Application of Linear Programming in optimization of parking slot: A case study of Tamale-Bolgatanga lorry station in Ghana

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Abstract—This paper deals with optimization of parking slot via linear programming of Tamale/Bolgatanga main lorry station at the Tamale Metropolis in the Northern region of Ghana. It examined the maximum parking capacity of the Terminal and how it will be optimized to avoid traffic congestion in the metropolis and determined the best parking slot allocation to be distributed among different types of vehicle on limited parking space.

Key word— Optimization, Parking slot, Linear, Programming.

I. MODEL FORMULATION

Proportionality of average parking accumulation is computed out of the daily data obtained for each type of vehicle. This implies that proportion of vehicle average parking accumulation daily for each type of vehicle is computed from the vehicle average parking accumulation divided by total average parking accumulation for each vehicles and then multiplied by parking space capacity of the form:

\[
\frac{q_1}{q_1 + q_2 + q_3 + q_4 + q_5} \left( y_1 + y_2 + y_3 + y_4 + y_5 \right) + \frac{q_2}{q_1 + q_2 + q_3 + q_4 + q_5} \left( y_1 + y_2 + y_3 + y_4 + y_5 \right) + \frac{q_3}{q_1 + q_2 + q_3 + q_4 + q_5} \left( y_1 + y_2 + y_3 + y_4 + y_5 \right) + \frac{q_4}{q_1 + q_2 + q_3 + q_4 + q_5} \left( y_1 + y_2 + y_3 + y_4 + y_5 \right) + \frac{q_5}{q_1 + q_2 + q_3 + q_4 + q_5} \left( y_1 + y_2 + y_3 + y_4 + y_5 \right)
\]

Where

- \( q_1 \) is taxi average parking accumulation (number of vehicles daily)
- \( q_2 \) is 207 Benz Bus average parking accumulation (number of vehicles daily)
- \( q_3 \) is Sprinter Benz Bus average parking accumulation (number of vehicle daily)
- \( q_4 \) is Benz Bus average parking accumulation (number of vehicle daily)
- \( q_5 \) is Yutong Bus average parking accumulation (number of vehicle daily)

While \( \left( y_1 + y_2 + y_3 + y_4 + y_5 \right) \) is parking space capacity allocated with

- \( y_1 \) is the parking space capacity Taxi
- \( y_2 \) is parking space capacity for 207 Benz Bus
- \( y_3 \) is parking space capacity for Sprinter Benz Bus
- \( y_4 \) is parking space capacity for Benz Bus
- \( y_5 \) is parking space capacity for Yutong Bus

Which represent the proportionality to average on-the-scale parking duration/time (in minutes) for Taxi, 207 Benz Bus, Sprinter Benz Bus, Benz Bus and Yutong Bus. This is computed from the vehicle average on-the-scale parking duration divided by total average on-the-scale parking duration for all vehicles in a day and then multiplied by parking space capacity mathematically written as:

\[
\frac{t_1}{t_1 + t_2 + t_3 + t_4 + t_5} \left( y_1 + y_2 + y_3 + y_4 + y_5 \right) + \frac{t_2}{t_1 + t_2 + t_3 + t_4 + t_5} \left( y_1 + y_2 + y_3 + y_4 + y_5 \right) + \frac{t_3}{t_1 + t_2 + t_3 + t_4 + t_5} \left( y_1 + y_2 + y_3 + y_4 + y_5 \right) + \frac{t_4}{t_1 + t_2 + t_3 + t_4 + t_5} \left( y_1 + y_2 + y_3 + y_4 + y_5 \right) + \frac{t_5}{t_1 + t_2 + t_3 + t_4 + t_5} \left( y_1 + y_2 + y_3 + y_4 + y_5 \right)
\]

Where

- \( t_1 \) is average on-the-scale parking duration for taxi in minutes,
- \( t_2 \) is average on-the-scale parking duration for 207 Benz Bus in minutes,
II. PARKING CHARACTERISTICS

We adopt the following Parking characteristics/parameters in the model formulation

1. Parking volume: The number of vehicle entering a parking site.
2. Parking accumulation: A number of vehicles parked at a parking site at a certain time.
3. Parking index: The percentage of the vehicle occupying the parking area.
4. Parking duration: The time interval (minute/hour) for a certain vehicle parked at a parking site. Percentage amount of parking duration is formulated as ratio between the amount of vehicle parked during certain time interval and total number of vehicle observed.

