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Examining Subdivision Layouts against Market Values – the Impact of the Parcels' Physical Properties

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Abstract. *The internal properties of land parcels in land subdivision layouts are known to impact land demand. Several layout options exist for the same land, in most cases. Accordingly, the study focuses on indexing the internal parameters of land parcels in the subdivision layout against their market value. An analytical hierarchical process (AHP) was used to develop the Weighted Index (WI). A structured questionnaire was used for data collection from experts in the residential real estate sector in Sri Lanka. The consistency ratio of the feedback was 0.096. The results show that eleven internal parameters mainly affect a land parcel's market value. The highest significant parameter was 'number of sides open to nature' (0.244), and the lowest significant parameter was 'compactness value of the land parcel' (0.016). To validate the results, a residential subdivision layout of 55 land parcels was selected from the western province of Sri Lanka, to be analysed for the correlation between the calculated weighted index and actual market value. Results show a significant positive correlation between the calculated weighted evaluation index and per perch (25.29 m^2) market value. Re-subdivision by eliminating the drawbacks associated with internal parameters shows a 2% increase in the market value of the proposed layout.*

Keywords: *land valuation, land market, residential real estate investment, subdivision layouts, weighted index*

1 Introduction

In many countries, real estate investments are seen as a platform for more wealth creation and economic growth than other investment sectors. Investing in the

real estate sector can be identified as a significant diversification of investment portfolio contributing to a country's economic development. Real estate refers primarily to land and other physical property, or improvements affixed to the land, including houses, buildings, landscaping, fencing, walls, air right above the land, and mining right under the land. Vacant land and residential lots, houses, outbuildings, decks, trees, sewers, and fixtures within the property's boundaries are all referred to as real estate (Apanavičienė, et al., 2015). The land is the fundamental layer of any real estate property with unique quality, immovable and everlasting attributes. Like other commodities, the value of land and real property will also be primarily determined by the market forces of supply and demand, further, it can be illustrated that the physical supply of property as such is fixed or completely inelastic (Kuo & Sullivan, 2001).

The value of a real property is mainly based on the production function of the area, for example, single-owned family, condominium properties, industrial land, industrial parks, mines, or plantations (Kazimoto, 2016). Commercial real estate involves facilities that are not residential or industrial, such as office buildings, warehouses, and retail buildings. These buildings may be standalone or situated in shopping malls. Compared with residential investment, commercial and industrial investment have more capabilities in profit generation; thus, the market values are also significant. Instead, residential investment is less expensive and a widely spread investment when compared with industrial and commercial investments (Boyd, 2014). Apart from functionality, the market value of land also depends on the internal properties associated with the land parcel, such as size, shape, frontage, and more (Arslan et al., 2021, Latruffe and Piet, 2014). Fragmented and deformed land parcels usually have less demand and usage (Villanueva et al. 2017, Gonzalez et al. 2004). Unlike the external factors, the internal factors are under the control of land sellers, hence, profit maximisation concerning these parameters is imperative.

However, most empirical studies focused on analysing external factors affecting land value. This generates insufficient knowledge regarding the impacts of internal factors on land value, especially within the Sri Lankan context. Sri Lanka is a lower-middle-income country with a GDP per capita of USD 4,073 (2017) and 21.4 million people (World Bank, 2019). After the civil conflict that dragged on for nearly three decades, Sri Lanka enjoyed a decade of relative calm. Sri Lanka's economy grew at an average of 5.8 per cent between 2010 and 2017, with the sectors being non-tradable like construction, transport, domestic trade and banking, insurance, and real estate investment, reflecting a peace dividend and a determined policy thrust towards reconstruction and growth. However, some signs of a slowdown in growth have been witnesses in the last few years, mainly because of internal political imbalances and the absence of a business-friendly environment (IMF, 2019). According to the Global Real Estate Transparency Index, Sri Lanka made its debut rank of 69 in 2016 and was promoted within two years in 2018 to rank 66 (Transparency, 2018). This is a remarkable performance, considering the relative maturity of the market. When considering the residential investment sector in Sri Lanka, the attraction towards luxury housing and semi-

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luxury residential markets has increased with the increment of the high and middle-income population. High demand for residential land and maintaining the quality of the land according to the price, are highlighted challenges in the Sri Lankan context. This encourages more consideration of the quality of the land, especially from the land developer side.

