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Coconut Tree Stress Detection as an Indicator of Red Palm Weevil (RPW) Attack Using Sentinel Data

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ABSTRACT

The red palm weevil (RPW) is one of the worst destructive pests of palms in the world. This study focuses for the first time on the coconut tree stress detection and discrimination among different stages of red palm weevil (RPW) stress-attacks using vegetation indices (VI) and the percentage of accuracy assessed. Different spectral indices were assessed using Sentinel 2A data of year 2018. Based on field identification, four classes of coconut tree were considered and evaluated using visual maps of VI: severe, moderate, early and healthy coconut trees. Results showed that the vegetation indices Normalized Differenced Vegetation Index (NDVI), Renormalized Difference Vegetation Index (RDVI), SQRT (IR/R), Difference Vegetation Index (DVI) and Green Vegetation Index (GVI) are sensitive to coconut trees caused by RPW attacks. They discriminated among the considered classes with more than 50% accurate from census data of field observation compared with remote sensing data of Sentinel 2A image. Nevertheless, they express the healthiness of tree stress between 0.308 – 0.673 range with 55% to 91% accurate. According to these results, it was concluded that remote sensing technique using Sentinel 2A data is a promising alternative for RPW detection based on VI.

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1. Introduction

Red Palm Weevil (RPW) (Olivier) (Coleopteran: Curculionidae) is a key pest of coconut Cocos nucifera L. originating from South and South East Asian Countries (Fiaboe et al., 2013). It can be found in Asia Pacific region such as India, China, Japan, Malaysia, Philippines, Vietnam, Thailand and Sri Lanka (Food and Agriculture Organization of the United (FAO) & International Center for Advanced Mediterranean Agronomic Studies (CIHEAM), 2017), that has significantly expanded its geographical and host range during the last three decades. In the Middle East, RPW is causing wide spread damage to date palm Phoenix dactylifera L., having both agricultural impacts on the palm production and environmental impacts. The rapid spread of RPW is due to many circumstances such as late detection of infested palms improper disposal of infested trees, improper assessment of the risks, few natural enemies of the pest, difficulties in managing the mass trapping and lack engagement with coconut farmers (CABI, 2017).

Since today, there is no effective techniques applied to detect the RPW infestation at the early stage because the infestation not clearly visible and only can be seen until it become severe or the coconut tree falls down. Likewise, nobody can confirm the conditions inside the coconut tree whether it is destroyed or not and with or without visible signals of damages from the outside. According to Dembilio and Jacas (2010), the morphological and biological characteristics of each one developmental instars are various among researches. (El-Shafie et al., 2013; Ju et al., 2011; Salama et al., 2009; Faghih, 1996; Kalshoven et al., 1981)

To date, according to Department of Agriculture (DOA) Malaysia, the lifecycle of RPW is 2-5 days for egg, 25-105 days for larva, 14-21 days for pupae and 60 – 105 days of adult which is stipulated in the Standard Operating Procedure (SOP) Malaysia (2017) on controlling the pest of RPW in Malaysia (DOA, 2017). It means that it took about 3.5 month of repeat cycle. Table 1 lists the different biological parameters, established by previous researches for each one of the developmental instars of R. ferrugineus.

Table 1 The development period of R. ferrugineus. (Adapted from: Ávalos et al., 2014; Dembilio & Jacas, 2010)

Development period (days)				Previous researches
Egg	Larva	Pupae	Total	
3 - 5	33 - 46	20 - 36	-	(El-Shafie et al., 2013)
3 - 4	30 - 67	23 - 36	-	(Ju et al., 2011)
-	69 - 128	16 - 29	-	(Salama, et al., 2009)
1 - 6	41 - 78	15 - 27	-	(Faghih, 1996)
-	44 - 210	-	105 - 210	(Kalshoven et al., 1981)

For instance, the extremity of the palm leafstalks become worn and histolytic with yellowish and brown colour, as well the top crown colour becomes pale-green. The green leaves around the palm crown may deform due to deterioration of the support axes, resulting in an umbrella-like appearance. A viscous and sticky brown liquid substance oozes out from small holes in the trunk of the palm trees, with emergence holes for the adult RPW occurring in the crown or trunk. Finally, the fine pieces of chewed-up fibers emerge from the points (Bannari et al., 2016). In the previous researches, several methods have been implemented including which introduced by the Integrated Pest management (IPM). This include controlling and monitoring in ecology (e.g. insects and surroundings), biology (lifecycle), physical (pheromone trap) and chemical (e.g. pesticide and trunk injection). Apart from that, several advanced early detection methods also have been proposed including visual inspection (CABI, 2017), acoustic sensor (Victoria Soroker et al., 2016; Mankin, 2012; Siriwardena et al., 2010), thermal imaging (Golomb et al., 2015; V. Soroker et al., 2013), specially trained sniffer dogs (Nakash et al., 2000). All these have been tested and investigated in order to assist in identifying the infestation at the early stages. However, each of these methods has encounter many issues especially in implementation because of different problems occur with different conditions. Based on the literature review, the symptomatology of a palm tree infested by R. ferrugineus varies depending on the palm tree species, infestation level, and attack area. In order to identify those symptoms, especially on the early stage of infestation, the lifecycle (i.e. from egg to larva, pupae and adult instars) of the present and absent insects need to be confirmed. The coconut tree may show different stage of severity which similar to severity level of palm species as outlined by V. Soroker (2013) in Table 2.

Table 2 The stage of Severity of RPW infestation at palm tree (V. Soroker et al., 2013)

Stages of Severity	
Stage	Description
1	Two differences – frond in V shape or in a zigzag position, holes in one or more leaves.
2	Some leaves collapsed, asymmetric inner leaf growth.
3	Crown partially collapsed, no new inner leaves.
4	All crown leaves collapsed into "umbrella" shape, tree cannot be recovered and chopped down.

Remote sensing technique is becoming an alternative as it can assist in detecting the attacks by RPW using the satellite imagery. The early stress detection of the tree before visual damage symptoms are detectable through vegetation indices over few decades of numerous study. (Lichtenthaler et al., 1996). Therefore, it is believed that different stage of coconut tree stress-attack can be differentiated using the empirical data with relation to spectral bands. The multispectral data of Sentinel 2A. Sentinel 2A comes with multispectral instrument (MSI) sensor with blue (band 2), green (band 3), red (band 4) and near infrared (band 8) at 10-meter spatial resolution. (SUHET, 2013). Additionally, Sentinel 2A image can access the vegetation status (Das et al., 2019; Sonobe et al., 2018) same like other multispectral images not only because of available

bands but the vegetated area which can be sensor-detected is not much comparable with other high resolution satellite such as SPOT and Landsat (Taylor et al., 2011). Thus, the suitable VI's can be identified based on the spectral bands. Table 3 below shows the spectral bands that are used with different algorithm of VIs'. The algorithm used the green (G) band, red (R) band infrared (IR) and near infrared (NIR) band of the spectral reflectance.

Table 3 The algorithm of vegetation indices based on spectral bands

Algorithm (VI)	Previous Implementation (Author, year)
NDVI = $(NIR - R)/(NIR + R)$	(Rouse et al., 1974)
RDVI = $(NIR - R) / \sqrt{NIR + R}$	(Roujean & Breon, 1995)
SQRT (IR/R) = $\sqrt{NIR/R}$	
DVI = $NIR - R$	(Richardson & Wiegand, 1977)
GVI = $(NIR - G)/(NIR + G)$	(Gitelson et al.,1996)

The use of spectral vegetation indices, calculated as a ratio or normalized difference from near-infrared (NIR, 750–1350 nm) and visible bands, has become one of the most common remote-sensing approach to retrieve biophysical variables over the past three decades (Colwell, 1974; Tucker 1979; Sellers 1985). Among all of the VI algorithm used, GVI and RDVI is the later used compared to DVI and NDVI. GVI is first implemented by Gitelson et al. (1996) that based on green and NIR spectral band (Panda, Ames, & Panigrahi, 2010) while Roujean and Breon (1995) introduced RDVI. NDVI is frequently used among reserchers in many studies, but in high vegetation cover, this index is saturated and also its relation with biophysical vegetation is not linear ((Haboudane et al., 2004; Vescovo & Gianelle, 2008; Jiang et al., 2008; Baret & Guyot, 1991; Gitelson, 2004). In contrast, the non-saturated index can be seen in low vegetation cover has been discussed by Barati et al. (2011). Although this has long been the traditional medium to highlight a particular property of vegetation, the introduction of further methods for detecting the coconut tree stress using these indices are currently under-used in the commercial, government, and scientific communities.

2. Materials and Methods

2.1 Description of Study Area

The study employs one coconut plantation of two-hectare coverage in Arau, Perlis with the total number of 395 coconut tree as shown in Figure 1. The geographic extent of the coconut tree plantation is found between latitudes of 6°27'35.84"N to 6°27'25.27"N and longitudes of 100°16'54.9"E to 100°16'54.8"E. The ground data sampling is done by gathering the ground data (census) which were collected at every coconut tree stands using a handheld Global Positioning System (GPS) unit (GPSMAP®62sc, Garmin Ltd., KS). The coordinate systems of the 395 samples were registered using World Geodetic System (WGS) 84 coordinate system. Then, the 395 ground data (census) will be compared with the VI extracted from the Sentinel 2A. The 395 sampling points will distinguish the severity level of coconut tree stress (i.e. healthy, early, moderate and severe). Apart from that, ground observations for vertical and horizontal control are recorded using GPS technique. The UAV image is used for reference (image to image registration) in order to geometric corrected the multispectral Sentinel 2A image of 2018 which is provided by the European Space Agency (ESA). This image is used to extract the VI for NDVI, RDVI, SQRT (IR/R), DVI and GVI in order to determine the coconut tree stress.

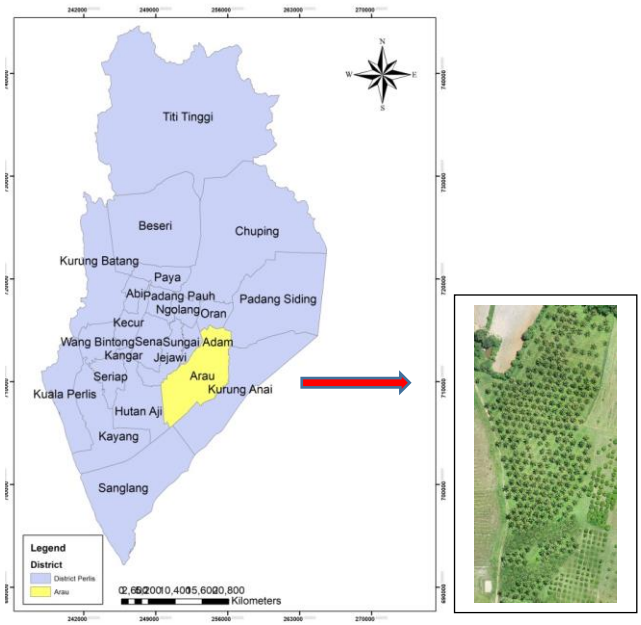

Figure 1 Location of study area and ground data sampling

2.2 Image Processing and Accuracy Assessment

The raw data obtained from the satellite sensors has to undergo a few image pre-processing (Jensen & Lulla, 1987) such as image subset and image enhancement in order to maintain the quality of the satellite image. The image pre-processing and image processing is done by using ERDAS Imagine 2014 and ArcGIS 10.4 software. Next, the VI will be extracted, for example, the NDVI extracted values will be between -1 to +1 (Conte et al., 2007; Panda et al., 2010).