5. Average parking duration: Total number of vehicle parked during certain time interval compared to vehicle enter parking site.
6. Parking exchanges: Measurement of parking occupation calculated as ratio between the numbers of vehicle parked compared to parking capacity available.
7. Parking utilization level, computed from the ratio between average parking and parking space capacity.

Here we want to maximize the parking space capacity at Tamale/Bolgatanga main lorry station subject to available parking land, and at the same time meet the demand of parking for each type of vehicle. Average parking is obtained from the ratio between sum of parking accumulation for all observation time and number of observation. The parking demand is based on proportionality of average parking accumulation and average on-the-scale parking duration.

Table 1 show the packing control unit (PCU) which depend on vehicle dimension with additional space needed for a vehicle to manoeuvre whose value depending on the parking angle showing the allocated parking space without additional space (PSWoAS) and parking space with additional space (PSWAS) of 0.5m² for all five types of vehicle is shown the table below.

<table>
<thead>
<tr>
<th>S/N</th>
<th>Type of Vehicle</th>
<th>Width/m</th>
<th>Parking Width/m</th>
<th>Length/m</th>
<th>Parking Length/m</th>
<th>PSWoAS/meter sre</th>
<th>PSWAS/meter sre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Taxi</td>
<td>1.90</td>
<td>2.40</td>
<td>4.42</td>
<td>4.92</td>
<td>8.40</td>
<td>11.81</td>
</tr>
<tr>
<td>2</td>
<td>Urvan</td>
<td>2.07</td>
<td>2.57</td>
<td>4.96</td>
<td>5.46</td>
<td>10.27</td>
<td>14.03</td>
</tr>
<tr>
<td>3</td>
<td>Ssang Young</td>
<td>2.07</td>
<td>2.57</td>
<td>5.49</td>
<td>5.99</td>
<td>11.36</td>
<td>15.39</td>
</tr>
<tr>
<td>4</td>
<td>207 Bus</td>
<td>2.20</td>
<td>2.70</td>
<td>5.57</td>
<td>6.07</td>
<td>12.25</td>
<td>16.39</td>
</tr>
<tr>
<td>5</td>
<td>Sprinter Bus</td>
<td>2.14</td>
<td>2.64</td>
<td>5.87</td>
<td>6.37</td>
<td>12.56</td>
<td>16.82</td>
</tr>
<tr>
<td>6</td>
<td>Benz Bus</td>
<td>2.20</td>
<td>2.70</td>
<td>7.22</td>
<td>7.72</td>
<td>15.88</td>
<td>20.84</td>
</tr>
<tr>
<td>7</td>
<td>Yutong Bus</td>
<td>2.44</td>
<td>2.94</td>
<td>11.89</td>
<td>12.39</td>
<td>29.01</td>
<td>36.43</td>
</tr>
</tbody>
</table>

From the table, the allocated parking space for all five types of vehicle is as follows:

a. Parking space for Taxi is 11.81m².
b. Parking space for 207 Benz Bus is 16.39m².
c. Parking space for Sprinter Benz Bus is 16.82m².
d. Parking space for Benz Bus is 20.84m².
e. Parking space for Yutong Bus is 36.43m²
Table 2 shows the structure of decision making for maximization of parking capacity.