The spatial arrangement of the land directly affects the quality of the land, hence, the subdivision layout, which shows the relative spatial arrangement of the land parcels, homes much imperative (Prematilaka & Abeygunawardana, 1992), (Lenth, et al., 2006). Evaluating the prepared subdivision layout is critical to reaching the best and maximum profit optimisation option concerning residential real estate investment. However, as (Prematilaka & Abeygunawardana, 1992) have exposed, a lack of proper understanding of the internal factors will affect the market value and thus can cause to generate significant impacts on both buyer and seller. Therefore, this research aims to identify all the internal factors affecting the quality of the land parcel and develop an innovative weighted index to evaluate the subdivision layout using scientific decision-making techniques.

2 Background

Within the next two decades, the world's urban population is expected to increase from 2.9 billion to around 4.9 billion; it will cover about 60% of the total population all over the world (Transparency, 2018). Current urban land areas need to be expanded to accommodate the high demand for the land. Therefore, the urban footprints that affect biological, hydrological, and climate systems will continue at a much higher rate. Urban expansion leads to land fragmentation, biodiversity damage, and ecosystem services disruption (Bowman, 2011). Presently, the real estate sector deploys development techniques to minimise the adverse impacts caused by urban expansion. Land subdivision layout is one of the sections in the real estate market that can utilise such development techniques. With the rapid increment of land demand, the need to study the effectiveness of land subdivision layouts has arisen. Effective land subdivision enables converting conventional parcel layouts into more convenient living spaces (Adams, et al., 2013).

One such method, the Conserving Subdivision Design (CSD) method (Bosworth, 2007), helps to create parcel layouts that are more open to the outside and more elegant than the conventional methods. According to this method, the building and road features are the first in the cover design. Finally, the lots are laid out. This can be named as a reverse of the conventional parcel layout method. The chart in Figure 1 highlights the main components of this method.

As may be seen in Figure 1, all the information relating to the natural, cultural, and historical features, as well as other important information such as topology, soil quality, hydrology, wildlife, and scenic view, are overlayed to identify the areas such as to be conserved, undecidable wetlands, floodplains, and slops areas. This leads to a four-step design process: first, identify the area that needs to be protected. Second, determine the locations for houses with scenic views. Third, locate the street lines, and finally, draw the lot lines. It creates a culture that predominantly prioritises people, not lot lines (Lollo et al., 2008).

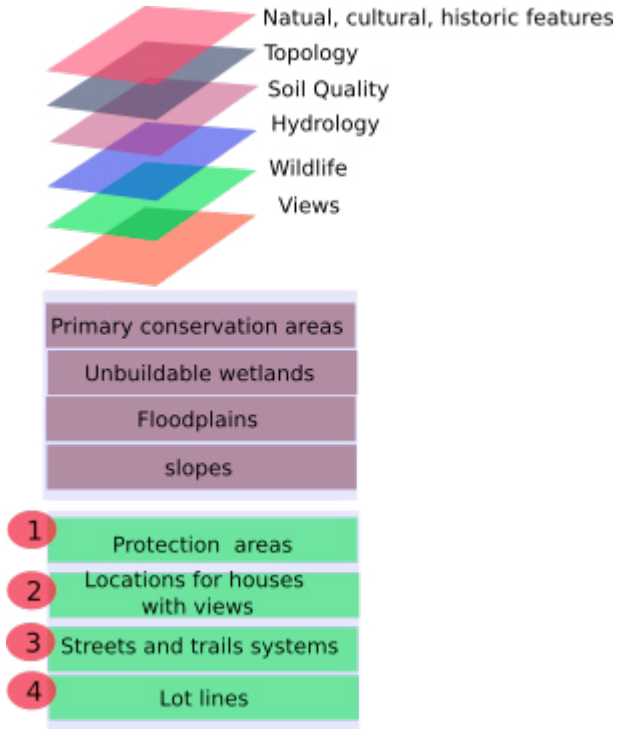

Figure 1. *The Conserving Subdivision Design (CSD) method.*

The Conservation Subdivision Design (CSD) method is a universally accepted subdivision method that mainly focuses on allocating more open spaces within the layout as much as possible. The principle of this method is more applicable to residential areas. However, the same can also be applied to other types of developments. The CSD is particularly essential for preventing the urban sprawl resulting from the ever-expansion of urban residence spaces (Carter, 2009). It protects essential natural features such as wetlands, floodplains, slopes, and other unbuildable lands and conserves sites of cultural and historical significance and other important natural features. Thus, residents are provided with improved access to nearby nature, serving as community gathering places and recreational areas (Haines, 2002). Determining the parameters that affect the choice of land parcels, especially the internal factors, could further improve the impacts of the CSD method.