Supervised classification technique is used in this project for quantitative analysis of multispectral image data. The classification is done by clustering the pixels in a dataset into classes corresponding to the testing classes. There are many supervised classification techniques (Lillesand et al., 2004) including Mahalanobis, Minimum Distance, Parallelepiped, Maximum Likelihood and Spectral Angel Mapper (SAM). But in this project, Maximum Likelihood technique is implemented.

The actual (i.e. census) data and predicted (i.e. classified) is done by a classification system. The accuracies of the pixel based classifications obtained were evaluated in terms of overall accuracy, producer's accuracy, user's accuracy metrics (Congalton, 1991). The percentage of overall accuracy was calculated using the following formula:

$$\text{Overall accuracy} = \frac{\text{Total number of correct samples}}{\%\text{Total number of samples}} \times 100$$

3. Findings and Discussion

3.1 Vegetation Indices

From our first visual analysis of the five VIs tested in this study, two provided results that showed some potential for correspondence with our field observations (Figure 2 and Figure 3). The NDVI enhanced the biomass density more than the GVI, which was expected because NDVI has been developed for purposes such as this. However, both indices show the top of the palm tree canopies almost uniformly with considerable biomass density. The spatial pattern discrimination of the various levels of attack is due to the palm tree crowns remaining green, despite earlier RPW attacks. Consequently, these VIs were sensitive only to vegetation cover and biomass density, but not to the pigmentation or physiological variation. Based on this visual analysis and interpretation, and the fieldwork (sampling and inspection), these VIs could discriminate among different levels of RPW stress- attack. This was confirmed by statistical regression tests that considered the four identified classes in the field (healthy; early attacked; moderate attacked; and severely attacked). For each class, 395 sampling points were located and the values of NDVI and GVI were extracted. Figure shows the results from first degree polynomial functions fitted through the full sample data set. For NDVI, the magnitude of separation amongst all classes was relatively high. NDVI showed a marginally better distinction between all classes however, it could significantly separate early and moderate attacked trees. Consequently, it is evident that the considered VIs extracted from Sentinel data are appropriate for RPW stress-attack detection.

It is clear from the results that, NDVI is the best reflectance index to explain variability of trees stress. The producer accuracy, user accuracy and overall accuracy are being accessed through four stages which are Healthy, Early, Moderate and Severe. The result of VI such as NDVI, RDVI, SQRT (IR/R), DVI and GVI are analyzed together with the severity level of coconut tree stress in a map representation (Figure 4 – 8). The map of coconut tree using the five methods are presented using green colour (lightness to brightness), orange and red colour to differentiate different stages of coconut tree stress. The method presented in this work is sufficiently general to be applied to classify the healthy and unhealthy coconut tree with respect to monitor vegetation characteristics (e.g. leaf area index (LAI), chlorophyll content, etc.)

