 38   |
| [11] | 1   | 1   | 1   | 1   | 1   | 1   | 7   | 1   | 1   | 2    | 4    | 1    | 1    | 1    | 2    | 1    | 1    | 2    | 1    | 1    | 1    | 38   |
| [12] | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 2    | 1    | 1    | 1    | 1    | 1    | 1    | 2    | 1    | 1    | 1    | 40   |
| [13] | 1   | 1   | 1   | 1   | 1   | 1   | 8   | 1   | 1   | 2    | 3    | 1    | 1    | 1    | 2    | 1    | 1    | 1    | 1    | 1    | 45   |
| [14] | 1   | 1   | 1   | 1   | 1   | 1   | 9   | 1   | 1   | 2    | 2    | 2    | 1    | 1    | 1    | 1    | 3    | 1    | 1    | 1    | 45   |
| [15] | 1   | 1   | 1   | 1   | 1   | 1   | 5   | 1   | 1   | 1    | 1    | 1    | 1    | 2    | 3    | 4    | 1    | 1    | 1    | 1    | 37   |
| [16] | 1   | 1   | 1   | 1   | 1   | 1   | 4   | 1   | 1   | 1    | 1    | 1    | 1    | 1    | 2    | 3    | 7    | 4    | 1    | 1    | 1    | 36   |
| [17] | 18  | 20  | 24  | 23  | 26  | 20  | 123 | 22  | 25  | 23   | 24   | 30   | 28   | 27   | 26   | 25   | 1    | 03   | 19   | 23   | 17   | 17   | 623  |

Table 4 above shows that there are differences in the total number of movements to and from each zone. This is due to differences in movement patterns based on the household interviews. Notably, inputting one person-trip for zones that have zero movement causes differences in final result. After
obtaining the ODM results, the authors multiplied the percentage of movements with the total population in the zone. The formula for this calculation is as follows:

\[
\text{Overall Movement in Zone} = \frac{\% \text{ Movement of Survey Results}}{\text{Total Zone Population}}
\]

After calculating the overall movements, these movements were classified into five groups to obtain the status of the movement. The five groups are Very Low (VL), Low (L), Medium (M), High (H), and Very High (VH) based on the average movement in each classification of each zone. The following interval formula is used and the number of movements based on their classification can be seen in Table 5.

### Table 5. Origin-Destination matrix based on household interview surveys.

| Classification | Movements |
|----------------|------------|
| VL Very Low    | 0 – 528 person-trip |
| L Low          | 529 – 1,056 person-trip |
| M Medium       | 1,057 – 1,584 person-trip |
| H High         | 1,585 – 2,112 person-trip |
| VH Very High   | >2,112 person-trip |

Based on this process, the patterns of community movements are translated through the Origin-Destination Matrix to produce the information as listed in Table 6 below:

### Table 6. Lembang district full Origin-Destination matrix.

| Zone | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [8] | [9] | [10] | [11] | [12] | [13] | [14] | [15] | [16] | [17] | [18] | [19] | [20] |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| [1]  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| [2]  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| [3]  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| [4]  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| [5]  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| [6]  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| [7]  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| [8]  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| [9]  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| [10] |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| [11] |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| [12] |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| [13] |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| [14] |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| [15] |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| [16] |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |

Table 6 shows three main community movement patterns in Lembang District. First, the intra-zonal trip movement is quite high. This is because the community of Lembang District works mostly in the non-formal sector, so they do not need to have a centralized working place. This is evidenced by the tendency of intra-zonal movement that can be seen in the ODM, which forms a staircase from zone 1;1 until 16;16. The second characteristic is the number of movements between internal zones towards zone 7 (Lembang Village). This is evident from the red color that dominates the destination matrix of zone 7.

The location of the Panorama Market and several other shopping centers in the village also contribute to the status of Lembang Village as a potential Central Business District. The third movement characteristic is internal to the external movement. This is the case towards the external zone 17 (Bandung City). This can be seen from the variation of colors towards this zone in the matrix. The function of Bandung City as a National Activity Center will certainly have an impact on the
movement of the people in Lembang District both directly and indirectly. The movement pattern towards Bandung City is a result of the differences in the availability of facilities and infrastructure between the two regions. Specifically, higher education facilities are only available in Bandung City, so students will move towards the city.