Regarding the land administration context of Sri Lanka, land registration is mainly performed under two legal frameworks: Deed Registration (Notaries Ordinance, 1907) and Title Registration (Title Registration Act, 1998). Under the registration system, land sub-divisional takes place according to the rules and regulations derived under the Urban Development Act (UDA Act, 1988). According to this act, the minimum land sub-divisional should be not less than six perch (152 m^2). However, depending on the development plans prepared by

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the local governing authorities, this amount can be changed. The width of the access road is regulated, as follows: 3 meters for 1 to 4 lots, 4.5 meters for 4 to 8 lots, 6 meters for 8 to 20 lots, and at least 9 meters for more than 20 lots. The building positioning within a lot, however, depends on the decision of the local governing authority. Apart from this, the lot frontage should be 6 meters, and the depth should not be less than 12 meters. A licensed surveyor performs land subdivision in private land through the delegated power of the Surveyor General according to the Survey Act (Survey Act, 2002). The Surveyor General office itself does government land matters.

3 Methods and data

This study commenced with a pre-survey. During the pre-survey phase, the subdivision layouts of two real estate companies were examined and determined the variation in the market value of the land parcels. Accordingly, three land subdivision layouts were selected, and their physical characteristics were measured using AutoCAD Civil 3D software. The hard copies of plans of subdivision layouts were scanned with 600 dpi and uploaded to software to maintain the measurements' accuracy in calculating the above parameters. The market value variation of each land parcel was then compared with measured internal factors. Expert opinions were also considered when determining the critical factors that affect the market value of a land parcel. Based on the opinion of the experts and the above comparison, the critical factors were identified.

The second phase of the study comprised Hierarchical Structure Development of factors. The dominant step is scaling out the impact of factors. In agreement with the objective, selected factors are arranged in a multilevel. The Analytical Hierarchical Process (AHP) was selected to determine the weights of the above-identified internal factors**.** AHP is one of the most inclusive systems that is considered helpful in analysing the multiple criteria associated with a problem and arranging them in a hierarchical order. Within the AHP method, quantitative and qualitative factors are considered when determining the hierarchical factors (Taherdoost, 2018).

Finally, a questionnaire for the Analytical Hierarchical Process (AHP) was sent to 11 selected experts through email, and ten responded. The survey included professionals from the real estate sector and academia, such as License Surveyors, Valuers, and academia from Land Management and Urban Planning. The research process is depicted in Figure 2.

The expert opinion taken from the questionnaire and the class ranges used in early studies were used to design hierarchical models and score each class according to relative importance. Each factor was classified and assigned a score from 1 to 5, with 5 being the highest impact and 1 for the lowest impact. All the classification and scoring were based on the experts' opinion and existing laws and standards (see Figure 2). Both qualitative and quantitative data collected from the questionnaires were used to develop a pairwise comparison. The AHP process initially involves a pairwise comparison matrix wherein each factor's relative dominance is compared by the standard variable (Bencure, et al., 2019).