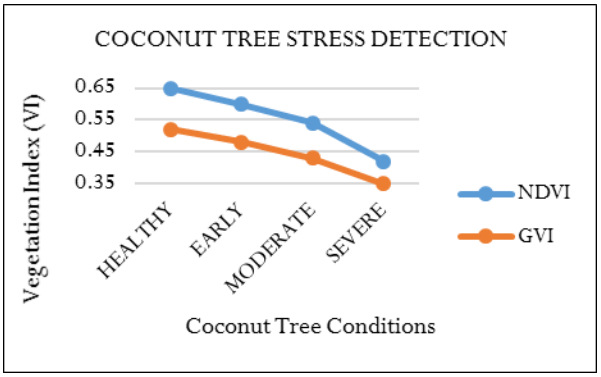

Figure 2 NDVI and GVI behavior for RPW stress-attack conditions

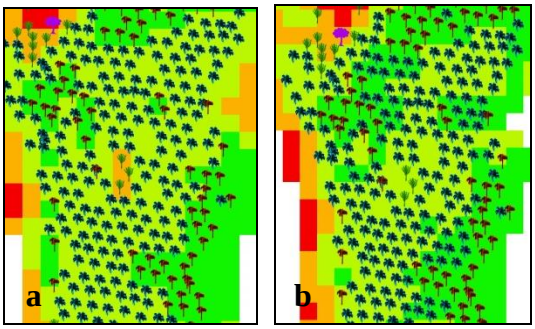

Figure 3 Derived maps of coconut trees: (a) NDVI; (b) GVI

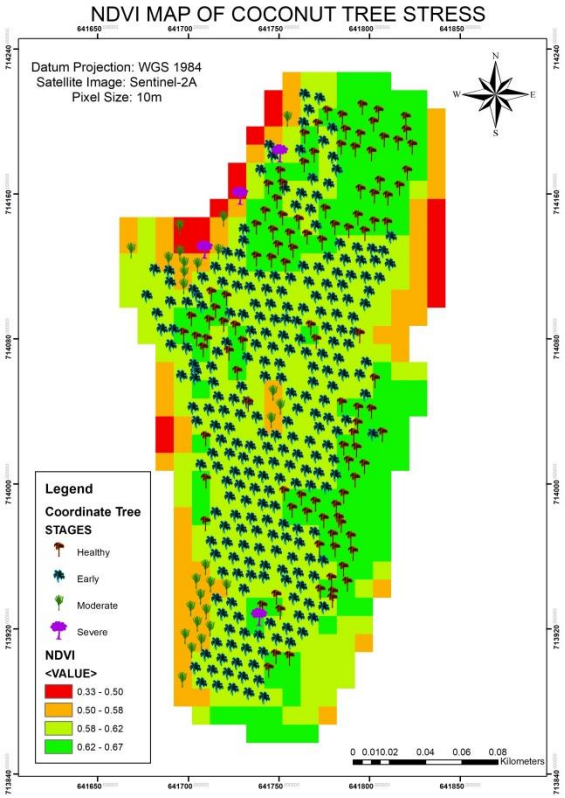

Figure 4 NDVI map of coconut tree stress

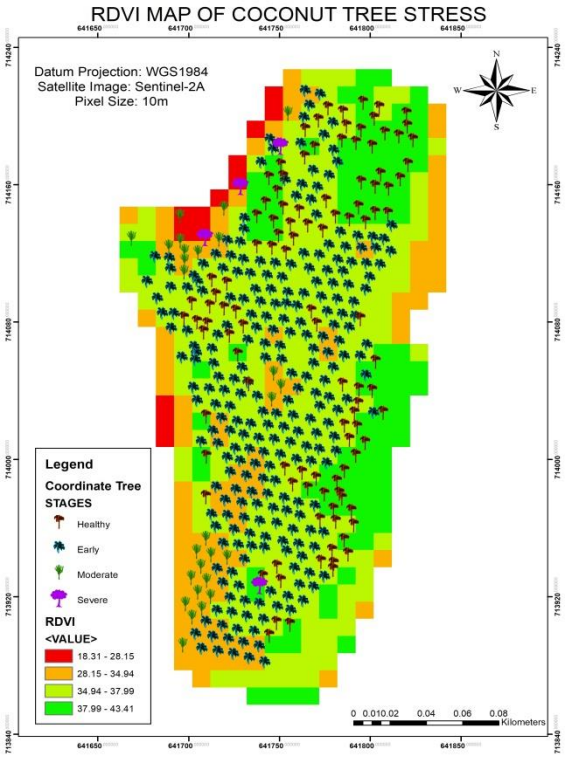

Figure 5 RDVI map of coconut tree stress

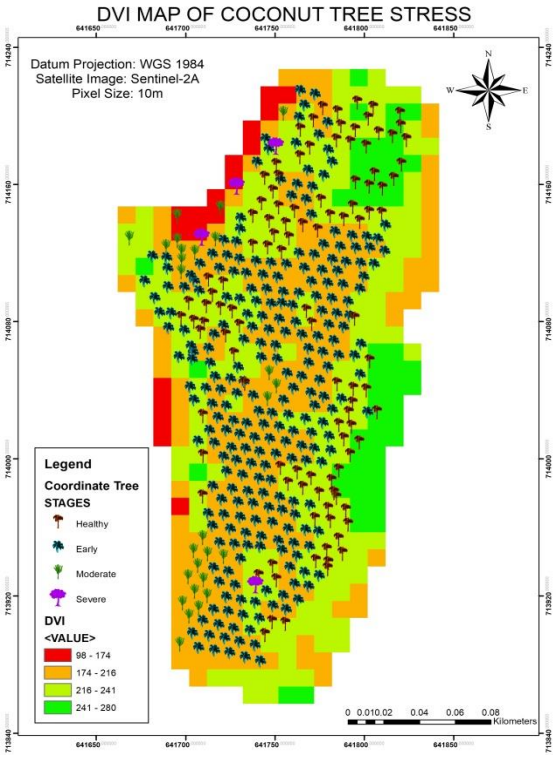

Figure 7 DVI map of coconut tree stress

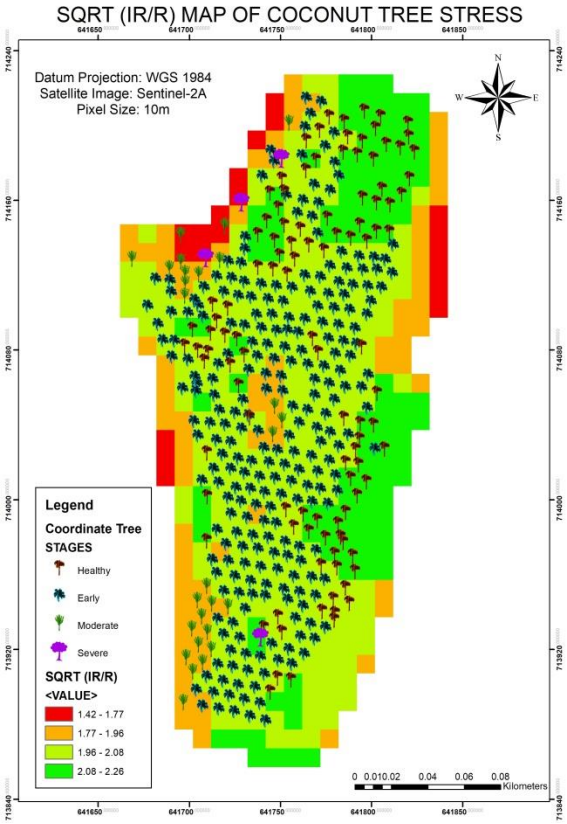

Figure 6 SQRT (IR/R) map of coconut tree stress

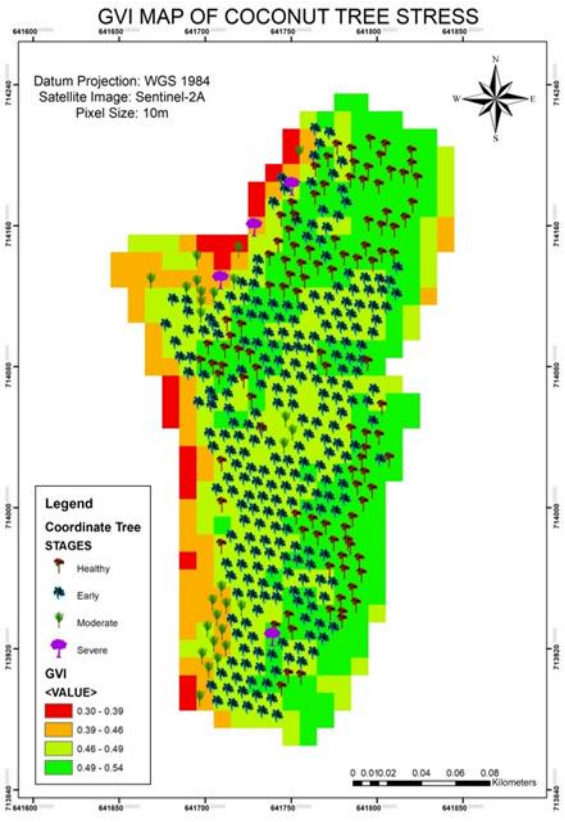

Figure 8 GVI map of coconut tree stress

The overall accuracy for NDVI, RDVI, SQRT (IR/R), DVI and GVI can be seen in Table 4 – 8 below. The highest accuracy is NDVI = 91% followed by SQRT (IR / R) = 71%, RDVI = 61%, GVI = 55% and the lowest accuracy is DVI = 30%.

Table 4 Accuracy Assessment of NDVI method

		Actual				
		Healthy	Early	Moderate	Severe	Total
Classified	Healthy	97	2	0	1	100
	Early	12	236	0	0	248
	Moderate	0	17	25	1	43
	Severe	0	0	2	2	4
	Total	109	255	27	4	395

Overall Accuracy	91%

Table 5 Accuracy Assessment of SQRT (IR / R) method

		Actual				
		Healthy	Early	Moderate	Severe	Total
Classified	Healthy	59	1	0	1	61
	Early	49	193	0	0	242
	Moderate	1	61	25	1	88
	Severe	0	0	2	2	4
	Total	109	255	27	4	395

Overall Accuracy	71%

Table 6 Accuracy Assessment of RDVI method

		Actual				
		Healthy	Early	Moderate	Severe	Total
Classified	Healthy	28	0	0	0	28
	Early	81	185	1	2	269
	Moderate	0	70	24	0	94
	Severe	0	0	2	2	4
	Total	109	255	27	4	395

Overall Accuracy	61%

Table 7 Accuracy Assessment of GVI method

		Actual				
		Healthy	Early	Moderate	Severe	Total
Classified	Healthy	91	121	0	1	213
	Early	17	105	3	0	125
	Moderate	1	28	21	1	51
	Severe	0	1	3	2	6
	Total	109	255	27	4	395

Overall Accuracy	55%

Table 8 Accuracy Assessment of DVI method

		Actual				
		Healthy	Early	Moderate	Severe	Total
Classified	Healthy	12	0	0	0	12
	Early	93	82	1	2	178
	Moderate	4	173	24	0	201
	Severe	0	0	2	2	4
	Total	109	255	27	4	395

Overall Accuracy	30%

Table 9 The maximum and minimum index value of NDVI and GVI method

Year (2018)	NDVI	GVI
Maximum value	0.673	0.548
Minimum value	0.339	0.308

Table 9 shows the contrast of maximum and minimum value of VI extracted from Sentinel-2A images in 2018. It can be concluded that NDVI and GVI give significant value of VI compared to DVI, RDVI and SQRT (IR/R). It shows that the healthiness of tree stress is ranged between 0.308 – 0.673.

3.2 Comparison The Accuracies Of Different Vegetation Indices

Table 10 Correlation coefficient between vegetation indices for classified (from Sentinel data) and actual (from ground observation)

Vegetation Index	NDVI	GVI	SQRT (IR/R)	RDVI	DVI
Correlation	0.996**	0.567**	0.917**	0.863**	0.366**

Note:** Correlation is significant at the 0.05 level (two-tailed)

A Pearson correlation test showed that the relationship between classified vegetation index (i.e. NDVI) and actual vegetation index (Table 10) are statistically significant, $r = 0.996$, $p = .004$.

Table 11 Relationship between NDVI, GVI, SQRT (IR/R), RDVI and DVI indices and different curve estimation methods

Method	NDVI		GVI		SQRT (IR/R)		RDVI		DVI	
	R^2	p	R^2	p	R^2	p	R^2	p	R^2	p
Linear	**0.993**	0.007	0.321	0.679	0.840	0.160	0.746	0.254	0.134	0.866
Exponential	0.789	0.211	0.643	0.358	0.660	0.340	0.508	0.492	0.172	0.828
Logarithmic	0.708	0.292	0.446	0.554	0.561	0.439	0.538	0.462	0.234	0.766
Polynomial	**0.993**	0.007	0.741	0.259	0.856	0.144	0.819	0.181	**0.996**	0.004

Note: Bold values represent significant regressions with $p < .05$

The polynomial method seems to be advantageous compared with the majority of studies on different vegetation indices (Table 11). In this analysis, R^2=0.558 show that 55.8% of total variation in classified point of tree data is explained by the total variation of actual point of tree. However, the good fit model (refer Table 12; Model Summary, ANOVA and coefficients) is shown significant (p- value = .000). A regression parameter test showed that the relationship between actual point of tree and classified point of tree is statistical significant, p-value = .000. In details, for each additional actual point of tree, classified point of tree will significantly increase by 0.805 unit.

Table 12 Analysis of regression parameter of classified and actual point of tree

Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.747[a]	0.558	0.533	68.891		
a. Predictors: (Constant), classified						
ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	107795.643	1	107795.643	22.7	.000[b]
	Residual	85428.107	18	4746.006		
	Total	193223.750	19			
a. Dependent Variable: actual						
b. Predictors: (Constant), classified						
Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	19.235	22.708		0.847	0.408
	classified	0.805	0.169	0.747	4.766	0.000
a. Dependent Variable: actual						

4. Conclusion

The results indicate that VI such as NDVI and GVI as derived from Sentinel 2A multispectral imagery offer a potentially viable and important alternative for discrimination the severity level of RPW stress-attack. Therefore, it can be concluded from this positive results that this proposed method can be further testing with other open access data, perhaps analyze with other parameters that might influence the RPW outbreak especially on palm tree species.

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Factors Influencing Supply of Affordable Housing in Nigerian Cities Using Confirmatory Factors Analysis

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ABSTRACT

Despite the Nigerian government's efforts to provide affordable housing to the country's low and medium-income groups, the efforts have not yielded the desired results. These have led individuals, families, and organisations to supply housing either on their own or on a rental basis. Although several scholars have attempted to investigate the problem, none has found a realistic solution. Only a few scholars have also used the confirmatory factor analysis to investigate and isolate and the critical factors influencing housing production and supply to the low and medium-income groups in the country. This research attempts to bridge this gap. Ekiti, Lagos and Oyo States were used as case study for the research. Two hundred and ten (210) survey questionnaires were administered on real estate developers using the purposive sampling technique. The data was analysed in SPSS. The study revealed that land accessibility, funding and demographics were found to be the significant factors influencing the supply of low and medium-income housing in the study area. The study recommends direct government intervention in housing supply in favour of an enabling environment for the housing sector in the country.

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1. Introduction

Housing is a basic need and a human right (Obi and Ubani, 2014; Nubi, 2011; Mojdeh and Abdollah, 2013). Housing is an indicator of the individual's standard of living and personality. Invariably, housing has become a priority for the attainment of a decent living standard for both the rural and urban dwellers (Ajibola *et al*. 2012, Agbola and Adegoke 2006). Additionally, housing is also worthy of attention as it is a crucial sector in the economy (Ademiluyi *et al*., 2008). Affordable housing is housing that incorporates all essential and fundamental costs and meets the needs of the low and medium-income families (Abelson, 2009). The inability of the majority of the Nigerian population to acquire affordable housing has been of concern to academia and the private sector, especially when it is evident of the wastefulness and the inability of the Nigerian public sector to provide affordable housing for the majority of the population (Henshaw, 2010).

There are, however, global movements that support a private sector driven alternative. In Nigeria, the private sector appears to be the second-largest producer of affordable housing after the individual (Agbola and Kasim, 2007; Taiwo *et al*., 2017). Hence, the role of the estate developer in the provision of affordable housing to Nigerians is of great importance. The Nigerian government acknowledged this view and has proposed various measures to encourage the private sector assumes the principal role in affordable housing production and supply process. The measures include the formation of Real Estate Developers Association of Nigeria (REDAN), Building Materials Producers Association of Nigeria (BUMPAN). The reduction imposed in the interest rates payable on national housing fund to individuals from

REDAN and the re-structuring of the housing finance sub-sector to include the presentation of free mortgage markets.

The population of South West Nigeria is 32.5 million and accounts for 21per cent of the total population of Nigeria (NBS, 2012). The size of the population has made it necessary to look into the activities of real estate developers in the region. The region's housing deficit is about 5 million or 29 per cent of the total Nigerian housing deficit (Lagos State Ministry of Physical Planning, 2010). More than 91 per cent of the population of Lagos with a density of about 20,000 people per sq. km lives in the metropolis (Lagos State Ministry of Physical Planning, 2010). The Lagos metropolis has an occupancy ratio of 8-10 persons per room, and 73 per cent of households occupy a one-room apartment. Overcrowding and homeless has become a norm in the region. Social problems, fire outbreaks and health-related issues are common in most of the urban centres. The housing deficit has caused many issues in the region. Several factors have influenced the provision of affordable housing in the country. These include land accessibility (Nubi, 2008), availability of funding (Akinmoladun and Oluwoye (2007), the demographic status of the people, government interventions (U.N. Habitat, 2011), provision of subsidy (Agbola and Olatubara, 1989), availability of tax breaks and land legislation (Melissa, 2013).

This study examines the factors influencing the supply of affordable housing in Nigerian cities. It uses the confirmatory factors analysis to identify the factors influencing the production and supply of housing to the low and medium-income groups in Nigerian cities. Earlier studies on affordable housing have not identified these critical factors. This study, therefore, bridges this gap.