### Table 2

<table>
<thead>
<tr>
<th>No</th>
<th>Activity</th>
<th>Coefficient of objective functions</th>
<th>Limitation factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Parking space area</td>
<td>$u_{11}$ $u_{12}$ $u_{13}$ $u_{14}$</td>
<td>$\leq v_1$</td>
</tr>
<tr>
<td>2</td>
<td>Taxi parking accumulation</td>
<td>$u_{15}$ $u_{21}$ $u_{22}$ $u_{23}$ $u_{24}$</td>
<td>$\geq v_2$</td>
</tr>
<tr>
<td>3</td>
<td>207 Benz Bus parking accumulation</td>
<td>$u_{25}$</td>
<td>$\geq v_3$</td>
</tr>
<tr>
<td>4</td>
<td>Sprinter Benz Bus parking</td>
<td>$u_{31}$ $u_{32}$ $u_{33}$ $u_{34}$ $u_{35}$</td>
<td>$\geq v_4$</td>
</tr>
<tr>
<td>5</td>
<td>Benz Bus parking accumulation</td>
<td>$u_{41}$ $u_{42}$ $u_{43}$ $u_{44}$ $u_{45}$</td>
<td>$\geq v_5$</td>
</tr>
<tr>
<td>6</td>
<td>Yutong Bus parking accumulation</td>
<td>$u_{51}$ $u_{52}$ $u_{53}$ $u_{54}$ $u_{55}$</td>
<td>$\geq v_6$</td>
</tr>
<tr>
<td>7</td>
<td>Proportional average on-the-scale parking duration for Taxi</td>
<td>$u_{61}$ $u_{62}$ $u_{63}$ $u_{64}$ $u_{65}$</td>
<td>$\geq v_7$</td>
</tr>
<tr>
<td>8</td>
<td>Proportional average on-the-scale parking duration for 207 Bus</td>
<td>$u_{71}$ $u_{72}$ $u_{73}$ $u_{74}$ $u_{75}$</td>
<td>$\geq v_8$</td>
</tr>
<tr>
<td>9</td>
<td>Proportional average on-the-scale parking duration for Sprinter Bus</td>
<td>$u_{81}$ $u_{82}$ $u_{83}$ $u_{84}$ $u_{85}$</td>
<td>$\geq v_9$</td>
</tr>
<tr>
<td>10</td>
<td>Proportional average on-the-scale parking duration for Benz Bus</td>
<td>$u_{91}$ $u_{92}$ $u_{93}$ $u_{94}$ $u_{95}$</td>
<td>$\geq v_{10}$</td>
</tr>
<tr>
<td>11</td>
<td>Proportional average on-the-scale parking duration for Yutong Bus</td>
<td>$u_{101}$ $u_{102}$ $u_{103}$ $u_{104}$ $u_{105}$</td>
<td>$\geq v_{11}$</td>
</tr>
</tbody>
</table>

### III. LINEAR PROGRAMMING PROCESSING MODEL

We set our objective function and its constraints as followed:

Maximize: $y_1 + y_2 + y_3 + y_4 + y_5$

Subject to:

$$11.81y_1 + 16.39y_2 + 16.82y_3 + 20.84y_4 + 36.43y_5 \leq PSArea$$

$$y_i \geq \frac{q_i}{q_1 + q_2 + q_3 + q_4 + q_5}(y_1 + y_2 + y_3 + y_4 + y_5)$$
Subject to:
Maximize: \[ Z = y_1 + y_2 + y_3 + y_4 + y_5 \]

Table 3

<table>
<thead>
<tr>
<th>Day</th>
<th>Taxi</th>
<th>Urvan</th>
<th>Ssang Yo</th>
<th>207 Benz</th>
<th>Sprinter</th>
<th>Benz</th>
<th>Yutong</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>515 (55)</td>
<td>229 (8)</td>
<td>95(2)</td>
<td>269(10)</td>
<td>124(3)</td>
<td>195(4)</td>
<td>434(4)</td>
</tr>
<tr>
<td>2</td>
<td>590 (65)</td>
<td>177(8)</td>
<td>267(2)</td>
<td>564(23)</td>
<td>289(3)</td>
<td>242(4)</td>
<td>570(4)</td>
</tr>
<tr>
<td>3</td>
<td>709 (62)</td>
<td>201(4)</td>
<td>41(1)</td>
<td>895(24)</td>
<td>662(7)</td>
<td>198(3)</td>
<td>401(3)</td>
</tr>
<tr>
<td>4</td>
<td>596 (55)</td>
<td>120(3)</td>
<td>99(2)</td>
<td>932(21)</td>
<td>629(7)</td>
<td>119(2)</td>
<td>434(3)</td>
</tr>
<tr>
<td>5</td>
<td>288 (33)</td>
<td>133(6)</td>
<td>22(1)</td>
<td>524(17)</td>
<td>461(6)</td>
<td>107(3)</td>
<td>278(3)</td>
</tr>
<tr>
<td>Tot.</td>
<td>2698 (270)</td>
<td>860(29)</td>
<td>524(8)</td>
<td>3184(995)</td>
<td>2165(26)</td>
<td>861(16)</td>
<td>2117(17)</td>
</tr>
</tbody>
</table>