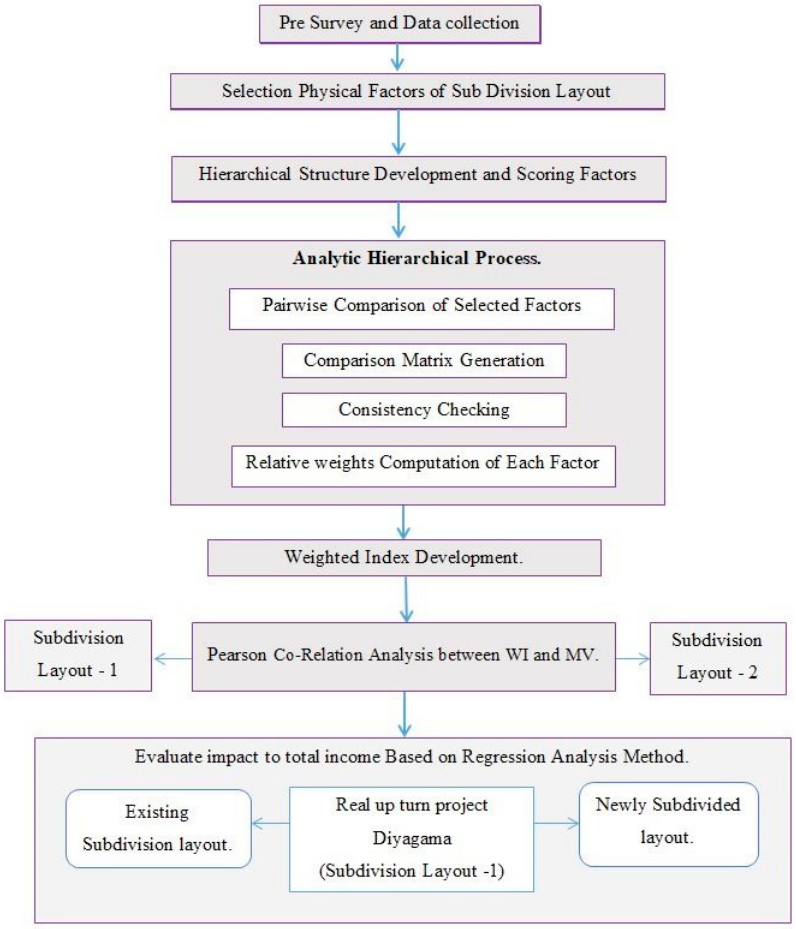

Figure 2. *Research Process.*

The consistency of derived weights (eigenvectors) is checked by calculating the consistency ratio (CR). In the judgment matrix consistency test, if the CR = 0, complete consistency is indicated; if the CR < 0.1, the degree of consistency is acceptable. Higher values of the CR indicate more significant inconsistency (Taherdoost, 2017). The Weighted Evaluation Index (WI) was then calculated according to equation 1, using the calculated weights from the Analytic Hierarchy Process, and scores were given to each factor.

$$WI = \sum_{i=1}^{11} W_i F_i \tag{1}$$

Its correlation with actual market value. Minitab 18.0 was used for this purpose.

3.1 Pearson Correlation analysis and evaluation subdivision layout

To validate the developed Weighted Index (WI), the method was applied to two residential real estate projects within the western province of Sri Lanka to

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identify the correlation between the market value of parcels and the calculated WI. One of the subdivision layouts prepared for Real Lands & Properties (Pvt) Ltd in Diyagama, Western Province, Sri Lanka, was then evaluated through the developed approach. There were 55 residential lots, and the existing subdivision layout was in Auto Cad drawing (.dwg) format. Accordingly, the Parcels were categorised into six categories based on calculated WI. This categorisation allows ranking the parcels and thus determining the drawbacks of the land parcels concerning the calculated WI. This allows the re-subdivision of the layouts after minimising drawbacks and optimising the spatial arrangement (SAVA, 2016).

The new WI for rearranged subdivision layout was then calculated and using the developed linear regression, the WI of each land parcel was converted to per-perch market values. The profit difference between the original and there-subdivision layout was then calculated to determine the profit differences. The following equations, 2 and 3, were used to calculate the total income of the land.

$$I_{ex} = \sum_{i=1}^{55} m_i s_i \tag{2}$$

$$I_{new} = \sum_{i=1}^{55} m_i^1 s_i^1 \tag{3}$$

where, I_{ex} – Income of existing blocking out, I_{new} – Income from new blocking out m_i is the per perch market value in rupees, and the s_i is the land parcel size in perches. Also, m_i^1 is the calculated per perch market value by linear regression, and s_i^1 is the new land parcel size in perches.

4 Results and Discussion

According to the expert opinions, 11 parameters have been identified as critical factors that have an impact on determining the market value of a land parcel, namely, the size of the land parcel, the ratio between the width and depth of the land parcel, road frontage of the land parcel, orientation of land parcel, distance from the entrance to the land parcel, compactness value of the land parcel, access road width to the land parcel, number of the corners inland parcel, number of access sides to the parcel, and number of an acute angle in the land parcel. Table 1 shows the score for each factor's impact levels according to the opinion of the experts and literature review.

Respective impact weights for the above 11 factors were calculated through the Analytical Hierarchical Process using the quantitative measures collected from the questionnaire and the qualitative aspects given by the real estate investment sector experts. Table 2 shows the result.