1.1 Factors Influencing the Production of Affordable Housing in Nigeria

Many internal and external factors influence the production of affordable housing in Nigeria. The external factors revolve around the cost of the housing, for example, land procurement (Kuma, 2015), provision of infrastructure in and around the site and adjoining sites, planning and design (Ifesanya 2012), administration and community services (Uganabo, 2011), financing costs, amortisation periods and subsidies (Agbola and Olatubara, 1989). The internal factors primarily refer to the socio-economic situations of the targeted groups or individuals, for example, the monetary and attributes of the group, which is further influenced by employment opportunities, occupation types and wages (Nubi,2008), and the expenditure profiles Ajibola *et al*., 2012). Besides, factors such as objective gatherings, social characters like family unit or sizes, family structures, needs, traditions, wants and desires, and priorities also play significant roles (Habte, 2010).

1.2 Global Experiences on Affordable Housing

Some large urban communities such as in South Africa, Kenya, Tanzania, Thailand, Indonesia and India, the working-class with higher earnings see affordable housing as exceptionally attractive. These working-class from the African or Asian countries who have considerable assets also invest in housing in different nations even though they do not live in these countries. In Africa, the United Nations estimated that, on average, for every new housing unit built in the city, at least ten new families migrate from the rural areas to occupy the new housing unit. The migration into the city for housing compounds the housing supply problem in the cities. One of the consequences of the supply gaps is the pressure generated on house prices and rent levels, with resultant housing stress and non-affordable housing among the low-income households (Gabriel *et al.,* 2005). Research conducted by some scholars (Onibokun, 1990; Aribigbola, 2006; Ibimilua and Ibitoye, 2015), concluded that housing problems occur in almost all countries. Developed countries still have pockets of isolated homeless people, just as the case in developing countries.

Making housing accessible and affordable to the urban population has been a continuous struggle for the government of Nigeria, both at the Federal and the State levels. The shortage of affordable housing has created urban slums and overcrowding in the cities. Table 1 shows the various government plans and efforts to increase the supply of housing in Nigeria. However, from 1962 to 1996, the achievement rate was just 17 per cent, and the shortfall is over half a million housing units. In 2001, the total housing units in Nigeria was 15,221,000 (UN-Habitat, 2001) while in 2006, the total housing stock was 28,197,085 units (NPC 2010). It was estimated that by 2020, the country's housing needs is 102,111,081 units (Onibokun, 1990). At present, the country's housing deficit is estimated at 17 million units (Centre for Affordable Housing in Africa, 2015). Therefore, there is needs to produce 800,000 per annum as against the current 100,000 per annum (Centre for Affordable Housing in Africa, 2015).

On the global scale, the housing industry in the Philippines strongly believes that every Filipino family has the right to live with dignity in the comfort of one's own home, irrespective of their economic status. The industry strives to eliminate the deficit of 3.9 million in the housing sector by the year 2030. Therefore, the country has generated and mobilised funds for end-user financing, improved the regulatory environment for housing development and implemented a comprehensive government housing subsidy for targeted groups. Namely, the country has vigorously pursued the low-cost, socialised and economic housing unit (World Bank Group, 2015). In Indonesia, where about 70 per cent of the total workforce is in the informal sector i.e. non-credit worthy enterprises (Utmo, 2014), the vast majority of low-income housing is self-help housing, which is incremental housing based on financial ability. To address the housing need in the country, the government embarked on multi-story low-income rental housing, unique purpose house, quality improvement of self-help housing and neighbourhood improvements, and the establishment of housing microfinance institutions and secondary

Table 1 Past Government Achievements in the Housing Sector in Nigeria

Plan Period	Target	Achievement		Shortfall	
		Units	%	Units	%
1st NDP (1962-68)	61,000	500	0.8	60.500	99.2
2nd NDP (1970-74)	59,000	17,700	30	41,300	70
3rd NDP (1975-80)	202,000	28,500	14	173,500	86
4th NDP (1980-85)	200,000	47,200	24	152,800	76
1994-1996 Rolling Plan	121,000	17,792	15	103,208	85
Total	643,000	111,692	17.3	531,308	82.7

mortgage facility corporations. To address affordable housing issues in Malaysia, the government set up housing strategies through a consecutive five years' agenda. The agenda includes low cost and affordable public housing programmes such as Projek Perumahan Rakyat that's created purposely for the middle-income households in central urban areas. Hence, Projek Perumahan Rakyat 1 Malaysia (PR1MA) and My First Home Scheme designed to help young adults who have just entered the workforce to purchase their first residential property with 100 per cent financing from financial institutions (Samad *et al.,* 2016). The My Home Scheme, initiated for the low-income group, saw the involvement of the private developers in building lower-cost housing. The Rumah Mesra programme made possible with the aid of government subsidies targets low-income groups.

In several Europeans countries like Bulgaria, Estonia, Hungary, Lithuania Latvia and Slovakia, the local authorities provide social housing for the people in need. More recently, in Austria, Greece, Germany, Italy and Spain, other entities such as communal developers and private owners, public companies or non-profit or limited profit associations, companies and cooperatives provide social housing. In Romania, housing for its population was achieved with public funding (Alpopi *et al.,* 2014). In South America, for example, Columbia, the self-help program was used to addressing housing supply, where the government assist the people through tax-breaks to increase housing supply and to deal with the problem of affordable housing. Other strategies include employer engagement, where employers could support local or regional efforts to increase housing supply. In the attempt to supply more housing, preservation of existing housing is considered critical. The country went further as to build new residential neighbourhoods on underused land near metro stations; construct high-density residential and mixed-use development along transportation corridors. This approach recognises that transportation offers people greater access to jobs, and reflects the importance of the cost of transportation in affordable housing. Besides, such an approach is likely to limit the opposition of the community (Blumenthal *et al*., 2016).

In North America, for example, in Mexico, housing development is private sector driven characterised by massive housing construction. The strategy used was to design an integrated housing policy. Other strategies include improved inter-institutional coordination, procurement of dignified housing for all Mexicans, the planned reduction of housing deficit and the implementation of a transition towards an intelligent, sustainable urban development model. The creation of the national registry of land reserves which was meant to provide certainty to developers regarding the land location was also put to use. Others include a subsidy program which was usually published six months before its commencement, and the strengthening of institutions that have a direct bearing on housing through loan guarantee, financing, and increased budgetary allocation for housing subsidy program (World Bank Group, 2014).

In addressing the housing supply issues in many countries of Africa and South Africa, attention shifted from state involvement in the provision of housing towards a support approach housing supply. The ad-hoc exploration of alternative approaches led to the emergence of the aided self-help movement. This strategy implicitly shifts housing supply away from state housing provision to a support approach system for housing. Other methods include the site and services and settlement upgrading schemes (Lombard, 1996).

1.3 Affordable Housing Strategies and Issues in Nigeria

Nigeria's housing strategies are similar to those adopted in some South American countries. Several affordable housing schemes exist in Nigeria which is either fully funded by the government or in partnership with the government under the public-private partnership (PPP) schemes, site and services schemes and the low-cost housing undertaken during the Shagari era. Depending on the prevailing situation, some selected developers were given concessions by the government to provide affordable housing, as was the case of the Federal Capital Territory (Jibril, 2009; Makinde, 2014).

It has become challenging for private financial institutions to grant loans to the people in most of the emerging industrialised and third world countries. Low per capita earnings and the absence of job security has made these financial institutions either unwilling or not able to grant long term credit facilities to accelerate the development of the urban owner-occupied sector (Dung-Gwon and Mallo, 2011). Additionally, these governments are also faced with scarcity and shortage of funds and other resources to supply

housing on a scale large enough to match the needs of the low and middle-income households (Balchin and Rhoden, 2002). Therefore, based on the above concerns, the objective of the study is to identify various factors affecting the supply of affordable housing in Nigeria as perceived by the real estate developers using confirmatory factor analysis.

2. Methodology

2.1 Theoretical Dimensions

The study adopts the Symbolic Interactionism theory approach to highlight the potentials of factors influencing the supply of affordable housing in Nigeria as perceived by real estate developers. Symbolic interactionism is a social theory, which states that human beings act towards social objects in terms of the meaning or symbolism they attribute to those objects, rather than the actual objects' or intrinsic value or character (McClelland, 2005; Carter and Fuller, 2015). The theory is used to explain that with all the challenges facing the housing sector, individuals still desired to own or rent a house because of the primary role it plays. Therefore, in relation to the factors influencing the supply of affordable housing in Nigeria, the study applies the conceptual framework (Figure 1) where affordable housing is the independent variable with two sub-variables or dimensions of (1) Government Intervention which also function through tax breaks and provision of subsidy and (2) Affordable Housing Supply Factors with three dimensions: land accessibility, availability of funding, and demographics. The dependent variable is homeownership. The required data will be derived from real estate developers.

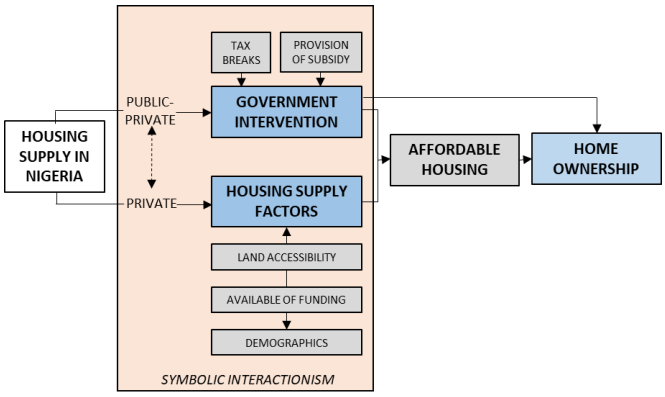

Figure 1 Theoretical Framework

2.2 Area of Study and Data Collection

The instrument used for the survey was a questionnaire, and the sampling frame was real estate developers registered with the Real Estate Developers Association of Nigeria (REDAN). A total of 210 questionnaires were administered on the top management levels of real estate developers in south-western Nigeria, namely the states of Ekiti, Oyo and Lagos as depicted in Figure 2 and Table 2.

2.3 Instrument Reliability and Method of Data Analysis

Two hundred and two questionnaires were returned and found useable for analysis. SPSS Version 22.0 and the SEM/Amos software were used for the analysis. Examination and screening of data were carried out to test for normality leading to 80% at z-value ± 1.96. Additionally, outliers were deleted and exploratory factor analysis conducted. The Bartlett's test of Sphericity, Kaiser-Meyer-Olkin was 0.726 and was found to be adequate for further study, as shown in Table 3. All the Cronbach Alpha met the threshold ≥ 0.7 i.e. Homeownership (0.700), Government intervention (0.875), Tax break (0.871), provision of subsidy (0.718), Land accessibility (0.880), Funding 0.883, and Demographics (0.756); and were found to have right internal consistency. The structural equation models (SEM) was used in furtherance to the exploratory factor analysis. SEM is a second-generation multivariate analysis technique developed to overcome some limitations in the traditional Ordinary Least Square (OLS), especially when dealing with latent constructs. The use of SEM/AMOS is increasingly popular among researchers and academia due to the need to develop theories concerning the relationship among certain hypothetical constructs.