Substituting for the values of \( q_1, q_2, q_3, q_4, q_5, t_1, t_2, t_3, t_4, t_5 \) and solve equations (1) and (2) with parking space area of 1163m² into the optimization problem yields:

Maximize: \[ Z = y_1 + y_2 + y_3 + y_4 + y_5 \]
Subject to:

\[ 11.81y_1 + 16.39y_2 + 16.82y_3 + 20.84y_4 + 36.43y_5 \leq 1163 \]
\[ y_1 \geq 0.5 \left( y_1 + y_2 + y_3 + y_4 + y_5 \right) \beta \]
\[ y_2 \geq 0.2 \left( y_1 + y_2 + y_3 + y_4 + y_5 \right) \beta \]
\[ y_3 \geq 0.1 \left( y_1 + y_2 + y_3 + y_4 + y_5 \right) \beta \]
\[ y_4 \geq 0.04 \left( y_1 + y_2 + y_3 + y_4 + y_5 \right) \beta \]
\[ y_5 \geq 0.03 \left( y_1 + y_2 + y_3 + y_4 + y_5 \right) \beta \]

Where \( y_1, y_2, y_3, y_4, y_5 \geq 0 \) and \( 0 \leq \beta \leq 1 \) When \( \beta = 0.80 \)

Maximize: \[ Z = y_1 + y_2 + y_3 + y_4 + y_5 \]
Subject to:

\[ 11.81y_1 + 16.39y_2 + 16.82y_3 + 20.84y_4 + 36.43y_5 \leq 1163 \]
IV. ANALYSIS OF OPTIMIZATION/RESULTS

Considering average parking accumulation and average on-the-scale parking duration at $\beta = 0.70$, 0.80, 0.90 and 1.00.

When $\beta = 0.70$

Maximize: $Z = y_1 + y_2 + y_3 + y_4 + y_5$

Subject to:

\[
\begin{align*}
1.181 y_1 + 16.39 y_2 + 16.82 y_3 + 20.84 y_4 + 36.43 y_5 &\leq 1163 \\
0.643 y_1 - 0.357 y_2 - 0.357 y_3 - 0.357 y_4 &\geq 0 \\
0.860 y_1 - 0.140 y_2 - 0.140 y_3 - 0.140 y_4 - 0.140 y_5 &\geq 0 \\
0.902 y_1 - 0.098 y_2 - 0.098 y_3 - 0.098 y_4 - 0.098 y_5 &\geq 0 \\
0.923 y_1 - 0.077 y_2 - 0.077 y_3 - 0.077 y_4 - 0.077 y_5 &\geq 0 \\
0.979 y_1 - 0.021 y_2 - 0.021 y_3 - 0.021 y_4 - 0.021 y_5 &\geq 0 \\
0.923 y_2 - 0.077 y_1 - 0.077 y_3 - 0.077 y_4 - 0.077 y_5 &\geq 0 \\
0.811 y_3 - 0.189 y_1 - 0.189 y_2 - 0.189 y_4 - 0.189 y_5 &\geq 0 \\
0.672 y_4 - 0.328 y_1 - 0.328 y_2 - 0.328 y_3 - 0.328 y_5 &\geq 0 \\
\end{align*}
\]