According to Table 2, the most weighted factor is the 'number of sides open to nature' (F9), which takes more than 24% of the total weight. In the residential real estate market, buyers are always concerned about open views. Furthermore, people prefer open green environments like paddy fields, tea estates, and grasslands for their residential property. Second, the distance from the entrance to the land parcel (F5) weighted 0.226, which means more than 22% of the total weight of

Table 1. *Hierarchical Structure of Considered Factors.*

Code	Factor	Score				
		5	4	3	2	1
F1	Size of the land parcel	6–8	8–10	10–12	12–15	15<
F2	The ratio between Width and Depth of land parcel. (Shape)	0.5	1–0.5	>1	1	0.5>
F3	Road Frontage of the land parcel	15<	12–15	9–12	6–9	6>
F4	The orientation of the land parcel	N	E	NE	S, SE	W, NW, SW
F5	Distance from the entrance to the land parcel	<20	20–70	70–120	120–170	170<
F6	Compactness value of the land parcel	0.055	0.055–0.058	0.052–0.055	1–0.058	0–0.052
F7	Access road width to the land parcel	8.5<	6–8.5	4.5–6	3–4.5	3>
F8	Number of the corners in land parcel	4	5	6	7	7<
F9	Number of Sides opens to nature	>3	3	2	1	0
F10	Number of Access sides to the parcel	>4	4	3	2	1
F11	Number of an acute angle in the land parcel	0	1	2	2<	

Table 2. *Weights of Factors.*

Code	Factor	Weight
F1	Size of the land parcel	0.055
F2	The ratio between Width and Depth of landparcel (Shape)	0.023
F3	Road Frontage of the land parcel	0.085
F4	The orientation of the land parcel	0.023
F5	Distance from the entrance to the land parcel	0.226
F6	Compactness value of the land par-cel	0.016
F7	Access road width to land parcel	0.147
F8	Number of the corners in land parcel	0.017
F9	Number of Sides open to Nature	0.244
F10	Number of Access sides to the parcel	0.132
F11	Number of an acute angle in the land parcel	0.032
	Difference between total expected income from the new subdivision and the existing subdivision	**1.000**

the area. Buyers always expect easy access to the land parcel. Most of the land with real estate in Sri Lanka is connected to developed and well-maintained roads. Nevertheless, it does not always allow easy access. These two factors (F5 and F9) have a comparatively high weight. Only these two factors exceed the 0.2 level. 'Access road width to the land parcel' (F7) has considerable weight. Several

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access sides to the parcel are also highlighted in the developed weighted index, with the high weight of the factor 'number of access sides to the parcel' (F10). Corner plots have a high probability of having more than one access. According to experts, this spatial arrangement can have merits and demerits. Easy access gives the potential to use the land for business activities. On the other hand, it may be highly vulnerable to external threats, and less privacy can be a drawback. The parcel's road frontage and the parcel's size in between has more than 5% weight. In the real estate sector, lands with ample road frontage have a higher demand rate than ordinary lands. The size of the land always depends on the affordability of the buyer. However, according to the regulation of UDA (Urban Development Authority), dividing land by less than six perch is not allowed. According to the experts, the land's most suitable and marketable size is in the 6 perch to 8 perch range. The other five factors comparatively have less weight, and all are under 0.05. According to the experts, these factors cannot significantly influence residential real estate market value and land demand.

When pairwise comparisons are performed, some inconsistencies may arise for several reasons. The AHP incorporates a useful technique for checking the consistency of the evaluations made by the decision-maker. The allowable level of consistency ratio of less than 0.10. Here for this comparison matrix, the consistency ratio is 0.09674. It ensures the consistency of the pairwise comparison matrix.

When considering the correlation between market value and the WI, the significance P-value was 0.000, and R-value was 0.739 for the Real Up Turn Project Diyagama (Figure 3). For the Real Treasure project, Kahathuduwa's significance P-value was 0.000, and R-value was 0.907 (Figure 4). Both results prove a significant positive correlation between calculated WI and per-perch Market value. Relationship between market value and Weighted index of subdivision Layout 1 and 2 represented by Figures 3 and 4, respectively.

When analysing layout 01 (Figure 5) of Real Up Turn Project Diyagama, the market value variation is between Rs.275, 000.00 to Rs.405, 000.00 and the variation of the calculated weighted index is between 1.615 to 3.654. The mean of the WI is 2.451, and the standard error of the mean is 0.0487. According to the parameters of the WI, several drawbacks of layout 01 (Figure 5) can be observed. Accordingly, some lands can be improved by rearranging the acute angle, number of corners, and compactness measures, while the WI of some lands can easily be improved by changing the frontage and size of the land. According to the WI parameters, the most suitable size was the 6 perch to 8 perch range, and most of the land was slightly higher than the optimum size. The WI of lots no 35 to 41 (Figure 5) can be improved by placing a straight access road (see Figure 6). However, the positively impacting parameters, such as the number of sides open to nature and access road width, cannot be easily changed.