Based on Awang (2014), this research complied with the recommendations that confirmatory factor analysis (CFA) be utilised to discover the construct validity of the instrument used. The verification of observed variables can be done using the confirmatory factor analysis (CFA). Confirmatory factor analysis usually (CFA) is a statistical technique which is used to verify the factor structure of a set of observed variables.

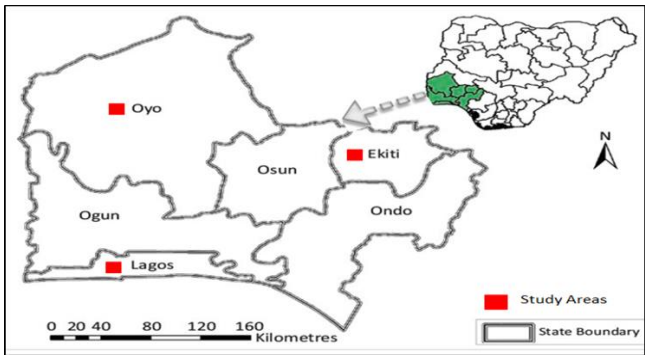

Figure 2 Map of South-West Nigeria showing the selected three states (Taiwo, 2018)

The CFA gives room to the researcher to test the hypothesis for association between the measured and the latent constructs Data gathered for this research were therefore quantified; in essence, prominence was given to the quantitative approach based on the data collected through the use of questionnaire administration.

Table 2 Sampling Frame of Real Estate Developers

S/N	State	Developers	
		No of Developers	**Sample**
1	Ekiti	36	16
2	Oyo	25	12
3	Lagos	407	182
Total		**468**	**210**

Table 3 Kaiser-Meyer-Olkin Measure of Sampling Adequacy

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.726
Bartlett's Test of Sphericity	Approx. Chi-Square	17715.897
	Df	1596
	Sig.	.000

It was considered that quantitative measures would usefully supplement and extend the qualitative analysis. Score values below 0.3 as recommended were deleted and those above 0.3 were retained for exploratory and confirmatory analysis. The first stage entails the development of a measurement model using confirmatory factor analysis to obtain the best fitting group of items to represent each constructs scale computed. SEM/AMOS allows for modelling theorised relationships with the sole aim of testing a theoretical model with the empirical data gathered from the field. In AMOS Graphics, the rectangles represent the observed variables, while the ellipses represent the latent constructs. The research questions for the study include; what factors affect affordable housing supply in Nigeria, to what extent have these factors influence affordable housing in Nigeria? The research is limited to land accessibility, funding availability, demographics, government interventions, tax breaks and availability of subsidy in the provision of affordable housing which were derived from the extensive literature reviews through the use of exploratory factor analysis (EFA) and later the application of confirmatory factor analysis.

3. Results and Discussion

A total of 202 out of the 210 questionnaires administered on the real estate developers were retrieved and found useable for analysis, hence, a response rate of 96 per cent and met the approximate 75 per cent response rate for interviews, as suggested by Kelly *et al*. (2003). The top management level of the real estate developers is the primary respondents to the questionnaire administration. The research found that 28 per cent of the real estate developers had established their private practice during 2000 and 2005 period. A majority of the real estate developers, 54 per cent, were established between the year 2006 and 2016. This period marked the beginning of much awareness about the real estate developers' contributions to the provision of housing. The scenario led to the establishment of the Real Estate Developers Association of Nigeria (REDAN). A tiny proportion, about 1 per cent of the developers, declined to disclose the year of their establishment.

Most of the participants employed by the real estate developers were direct labour, and subcontractors hired some. Majority of the respondents were on the pay-roll of developers. The research also found that 36 per cent of the real estate developers had a workforce of 1-10 staff, 26 per cent with between 11-20 workforce and 14 per cent have a workforce of 21-40 people, respectively. However, Companies with a workforce of more than 40 people accounts for about 23 per cent. The real estate developers were also sources of employment for several professionals and administrative staff, other than the skilled and unskilled labour. The research further found that from the 202 developers interviewed, a total of 9,463 employment opportunities were created and these are as follows: professionals 24 per cent, administrative staff 17 per cent, skilled labour 19 per cent, while, unskilled labour constituted 40 per cent.

With regards to the professional affiliations of the respondents, the Nigerian Institution of Estate Surveyors and Valuers' members (NIESV) accounted for 45 per cent, the Architects Registration Council of Nigeria (ARCON) members 14 per cent, the Nigerian Institution of Building (NIOB) 7 per cent and the Nigerian Institution of Quantity Surveyors 12 per cent. Twenty-two per cent belonged to other related fields in engineering. Fifty-two per cent of the real estate developers are registered with the Real Estate Developers Association of Nigeria (REDAN), the umbrella association of practising developers, while, 48 per cent are not registered with REDAN.

On the number of projects so far undertaken by the real estate developers, 23 per cent disclosed that they had taken less than five projects from their inception, 15 per cent had done 5-9 projects, 17 per cent had between 10 and 14 projects, 39 per cent between 15-19 projects from the time of their establishment. A majority of

the real estate developers did not have many projects to handle. This could probably be due to factors such as the scarcity of funds and other social and economic factors. Housing projects are capital intensive, and in order to deliver quality housing, much capital is needed. Real estate developers disclosed that they obtained loans from Banks when sourcing for funds. The inability of the private and public developers to have access to mortgage financing contributed to their failure to meet the housing demand of the masses.

Forty-nine per cent of the housing units built were blocks of flats, 31 per cent were duplexes, 7 per cent were detached housing, 10 per cents were semi-detached housing and rooming housing accounts for 3 per cent. The value of the projects handled by the real estate developers was as follows; the value of less than USD3,174.60 accounted for 16 per cent, between USD3,174.60-USD76,190.47 was 39 per cent, and projects valued between USD 79,365.08- USD107, 936.51 accounted for 14 per cent. About 30 per cent had undertaken projects valued between USD111,111.11- USD139,682.53 and only 1 per cent had handled projects worth more than USD142,857.14. The findings above stipulate that the availability of funds for the real estate developers to embark on the construction of affordable houses were scarce, insufficient or limited. The average cost of a flat of less than USD9, 523.81 constructed by the real estate developers accounts for 69 per cent, a duplex house of USD19, 047.62 was 15 per cent, a detached house of USD15, 873.02 was 6 per cent, semi-detached of less than USD15, 873.02 was 5 per cent and a rooming home of USD15, 873.02 was 5 per cent.

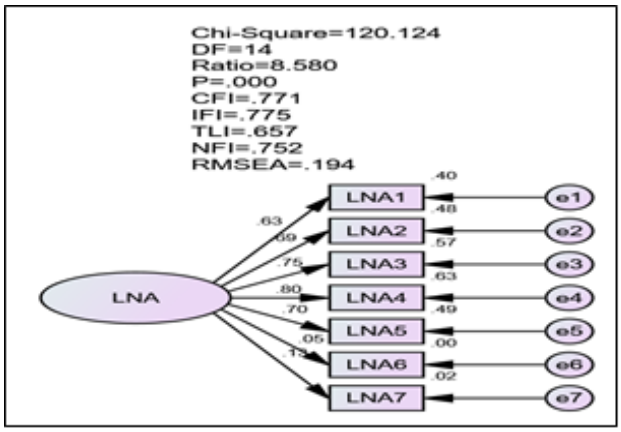

Figure 3a Initial CFA of Land Accessibility

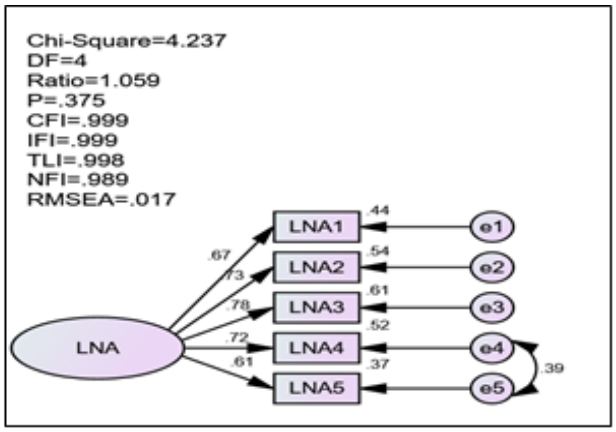

Figure 3b Revised CFA of Land Accessibility

Despite the low economic condition of the population, a majority of the clients of the real estate developers were private individuals who account for 45 per cent. In comparison, corporate organisations constituted 28 per cent. The Federal Government is one of the major clients of the real estate developers and accounts for 16 per cent while state and local government accounted for 10 per cent and 2 per cent respectively. Fifty-one per cent of houses built by the real estate developers are for sale, and 49 per cent were built as rental housing.

The primary source of funding for the real estate developers was loaned from banks (55 per cent) which, in most cases, were with high-interest rates and other stringent conditions. The research also found that 3 per cent of the real estate developers borrowed from friends to fund their projects whenever the need arises. The cooperative societies which account for 13 per cent are also another channel available to real estate developers to raise funds to finance housing projects. Personal savings account for 21 per cent, and clients' funds accounted for 8 per cent

In Nigeria, the various approach to the supply of affordable housing yielded little success. The 17 million housing deficit remains as it is for the country. In addition, the upward trends in real house prices have been driven primarily by the interaction of population growth, increase in household income, cheap and available credit, and the unresponsive supply of land on which to build the housing units. A result of which is the general upward trend in house prices, which has significantly affected affordable housing, both for intending home buyers and potentials renters.

Previous studies on affordable housing have based their criteria for the selection of approaches to address affordable housing problems on income and expenditure ratios (Hulshanki, 1995; Gan and hall, 2009; William, 2011; Bramley, 2012; Heylen and Halfiner, 2013). Based on this premise, this research has launched an investigation into other inputs such as housing subsidies and tax breaks. Much attention should be shifted to the factors to improve the supply of housing and increase the homeownership rate in the country. The research also revealed that most of the factors are mentioned or described in qualitative terms rather than in quantitative terms (Agbola, 1988; Akinmoladun and Oluwoye, 2007; Emeka-Okereke, 2015).

The strength of the current research lies in the deployment of the confirmatory factor analysis to confirm the identified factors. The application of confirmatory factor analysis to the study of affordable housing problems will bring about a better understanding and improvement in the housing supply process. Therefore, the identification of the housing supply factors is critical to developing a new set of alternatives for sustainable housing supply in Nigeria. The verification of observed variables for the research was done using the confirmatory factor analysis (CFA). The CFA allows the researcher to test the hypothesis for the association between the measured and the latent constructs depending on certain conditions. The conditions are listed as

follows (ii) the modification indices such as CFI, IFI, TLI must be above 0.90, (iii) the Ratio of the Chi-square and the degree of freedom (df) must range from as high as 5.0 to as low as 2.0 (Tabachnick and Fidell, 2007) and (iv) RMSEA<0.08 (Wheaton et al., 1977).