Where $y_1, y_2, y_3, y_4, y_5 \geq 0$ & $\beta = 0.80$

When $\beta = 0.90$

Maximize: $Z = y_1 + y_2 + y_3 + y_4 + y_5$

Subject to:

\[
\begin{align*}
1.181 y_1 + 16.39 y_2 + 16.82 y_3 + 20.84 y_4 + 36.43 y_5 &\leq 1163 \\
0.541 y_1 - 0.459 y_2 - 0.459 y_3 - 0.459 y_4 - 0.459 y_5 &\geq 0 \\
0.820 y_1 - 0.180 y_2 - 0.180 y_3 - 0.180 y_4 - 0.180 y_5 &\geq 0 \\
0.874 y_1 - 0.126 y_2 - 0.126 y_3 - 0.126 y_4 - 0.126 y_5 &\geq 0 \\
0.901 y_1 - 0.099 y_2 - 0.099 y_3 - 0.099 y_4 - 0.099 y_5 &\geq 0 \\
0.964 y_1 - 0.036 y_2 - 0.036 y_3 - 0.036 y_4 - 0.036 y_5 &\geq 0 \\
0.973 y_1 - 0.027 y_2 - 0.027 y_3 - 0.027 y_4 - 0.027 y_5 &\geq 0 \\
y_1, y_2, y_3, y_4, y_5 \geq 0 & \beta = 0.70 \\
0.901 y_1 - 0.099 y_2 - 0.099 y_3 - 0.099 y_4 - 0.099 y_5 &\geq 0 \\
0.757 y_1 - 0.243 y_2 - 0.243 y_3 - 0.243 y_4 - 0.243 y_5 &\geq 0 \\
0.838 y_1 - 0.162 y_2 - 0.162 y_3 - 0.162 y_4 - 0.162 y_5 &\geq 0 \\
0.631 y_1 - 0.369 y_2 - 0.369 y_3 - 0.369 y_4 &\geq 0 \\
y_1, y_2, y_3, y_4, y_5 \geq 0 & \beta = 0.90
\end{align*}
\]

When $\beta = 1.00$

Maximize: $Z = y_1 + y_2 + y_3 + y_4 + y_5$

Subject to:

\[
\begin{align*}
1.181 y_1 + 16.39 y_2 + 16.82 y_3 + 20.84 y_4 + 36.43 y_5 &\leq 1163 \\
0.49 y_1 - 0.51 y_2 - 0.51 y_3 - 0.51 y_4 - 0.51 y_5 &\geq 0 \\
0.80 y_1 - 0.20 y_2 - 0.20 y_3 - 0.20 y_4 - 0.20 y_5 &\geq 0 \\
0.86 y_1 - 0.14 y_2 - 0.14 y_3 - 0.14 y_4 - 0.14 y_5 &\geq 0 \\
0.89 y_1 - 0.11 y_2 - 0.11 y_3 - 0.11 y_4 - 0.11 y_5 &\geq 0 \\
0.96 y_1 - 0.04 y_2 - 0.04 y_3 - 0.04 y_4 - 0.04 y_5 &\geq 0 \\
0.97 y_1 - 0.03 y_2 - 0.03 y_3 - 0.03 y_4 - 0.03 y_5 &\geq 0 \\
0.89 y_1 - 0.11 y_2 - 0.11 y_3 - 0.11 y_4 - 0.11 y_5 &\geq 0 \\
0.73 y_1 - 0.27 y_2 - 0.27 y_3 - 0.27 y_4 - 0.27 y_5 &\geq 0 \\
0.82 y_1 - 0.18 y_2 - 0.18 y_3 - 0.18 y_4 - 0.18 y_5 &\geq 0 \\
0.59 y_1 - 0.41 y_2 - 0.41 y_3 - 0.41 y_4 - 0.41 y_5 &\geq 0 \\
\end{align*}
\]

Where $y_1, y_2, y_3, y_4, y_5 \geq 0$ & $\beta = 1.00$

Optimization considering both parking

Accumulation and parking duration at $\beta$ values from 0.5 and 0.6

When $\beta = 0.50$
Maximize: $Z = y_1 + y_2 + y_3 + y_4 + y_5$

Subject to:

11.81y_1 + 16.39y_2 + 16.82y_3 + 20.84y_4 + 36.43y_5 \leq 1163
0.745y_1 - 0.255y_2 - 0.255y_3 - 0.255y_4 - 0.255y_5 \geq 0
0.90y_2 - 0.10y_1 - 0.10y_3 - 0.10y_4 - 0.10y_5 \geq 0
0.93y_1 - 0.07y_2 - 0.07y_3 - 0.07y_4 - 0.07y_5 \geq 0
0.945y_4 - 0.055y_1 - 0.055y_2 - 0.055y_3 - 0.055y_5 \geq 0
0.98y_3 - 0.02y_2 - 0.02y_3 - 0.02y_4 \geq 0
0.985y_2 - 0.015y_3 - 0.015y_4 - 0.015y_3 - 0.015y_4 \geq 0
0.945y_4 - 0.055y_1 - 0.055y_2 - 0.055y_3 - 0.055y_4 \geq 0
0.865y_3 - 0.135y_1 - 0.135y_2 - 0.135y_3 - 0.135y_4 \geq 0
0.91y_4 - 0.09y_1 - 0.09y_2 - 0.09y_3 - 0.09y_5 \geq 0
0.795y_4 - 0.205y_1 - 0.205y_2 - 0.205y_3 - 0.205y_4 \geq 0

Where $y_1, y_2, y_3, y_4, y_5 \geq 0 & \beta = 0.50$

When $\beta = 0.60$

Maximize: $Z = y_1 + y_2 + y_3 + y_4 + y_5$

Subject to:

11.81y_1 + 16.39y_2 + 16.82y_3 + 20.84y_4 + 36.43y_5 \leq 1163
0.694y_1 - 0.306y_2 - 0.306y_3 - 0.306y_4 - 0.306y_5 \geq 0
0.88y_2 - 0.12y_1 - 0.12y_3 - 0.12y_4 - 0.12y_5 \geq 0
0.916y_3 - 0.084y_1 - 0.084y_2 - 0.084y_3 - 0.084y_4 \geq 0
0.934y_4 - 0.066y_1 - 0.066y_2 - 0.066y_3 - 0.066y_5 \geq 0

0.976y_5 - 0.024y_1 - 0.024y_2 - 0.024y_3 - 0.024y_4 \geq 0
0.982y_1 - 0.018y_2 - 0.018y_3 - 0.018y_4 - 0.018y_5 \geq 0
0.934y_2 - 0.066y_1 - 0.066y_3 - 0.066y_4 - 0.066y_5 \geq 0
0.838y_3 - 0.162y_1 - 0.162y_2 - 0.162y_3 - 0.162y_4 \geq 0
0.892y_4 - 0.108y_1 - 0.108y_2 - 0.108y_3 - 0.108y_5 \geq 0
0.754y_5 - 0.246y_1 - 0.246y_2 - 0.246y_3 - 0.246y_4 \geq 0

Where $y_1, y_2, y_3, y_4, y_5 \geq 0 & \beta = 0.60$

V. RESULTS

The model was tested for $\beta$ value ranging from 0.70 to 1 with an interval of 0.10 using Management Scientist Version 5, (2000) to find the optimal solutions with respect to the various constraints and results as tabulated below

1. Optimization considering average parking accumulation constraints with $\beta$ value of 0.70- 1.00.
2. Optimization considering only average on-the-scale parking duration constraints with values $\beta$ from 0.70 to 1.00.
3. Optimization considering both constraints of average parking duration and average parking accumulation with values of $\beta$ 0.50 and 0.60

Formulation Considering Parking Accumulation Only

Table 4 Results of Optimization considering average parking accumulation only

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\beta = 0.70$</th>
<th>$\beta = 0.80$</th>
<th>$\beta = 0.90$</th>
<th>$\beta = 1.00$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_1$</td>
<td>53.333</td>
<td>48.147</td>
<td>43.207</td>
<td>38.501</td>
</tr>
<tr>
<td>$y_2$</td>
<td>11.365</td>
<td>12.670</td>
<td>13.913</td>
<td>15.099</td>
</tr>
<tr>
<td>$y_3$</td>
<td>7.955</td>
<td>8.869</td>
<td>9.739</td>
<td>10.569</td>
</tr>
<tr>
<td>$y_4$</td>
<td>6.251</td>
<td>6.969</td>
<td>7.652</td>
<td>8.304</td>
</tr>
<tr>
<td>$y_5$</td>
<td>2.273</td>
<td>2.534</td>
<td>2.783</td>
<td>3.020</td>
</tr>
</tbody>
</table>