There is a new road in the corrected subdivision layout (Figure 6), and all the acute angles were corrected except a few lots. A significant change in the WI has been observed in lots 12 and 25, which shows weak performance in the previous subdivision layout (Figure 5). The total number of land parcels within the layout remains the same in both cases. When considering the overall performance of

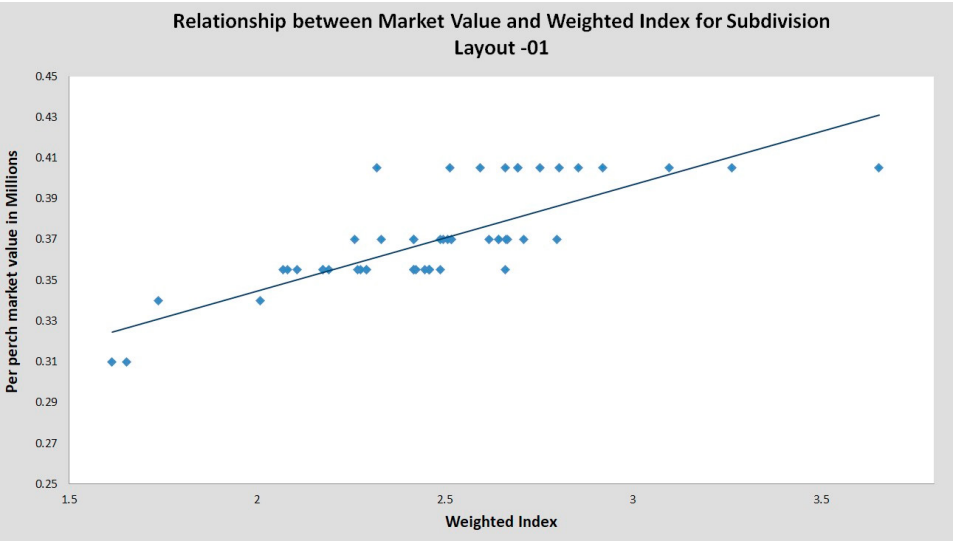

Figure 3. *Relationship between Market Value and WI for subdivision Layout -01- Real Up Turn Project Diyagama.*

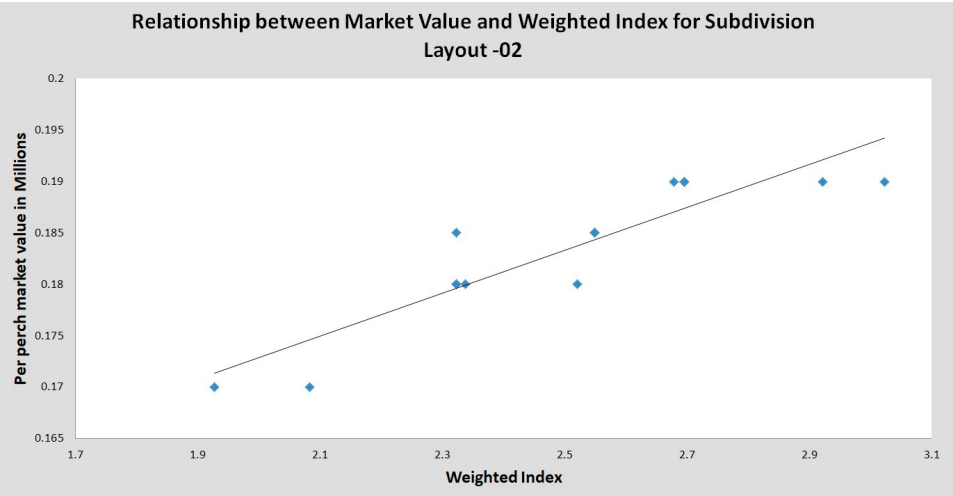

Figure 4. *Relationship between Market Value and WI for subdivision Layout -02-Real Treasure project, Kahathuduwa.*

the new subdivision layout (Figure 6), there is no land parcel WI that is less than 1.750, whereas the previous layout (Figure 5) has three land parcels, of which WI is less than 1.750.