3.1 Confirmatory Factor Analysis: Land Accessibility

In the case of Land Accessibility (LNA), the initial CFA model did not comply with the goodness model fit criteria due to the high ratio, which exceeded the recommended 5.0 The Root Mean Square Error Approximation (RMSEA) also indicated that the models model did not provide a good fit for the data at hand, as indicated in Figure 3a and Figure 3b. Consequently, the revised CFA based on the real estate developers is shown in Figure 3b.

In this case, items LNA6 and LNA7 were trimmed due to poor factor loadings. To improve the measurement model, items e4 and e5 were co-varied. After re-specifying the model, it was revealed that the; Chi-square=4.237; DF=4, Ratio=1.059.782, P=.375, CFI= .999, IFI =.999, TLI=.998, NFI =.989 and the RMSEA= .017 respectively.

3.2 Confirmatory Factor Analysis: Availability of Funding

The initial CFA of Funding model failed to meet the goodness of fit criteria. The CFI, IFI, TLI NFI and the Root Mean Square Error Approximation (RMSEA), also indicated that the model did not provide a good fit for the data as shown in Fig 4a and 4b. The revised CFA models based on the real estate developers are shown in Figure 4b. In this case, items FND1, FND2 and FND 3 were covaried sequentially to improve the goodness of fit criteria. he Chi-square=36.187, DF=16, Ratio=2.262, P=.003, CFI= .974, IFI =.974, TLI=.954, NFI =.955 and the RMSEA= .079

3.3 Confirmatory Factor Analysis: Demographics

On Demographics, Figures 5a and 5b show the CFA of demographics as a factor affecting affordable housing based on the responses of the participants' real estate developers. Items considered are as follows: DEF1- level of income/social status encourage construction of affordable houses, DEF2- closeness of

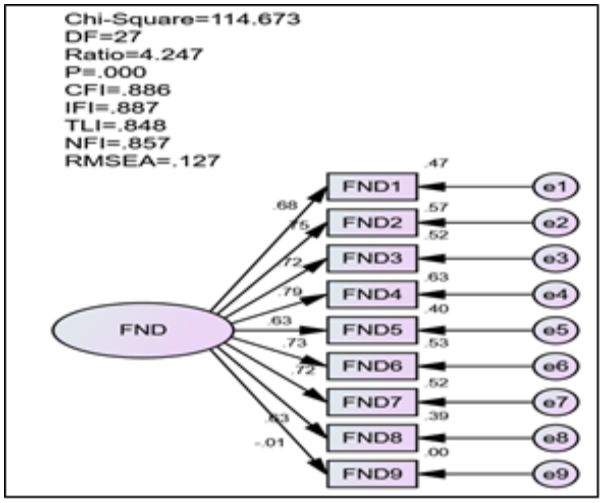

Figure 4a Initial CFA of Funding

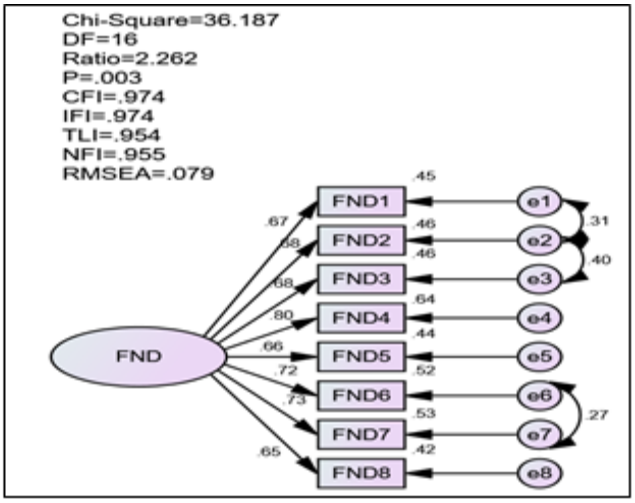

Figure 4b Revised CFA of Funding

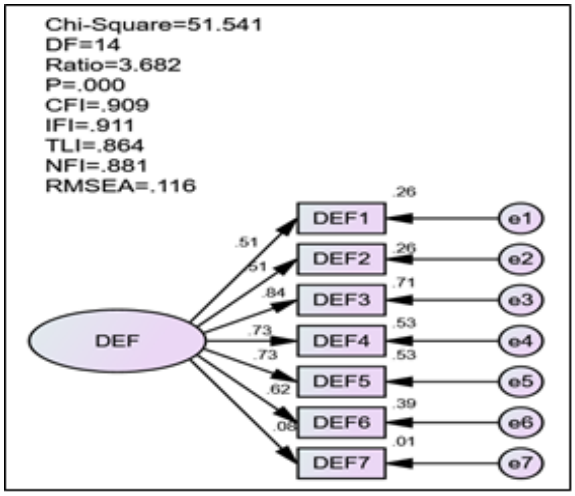

Figure 5a Initial CFA of Demographics

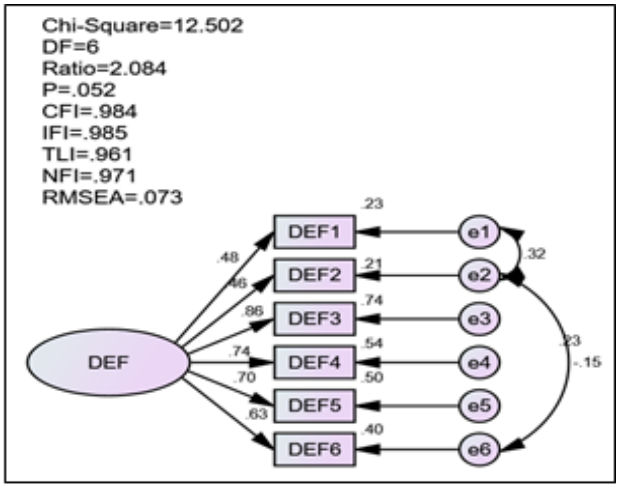

Figure 5b Revised CFA of Demographics

families' increase demand for affordable houses DEF3- household size determines the choice of household's house type, DEF4- cultural values demand the construction of affordable homes, DEF5- rate of the household formation increases the demand for affordable houses. DEF6- age of head of household has an influence on the construction of affordable homes DEF7- marital status influences the construction of affordable housing.

The initial CFA of this construct did not meet the goodness of fit criteria where, TLI=.864 and NFI =.881, RMSEA .116. The values obtained after modifications to the demographic constructs are; Chi-square=12.502, DF=6, Ratio=2.084, P=.052, CFI= .984, IFI =.985, TLI=.961, NFI =.971 and the RMSEA= .073

3.4 Confirmatory Factor Analysis: Government Interventions

Figures 6a and 6b revealed the initial and revised CFA model for government intervention. Government interventions are variables that can be introduced to promote homeownership among the participants. Items measured include: INT1-government interventions encourage affordable housing supply INT2- government helping people to possess their own houses, INT3- absence of government interventions make people remain effective operations of Federal agencies concerned with housing will enhance homeownership. INT7- developing the private rental sector was better than government supply housing decision.

The initial CFA model for government interventions did not meet the goodness fit criteria. INT1 was trimmed, and further model specifications were made by co-varying items INT3 and INT4 sequentially, and Items INT4 and INT 8. After the trimming of the models, the values obtained for the revised model is shown in Figure 6b, Chi-Square=26.309; DF= 16; Ratio =1.644; P=0.050; CFI=.988; IFI=.988; TLI=.979; NFI=.970; RMSEA=.057

3.5 Confirmatory Factor Analysis: Homeownership Determinants

Figures 7a and 7b show the CFAs of homeownership determinants based on the responses of the real estate developers. The CFA did not conform to the goodness fit criteria The Chi-Square= 19.524, DF=2, Ratio= 9.762, P=.000, CFI= .887; IFI=.890, TLI=.662 and NFI =.879, RMSEA .209. The items considered were; HOW1- marital status influence the rate of homeownership decisions, HOW2- investment in education and training delays the rate of homeownership, HOW3- investment in homeownership can guarantee future savings, HDS4- the pride of being a homeowner encourages investment in the housing sector. The covariance of items HOW1 and HOW4 shown in Fig. 7b improved the modification indices criteria. The results obtained are Chi-Square= 25.524, DF=8, Ratio= 3.191, P=.001, CFI= .989, IFI=.989, TLI=.960 and NFI =.984, RMSEA .063.