Furthermore, the higher wages in Bandung City is its main attraction, as evidenced by the many private employees who traveled from Lembang District to Bandung City. Figure 4 presents the map with desire lines to facilitate understanding the ODM that was developed.

Figure 4. Desire line movements map in Lembang District.

6. Conclusion
This study draws the following conclusions in terms of the movement patterns by the community of Lembang District:

- The people in Lembang District carry out daily activities with various movement characteristics.
- The people of Lembang District show a trend of movements from their origin zones to Lembang Village and to Bandung City, as can be seen from the thickness of the desire line in Figure 4. The members of the community also tend to make movements in their zones, without moving to other zones. From the information above, it can be concluded that the traffic towards Lembang Village and Bandung City may potentially accumulate with the agriculture and tourism movements.
- Based on the second conclusion, the land use in Lembang District has an impact on the movement patterns. From this study, we know that the people in Lembang District tend to move...
to the built-up land uses. However, some local movements concentrate on some local land uses in their zones. A study that concentrates on the socio-economic factors behind these movement patterns is needed to explain this trend.

- Given the patterns of movements, a plan is needed to mitigate the potential traffic accumulation between Lembang District and Bandung City, towards Lembang Village, and within Lembang Village.

In terms of methodology, it can be concluded that:
- The home base approach in this study can show the real movement patterns based on home base interviews, which the traffic model approach cannot detect.
- To ensure the validity of the findings, it is needed to test and compare potential different results from the use of an average sampling method as applied in this study with the use of the proportional sampling method.
- Based on the results of this study, the use of a home base approach is accurate for the purpose of small-scale transportation planning.

References
[1] Septian R and Judiantono T 2017 Identifikasi Karakteristik Perangkutan Pasca Produksi Pertanian di Kecamatan Lembang, Kabupaten Bandung Barat Jurnal Perencanaan Wilayah Kota Universitas Islam Bandung 16 6 [cited 2019 November 27] Available at https://ejournal.unisba.ac.id/index.php/planologi/article/view/1/pdf
[2] Annesya 2017 Laporan Praktek Stream, Analisis Bangkitan, Tarikan, dan Distribusi Angkutan Wisata di Kecamatan Lembang, Kabupaten Bandung Barat (Bandung: Bandung Islamic University) p 51
[3] Tamin O Z 2000 Perencanaan dan Pemodelan Transportasi (Bandung: Bandung Institute of Technology)
[4] Ernawaty I 1996 Analisis Bangkitan Perjalanan Penduduk Perumahan di Coridor Soekarno Hatta Kotamadya Bandung (Bandung: Bandung Islamic University) p 25
[5] Masalle D A D, Paransa M J and Sendow T K 2016 Analisis Kebutuhan Angkutan Kota Manado (Studi Kasus: Trayek Pusat Kota – Malalayang dan Trayek Pusat Kota-Karombasan) Jurnal Sipil Statik 4 334 [cited 2019 November 27] Available at https://ejournal.unsrat.ac.id/index.php/jss/article/view/12553/12125
[6] Judiantono T and Yuliska A 2011 Estimasi Pergerakan dari Perumahan dengan Pendekatan Disagregat di Coridor Cicaheum – Cibiru Kota Bandung Proc. The 14th FSTPT Int. Symp. vol 14 (Pekanbaru: Riau University, Riau Islamic University)
[7] Judiantono T and Rica R 2010 Estimasi Bangkitan Pergerakan Penumpang Angkutan Umum Di Kota Banda Aceh Jurnal Perencanaan Wilayah Kota Universitas Islam Bandung 10 1 [cited 2019 November 27] Available at https://ejournal.unisba.ac.id/index.php/planologi/article/view/1370
[8] Judiantono T 2014 Pengukuran Tingkat Aksesibilitas Angkutan Umum di Kota Banda Aceh The 17th FSTPT Int. Symp. Vol 17 (Jember: Jember University)
[9] Morlok E K 1984 Pengantar Teknik Dan Perencanaan Transportasi (Jakarta: Erlangga)
[10] Sudjana 1986 Metoda Statistika Edisi Keenam (Bandung: Tarsito)