For the existing subdivision Layout (Figure 5), the significance P-value was 0.000, and R-value (Pearson Correlation) was 0.739 between the calculated WI and per perch market value. After the parcel adjustment (Figure 6), the minimum WI value increased to 2.06. The mean of the WI is increased to 2.571, and the

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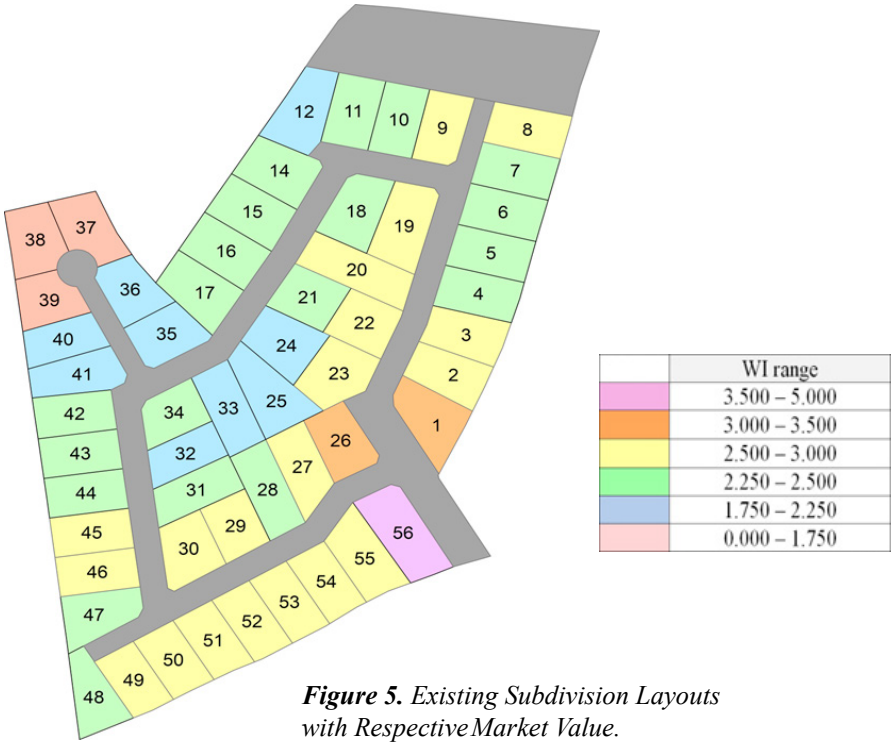

Figure 5. *Existing Subdivision Layouts with Respective Market Value.*

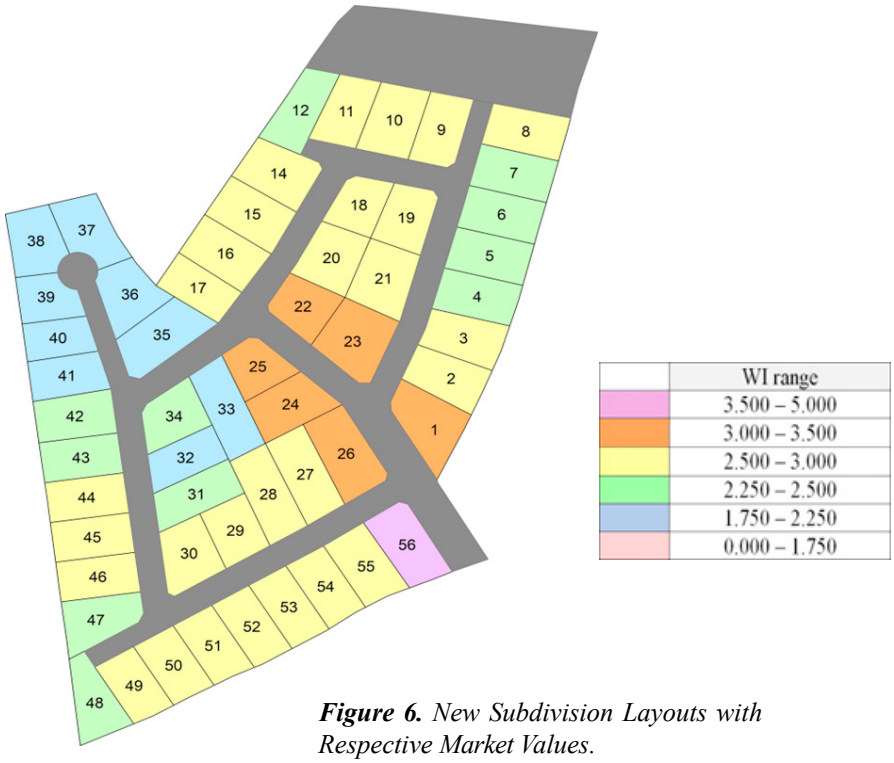

Figure 6. *New Subdivision Layouts with Respective Market Values.*

Table 3. *Comparison of Existing and New Blocking Out.*

	No of Lots	Mean Value of Perch Market Value (Rs.)	Total Marketable Land Area (P.)	Total Income (Rs.)
Existing subdivision layout	55	366,090.91	411.95	150,669,750.00
New subdivision layout	55	373,357.36	407.5	152,429,096.00
Difference between total expected income from the new subdivision and the existing subdivision				1,759,346.00

new standard error of the mean is 0.045. The results also prove a close correlation between the market value and the calculated weighted index.