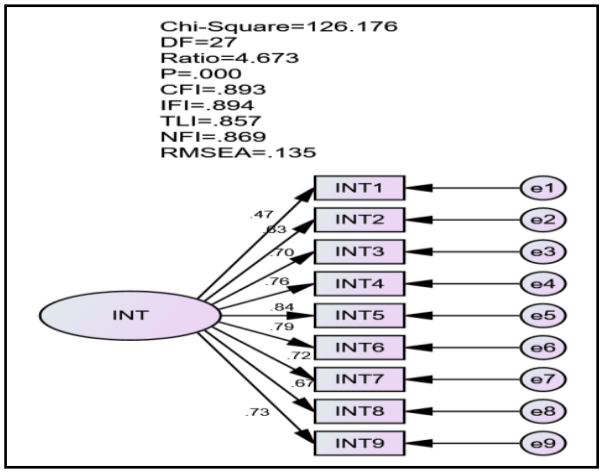

Figure 6a Initial CFA of Interventions

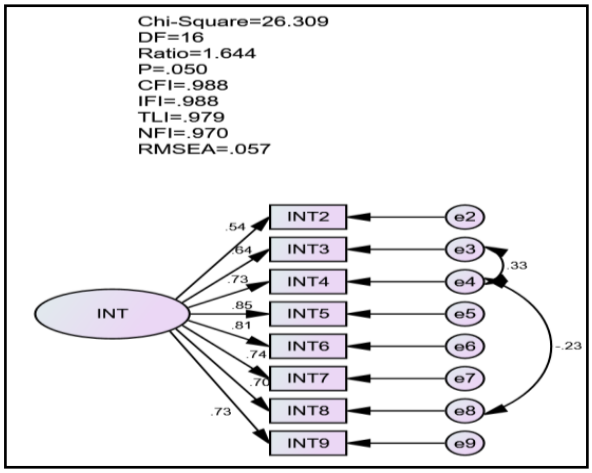

Figure 6b Revised CFA of Interventions

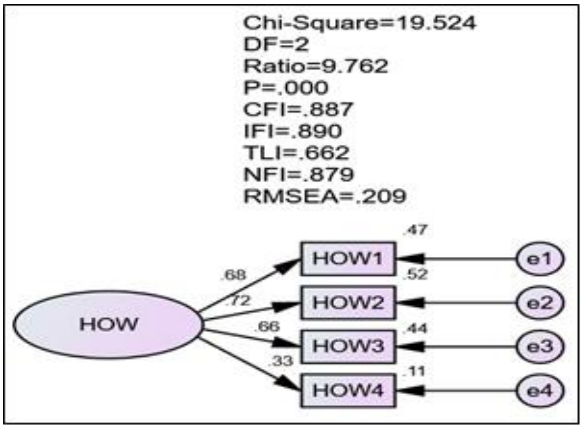

Figure 7a Initial CFA of Homeownership

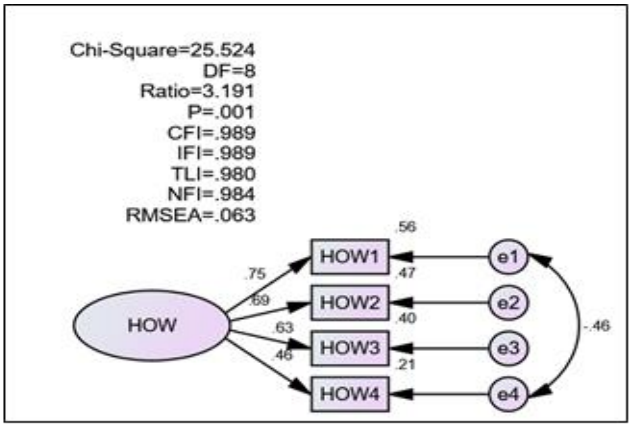

Figure 7b Revised CFA of homeownership

4. Conclusion

The study reveals that accessibility of developers to land is one of the constraints affecting the housing supply process. The government does not usually provide infrastructural facilities such as roads, water, drainage and electricity that will aid the housing supply process. Land accessibility, availability of funding and demographics had significant and direct effects on affordable housing supply in Nigeria. The availability of subsidised land from the government was also revealed to be a factor in the construction of more affordable housing in Nigeria. The availability of communal land at low prices will increase housing production. The income level of households has an influence on the construction of affordable houses for homeownership by the real estate developers. Thirty-three per cent of households earn <USD2 per day. Large family size is prevalent where 50 per cent of respondents have a family size greater than 5. About 42 per cent of the respondents live in rented housing. Government intervention did not contribute significantly to homeownership. The study indicates that the housing developers' ability to supply new homes is curtailed by their financial incapability, household's demographics and scarcity of land. The developers of affordable housing were constrained by rent and lack of collateral.

The study established that availability of funding, accessibility to subsidised or cheap land and demographic factors, constitute the main issues that urban housing providers must contend with in order to provide affordable housing in Nigeria. These findings are supported by Nubi (2008); Kuma (2015) and Agbola and Kasim (2007). These scholars assert that the lack of access to finance is a significant bottleneck to households and developers alike. Consequently, developers cannot participate meaningfully in the building process, either for rental or homeownership. The Presidential Committee on Urban Development and Housing (2001), recognised the seriousness in the shortage of suitable land for affordable housing. It concludes that the limitation to land for housing by potential developers could negatively interfere in the response of the housing market to any swift changes in the demand for more housing units in Nigeria. Affordable housing is achieved when strategies are put in place to support the proper supply of land suitable for development. There is, therefore, the urgent need for the government to adopt a genuine land reform in the country in order to make land more accessible to Nigerians in pursuance of this goal, serious attention must focus on the urgent need to review the Land Use Act promulgated in 1978.

Additionally, the governments of various states are directed to simplify and reduce the cost of obtaining consent to land transactions and building approvals. The main focus of the government should be to formulate a functional policy framework and to ensure the provision of the needed inputs and funding. If all these steps were taken into dire consideration, it would ultimately boost the systematic development of affordable housing in the country.

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Appendix I

S/N	FACTORS INFLUENCING AFFORDABLE HOUSING SUPPLY	SUPPORTING LITERATURES
1	Limited land accessibility	Nubi (2000), Oyinke (2009), Akinmoladun (2007), Windapo *et al*. (2007), Abdulahi *et al*. (2010), Ademiluyi and Raji (2008)
2	Funding/ finance	Akinmoladun (2007), Oyinke (2009), Uganabo *et al*. (2011), Ifesanya (2012), Ibrahim and Mbamali, (2013), Anayouchukwu (2011)
3	Cost of Construction	Australian Housing and Urban Research Institute (2007) Ademiluyi and Raji (2008)
4	High population growth and density	Akinmoladun (2007), Ifesanya (2012), Ibem *et al*. (2011)
5	Real income/ affordability	Ibem *et al*. (2011), Ifesanya (2012)
6	Demographics	Un-Habitat (2007), City of Calgary, (2008), Ajibola *et al*. (2012)
7	Provision of Subsidies	Agbola and Olatubara (1989), Gilbert (2004)
8	Tax Break	Ifesanya (2012), Melissa *et al*. (2013),
9	Homeownership	Ajanlekoko (2001), Jimoh *et al* (2014), Suhaida *et al (2010)*

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Investigating the Impact of Spatial Configuration on Users' Behaviour in Shopping Malls Case of Bab-Ezzouar Shopping Mall in Algiers

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ABSTRACT

Recently, Shopping malls are introduced in Algerian cities as new commercial structures instead of traditional markets; they become a part of the daily life allowing people to have a new shopping experience. This paper aims to explore the influence of visual accessibility and spatial configuration on the navigation of individuals in a shopping mall through the analysis of Bab-Ezzouar shopping centre. The analysis of spatial and visual patterns adopts space syntax techniques and methods, a survey analysis based on people tracking and a questionnaire is applied to collect data on the shopping centre visitors' behaviour. The results show that the perception of shopping spaces differs from familiar to unfamiliar visitors, familiar visitors are guided by their shopping habit more than spatial patterns and unfamiliar visitors are influenced by visual patterns of space more than accessibility. Visitors tend to choose the most open spaces that offer maximum visual accessibility more than physical accessibility, they also prefer walking in a straight-line avoiding change of direction. These features can guide designers in their process for better understanding of shopping space.

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1. Introduction

Finding the way in a shopping centre is a topic of interest for both visitors and managers. It is, therefore, essential to study it to understand the commercial space and increase profits to satisfy visitors. Research on the subject remains limited, which leads to fact that designers does not consider this issue during the design process. People visit shopping centres for multiple reasons, it can be for exploration or discovery visit, an informed or uninformed research, discovering space or for a planned shopping visit.

The discovery of space implies a set of cognitive faculties; a planned visit uses as a reference the experience of the visitors, based on their knowledge of space or their lived experiences in similar spaces. Therefore, the different forms of indoor navigation in complex spaces require reading their spatial setting through their physical and visual patterns.

This research is based on the study of the influent factors on the visitors' navigation in shopping centres, as they are new forms of shopping in Algeria, to define the impact of spatial patterns and visitors' chopping habits on their choices during their navigation in shopping malls. The main purpose is to define the solve conceptual problems and guide the design of commercial spaces so that they become more functional and more suitable for users according to their commercial skills and experience.

Many studies were interested in the subject, starting from different viewpoints relative to their disciplines: psychology, behavioural sciences, architecture, and urban planning. Studies interested in the evaluation of the indoor navigation of visitors in complex buildings (Harper, Avera, Crosser, Duke, & Jefferies, 2018; Nourian, 2018; Romedi Passini, 1980; Vilar, Teixeira, Rebelo, Noriega, & Teles, 2012), mainly shopping malls, we can distinguish two groups; case studies using observation and survey (Boumenir, Georges, Valentin, Rebillard, & Dresp-Langley, 2010; Dogu & Erkip, 2000), others based on simulations and virtual reality to experiment the visitor's behaviour (Joshi, 2019; Li, Thrash, Hölscher, & Schinazi, 2019; Münzer, Loerch, & Frankenstein, 2019; Pielot & Boll, 2010; Yang, 2015) or combining the two methods(Dogu & Erkip, 2000; Pielot & Boll, 2010).

2. Literature Review

Spatial Navigation is a permanent activity in our daily life; it is a major concept in the environmental behaviour that requires the use of cognitive skills for decision-making. Many factors affect the navigation of visitors in a shopping mall, Dogu and Erkip (2000) showed that wayfinding behaviour in shopping malls is influenced by building configuration, circulation systems, visual accessibility, and signage.

Many researchers tried to define the navigation and wayfinding in familiar and unfamiliar environments in the different architectural and urban scales (Dogu and Erkip, 2000; Wiener et al., 2009; Boumenir et al., 2010; Münzer et al., 2019). Kevin Lynch (1960-1984) introduced the mental model (mental map) as a guiding system of pedestrians, it's the result of a cognitive perceptual process but also based on the previous experience and the pedestrian's knowledge of the urban network and his ability to read its landmarks. In 1960 Kevin Lynch gave the definition of wayfinding as a process of consistent use and organization of sensory cues from the external environment to efficiently move through space. Golledge (1999) identified wayfinding as purposive, directed and motivated activity, "a process of determining and following a path or a route from an origin to a destination" (Golledge, 1999).

Wiener et al. (2009) proposed a taxonomy of wayfinding in which they classified the pedestrian movements in twelve categories, based on Montello's definition that navigation as consisting of two elements: locomotion and wayfinding, influenced by four parameters: Navigation assistance or external aid (signage, maps), destination knowledge, route knowledge and survey knowledge. Thus, they suggested a classification based on three tasks: exploratory navigation, navigation to a familiar destination, navigation to original destinations.

Boumenir et al. (2010) argued that finding one's way through an unfamiliar environment is facilitated by prior experience through direct and guided exposure which is not easy to have with newly explored environment. According to (Yang, 2015) wayfinding is the process of finding the way to a destination in a familiar or unfamiliar place, using environmental cues; although, this process is being affected by the impact of two types of factors (Yang, 2015, Boumenir et al., 2010) : internal or personal factors that may include culture, gender, psychological characters, experience, familiarity with environment and personal preferred strategies; external factors that belong to environment and may include signage, availability of landmarks, navigation aids, geometric layouts and density of buildings. Arthur and Passini (1992) classify them into three groups: personal factors, environmental factors and information factors. Personal factors include: age, gender and familiarity with the environment (the experience).

Although, wayfinding and orientation in complex buildings require more attention from designers. According to Vilar et al. (2012) there are two categories of trips: planned trips with a known origin and destination and unplanned trips or exploratory with an unknown destination. Dogu and Erkip (2000) maintained that wayfinding difficulties may cause problems such as the loss of time, decreased safety, stress, or discomfort. The wayfinding depends essentially on the elements constituting the space as well as their modes of arrangement. According to Passini (1984), the architectural environment has become more complex over time and humans have modified it to better meet their needs, the environment contains both the problem and the possible solutions. People go to shopping centres not only for shopping, but also for social entertainment. So, their motivation can be directed towards consumption (of products or services, food) or experience (entertainment, product research, etc.) (Kim et al., 2005).

Familiar visitors attend the malls for a planned visit, while unfamiliar visitors seek their goals and navigate according to the signs and the parameters of the environment. According to Dogu and Erkip (2000) the simplicity and regularity of plans help people in learning the layout. The circulation system may not necessarily be visible to the users but it could be easy and simple to use (Arthur and Passini, 1992). "The architectural expression of the circulation system makes a building easier to understand. The well-articulated building tells us everything about its internal central organization" (Dogu and Erkip, 2000).