$Z$ | 81.176 | 79.189 | 77.297 | 75.493

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From the above table, the result indicate that the higher the value of $\beta$ (level of satisfaction), the smaller the parking slot obtained with Taxi having the highest accumulation and Yutong bus ($y_3$) having the lowest accumulation in comparison to the others.

Table 5 shows Optimization considering average on-the-scale parking duration only.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\beta = 0.70$</th>
<th>$\beta = 0.80$</th>
<th>$\beta = 0.90$</th>
<th>$\beta = 1.00$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_1$</td>
<td>17.514</td>
<td>12.496</td>
<td>6.147</td>
<td>1.374</td>
</tr>
<tr>
<td>$y_2$</td>
<td>4.202</td>
<td>5.772</td>
<td>4.792</td>
<td>5.039</td>
</tr>
<tr>
<td>$y_3$</td>
<td>10.313</td>
<td>8.942</td>
<td>11.761</td>
<td>12.369</td>
</tr>
<tr>
<td>$y_4$</td>
<td>6.875</td>
<td>7.421</td>
<td>7.841</td>
<td>8.246</td>
</tr>
<tr>
<td>$y_5$</td>
<td>15.661</td>
<td>16.903</td>
<td>17.860</td>
<td>18.783</td>
</tr>
<tr>
<td>$Z$</td>
<td>54.567</td>
<td>51.533</td>
<td>48.401</td>
<td>45.812</td>
</tr>
</tbody>
</table>

From the table, it shows that the higher the value of $\beta$ (level of satisfaction) the smaller the parking slot obtained especially, Taxi ($y_1$) having the highest average parking accumulation and parking duration in comparison to the others.

However, as average on-the-scale parking duration for all vehicles almost closed, the differences were not very extreme and the resulting parking slot allocations were also closed among all five types of vehicle.

Table 6 shows Optimization considering both parking accumulation and parking duration.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\beta = 0.50$</th>
<th>$\beta = 0.60$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_1$</td>
<td>29.069</td>
<td>20.954</td>
</tr>
<tr>
<td>$y_2$</td>
<td>6.185</td>
<td>6.908</td>
</tr>
<tr>
<td>$y_3$</td>
<td>8.349</td>
<td>9.326</td>
</tr>
<tr>
<td>$y_4$</td>
<td>5.566</td>
<td>6.217</td>
</tr>
<tr>
<td>$y_5$</td>
<td>12.679</td>
<td>14.161</td>
</tr>
<tr>
<td>$Z$</td>
<td>61.848</td>
<td>57.566</td>
</tr>
</tbody>
</table>

From the table, it shows that the higher the value of $\beta$ (level of satisfaction) the smaller the parking slot obtained especially,
In contrast, parking slots for the remaining types of vehicle increased with the increase of the $\beta$ value (i.e. level of satisfaction). Comparison of all three procedures suggest that the formulation considering parking accumulation only is the best option if the total number of optimal parking slot is used as a performance measurement and the formulation considering average on-the-scale parking duration only is clearly less preferable as it gives the result of less number of optimal parking slot and it does not relate significantly with the customer satisfaction practically.

VI. CONCLUSION

This paper deal with optimization of parking slot using linear programming at the Tamale Metropolis in the Northern Region of Ghana with particular emphasis at the Savelugu Terminal (i.e. Tamale/Bolgatanga main lorry station) where we examine the maximum parking capacity of the Terminal and how it will be optimized to avoid traffic congestion in the metropolis and determine the best parking slot allocation to distribute among different types of vehicle on limited parking space. It shows that the higher the value of $\beta$ (level of satisfaction) the smaller the parking slot obtained as the formulation considering parking accumulation only is the best option if the total number of optimal parking slot is used as a performance measurement.

REFERENCES