Equation 4 was used to predict the market value per perch of the new subdivision using the WI. Equation 4 shows that a linear relationship between the market value per perch (rupees in a million) of the land (dependent variable; Y) and developed (independent variable; X) Weighted Index, WI exists. The results estimated that R2 was 0.580 and the significance number was 0.000. Equation 4:

$$Y = 0.0198W_i^3 + 0.1351W_i^2 + 0.4147 \quad (4)$$

According to Table 3, a significant profit difference between existing and newly subdivided land exists. The total of 4.45 perches has been reduced (Figure 6) due to extra roads from the total marketable land. However, approximately 1.7 million rupees increase in profit.

Figure 7 shows the total income increment of most of the parcels. The reduction of the market value of some parcels is mainly caused due to the reduction of the parcel area.

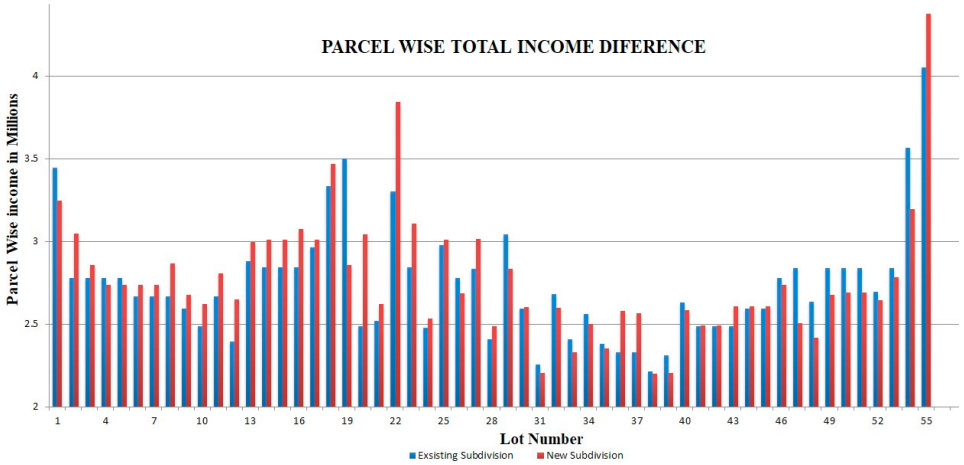

Figure 7. *Existing and expected parcel-wise income for Subdivision Layout -01.*

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5 Conclusion and recommendation

Two ways to develop residential real estate dominate. One is condominium property development, which supplies residence for several families within a small land area. The second the single-family housing development, where housing units and land ownership are under the household. The second type is the most popular in Sri Lanka, especially in suburban areas. When developing single-family housing, the quality of the land parcel is significant. The spatial arrangement of the land parcel is one of the integral elements that affect their marketability. Hence, unplanned land subdivision layouts directly affect financial results for both seller and buyer. Even though many rules and regulations regulate land subdivisions, they are not guiding the surveyors or land developers to optimise the market value of land parcels. This study developed a Weighted Index (WI) to evaluate the internal parameters of land subdivision layouts, enabling the optimization of the expected market values of a land parcel. This study adopted the AHP method, and the Pearson correlation method to identify the correlation between per perch market value and calculated each WI of land parcel. Accordingly, a significant positive correlation was found to exist between actual market value and calculated WI. Applying the method to an actual subdivision layout revealed that changing the internal parameters that increase the WI of each land parcel, may increase the market value of a subdivision layout by 2%. Accordingly, reviewing parcel subdivision layouts with regard to the internal parameters identified in this study, is imperative. However, surveyors do not currently give proper attention to the internal parameters as they are unaware of their impact on the market value. This is mainly due to the lack of proper market-based study in the Sri Lankan real estate sector on the impact of internal factors on its value. The advanced indexing method allows a surveyor to review their sub-divisional layout to optimise the market value of those land parcels. The highlighted drawback of this application is that it takes time to measure physical factors from AutoCAD drawings. This can be eliminated through developing a software application to calculate the internal parameters automatically. The study shows that effective integration of scientific approaches to the land subdivision layout has the potential to increase the expected market value of land parcels.

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