Ruddle and Jones (2001) in their studies on navigation in virtual environments have shown the effects of familiarity and experience on spatial knowledge and the task of wayfinding. Brown et al. (1998), Appleyard (2017) confirmed the effect of gender difference in the spatial orientation and the indoor wayfinding, researchers reported this difference to several factors, namely:

- Biological factors such as the differences in the organization of the brain.
- The use of distinct strategies (Lawton et al., 1996).
- In some cultures, men are more likely to travel, and therefore to have more experience in spatial orientation.

Navigation and orientation skills in space are certainly related to age and the more it increases the more cognitive skills will tend to decrease. Studies have found that orientation is better for older children than younger children and for younger adults than for older adults (Fenner et al., 2000).
Münzer et al. (2019) argues that, during the navigation, the orientation changes when the person makes a turn, spatial knowledge should be stored in several local orientations related to the environmental visual features.

Recently, space syntax appears as a new technique for analysing spatial configuration in relation to the use of space and human behaviour. Pedestrian navigation depends on accessibility of a particular space compared to other locations in the spatial arrangement (Hillier, 1996). Space Syntax analysis quantifies this 'structure' of the spatial arrangement as a determinant for accessibility (Deb, 2013). Studies on indoor navigation using space syntax user's choices are influenced by syntactic properties of space (Dogu and Erkip, 2000; Haq and Zimring, 2003; Hölscher, Brösamle et al., 2010; Li, Thrash et al., 2019).

Bai (2005) in his research on planning and design Shopping Mall based on space syntax, uses syntactic data analysis with a survey and a questionnaire survey to verify the reasonableness of the organizational structure of the Shopping Mall building space. This research show that Shopping Mall space organization has a considerable impact on customer flow, the complexity of shopping space makes the customer feel lost. (Kong and Kim, 2012) trying to clarify the correlation between spatial configuration and sales, suggested a spatial analysis model relying on the Visibility Graph Analysis, this research concluded that spatial configuration has the potential to influence pedestrian movement and sales.

Omer and Goldblatt (2016) analysed two shopping malls to show the conjunction between space syntax and Q-analysis methodologies for investigating patterns of movement flows in buildings. Spatial configuration was analysed using space syntax techniques focusing on accessibility patterns, movement data was collected and analysed through Q-analysis. The results indicate that high spatial integration and intelligibility levels in shopping space have a high impact on the movement in accessible and central areas and also the spread of movement paths and their formation.

Sumanta Deb made many researches in the subject, focusing on the effect of customer density distribution within a shopping mall in predicting the optimum area and rent of stores, by exploring the navigational behaviour of individuals in a shopping mall and the role of shopping motivators behind navigational preferences (Deb, 2013; Deb and Mitra, 2016; Deb and Mitra, 2018). All these researches used space syntax techniques as an analysis tool, mainly Visibility Graph Analysis (VGA) to predict customer density distribution and explore the effect of visibility in the distribution of customer movement within a shopping mall. The analysis of accessibility and visibility patterns through two syntactical parameters, integration and connectivity. These researches show a high correlation between local integration and connectivity with the user's movement and distribution in the space.

Haofeng, Yupeng, and Xiaojun (2017) analysing multi-level shopping centres examined the impact of spatial patterns on movement distribution in Nanash commercial district in Shenzen, China. The research used spatial configuration analysis of space syntax, based on spatial accessibility measures. The spatial analysis of axial maps focused on connectivity, local and global integration combined with the gate count method to collect behavioural data. The correlations confirmed the impact of the spatial patterns on pedestrian flow in multi-level shopping buildings. Syntactic variables, in particular integration and localisation of escalators which contributes to the explanation of patterns of movement distribution.

Aydoğan and Şalgamcıoğlu (2017) in a comparative case study of two shopping malls of Istanbul, examined the impact of configuration and tenant types on user movement in shopping malls, through space syntax analysis focusing on natural movement theory. This study shows that the impact of spatial configuration on users' movement is more important in spaces with strong syntactic values, mainly integration and connectivity, however content is dominant where syntactic value is not very strong.

The research of Seon, Ju, and Kim (2020) on the impacts of spatial configuration of a commercial facility and pedestrian movement on users' behaviours in the complex commercial facilities. The study adopted space syntax analysis to clarify the correlation between physical environment characteristics of a complex commercial facility and users' behaviours combining both axial and visual analysis, focusing on global and local integration correlated with an observation analysis of pedestrian movement. This analysis proved a high correlation between integration and the distribution of retail facilities, consumption behaviours are highly influenced by their position, which is relative to the level of local integration.

3. Methodology:

The method of this research combines traditional methods and recent techniques for predicting users' spatial behaviour. Space syntax offers a series of tools and measures to predict visitor choices according to the spatial configuration, these usage potentials will make the subject of a comparison with real usage data, which is collected using traditional methods of observation, counting and people following. The correlation of the results of the two methods, it is possible to find out the conflicts of use of space. Implementing a questionnaire survey can lead to clarifying the causes of the differences between the potential uses of the space and the attitudes of the users.

This research is structured in three phases of analysis: The first one is a spatial analysis based on two parameters accessibility and visibility through space syntax methods: the axial map analysis and the visual graph analysis, in order to understand the configuration of the shopping centre according to the two mentioned methods of analysis. This phase aims to predict the navigation of visitors and to find out the conceptual problems and conflicts (Hillier and Hanson, 1984, Hillier et al., 1993). Space syntax theories and methods are widely used in architectural and urban studies to define the relationship between the spatial configuration and the use of space,

based on the idea that space has a significant impact on the way that people use space and move through it (Dursun, 2007).

Axial map analysis of the fewest line map taking into consideration the accessibility measures that are supposed to influence visitor's navigation: Connectivity, integration, and intelligibility (Hillier et al., 1993, Hillier, 1996). Connectivity measures the number of immediate neighbour spaces directly connected to a space. While the Integration gives us is the distance from a space to all remaining spaces a system (Hillier and Hanson, 1984) it is used to predict the to-movement (Hillier and Hanson, 1987), the more a space is integrated the more it offers potential for use (Hillier et al., 1993). The intelligibility of a system indicates the clarity of the system and the possibility to be read by its users, mainly unfamiliar users (Hillier, 1999).

The visual graph analysis (VGA) is used to evaluate the potential visual guidance of space (Turner, 2003). As a method, it was initiated by Turner (2001), developed on the basis of the previous studies of Thiel (1961) and Benedikt (1979) who introduced the "isovist" as all points in space visible from a defined point respecting the environmental setting. Varoudis and Penn (2015) consider isovist as a representation of the way that people perceive, move and interact with space. The visual field generated by space and configuration has a great impact on human behaviour (Bendjedidi et al., 2018)

Accessibility and visibility measures are analysed in both axial map and visual graph to predict the potential use of space and visitors flow. It's supposed that familiar visitors use their mental maps more than configurational measures while unfamiliar visitors refer in their navigation to the visual or spatial parameters. The analysis of the axial and visual maps proposes the following measures:

Connectivity measures the number of immediate neighbouring spaces that are directly connected to a space. This is a static local measure (Klarqvist, 1993). By comparing the levels of connectivity of spaces to their functional requirements (public or private, circulation or exposition of goods, etc.) The most connected spaces offer the highest potential for accessibility or visibility and are the most likely to be the most visited. For example, if a circulation space presents low connectivity, it could not function correctly, so users avoid it during their navigation.

Integration is an overall static measure. It describes the average depth of a space to all other spaces in the system. The spaces of a system can be classified from the most integrated to the most segregated (Klarqvist, 1993) (from red to blue in the map). The most integrated spaces are the most accessible from all other spaces in the system (Hillier, 1996), so they are the most used by visitors, in this case they must be the distribution or exposition spaces, the most segregated spaces must be private spaces or those with restricted accessibility. "integration value is believed to be a potential determinant of human concentration and movement in that particular location compared to other spaces within the spatial arrangement" (Deb, 2016) .

Intelligibility is a static global measure which is measured by the correlation between global and local variables and more generally between global integration and local connectivity (Araba, 2018). It expresses the clarity of the space system for its users. It is represented with a regression coefficient with a value of 0 to 1, the more a space is intelligible, the clearer it is for its users, so unfamiliar users can navigate by reading the space without having to refer to a mental map, a global understanding of space structure is enough to guide visitors whatever is their shopping experience.

The second phase of the analysis is a field survey, in order to collect information on the real use of space through the people following technique and the questionnaire. The collected data concerns the rate of use of each space and zone in the shopping centre, the use of space according to the visitors' level of knowledge of the space, in addition to their preferences while they navigate in the shopping centre.

Observation using the "people following" technique consists in observing the paths chosen by the visitors in the centre and reporting them on a map. This aims to verify which routes are chosen by the visitors and analyse them in relation to the configurational analysis. The observation was conducted during April 2019 in Bab-Ezzouar shopping centre in Algiers during 07 days, taking into account the gender and age of the visitors. The subjects of this observation themselves make the subjects of the questionnaire survey and they were informed of.

The third phase is the comparison of the results obtained by spatial analysis with those obtained through the survey. The purpose of this confrontation is to find out what influences the orientation and the choice of the visitor's itinerary in the shopping centre. Two types of confrontation are proposed:

- The first is to compare the results of "fewest line analysis" with the results of the people following survey. The objective through this confrontation is to examine if the most chosen itineraries are the same ones predicted through the spatial analysis following the fewest line map analysis technique. That means to verify if people are guided through the spatial configuration or not.

- The second confrontation consists in comparing the results of observation of the itineraries with the results of the VGA analysis. The objective is to figure out if the most integrated and connected spaces on the visual integration and connectivity maps are the same ones most crossed and chosen by visitors, that means the verification of the relation between visual accessibility and use of space. These confrontations allow us to find out the conflicts in people navigation caused by the incompatibility between the spatial configuration and the commercial habits of visitors.

The questionnaire survey aims to justify the causes of the mentioned anomalies carried out through the precedent analysis, it will be structured in two parts: the first consists in collecting information on the visitor, the aim of his visit and his level of knowledge (familiarity) with the shopping space. The second part concerns the visitor's strategies and guides for the navigation in the shopping centre.

The questionnaire sample should be composed from visitors of the shopping centre during their visit, taking into account to cover

with balance the different categories of visitors, according to the statistics conducted by the shopping centre, in terms of gender and age. In this research, the questionnaire was conducted in the Bab-Ezzouar shopping centre for one week in April 2018, covering all the working hours of the day (from 8 a.m. to 7 p.m.). the sample of the questionnaire is composed of 193 visitors, questioned individually, the respondents are adult visitors and divided between 2/3 women and 1/3 men (according to the attendance statistics carried out by the administration of the centre).

4. Presentation of the case study (Bab-Ezzouar shopping centre):

The case study is one of the first shopping malls in Algeria, situated in Bab-Ezzouar (east of Algiers) from which it takes its name, in a business district not far from the airport (5 min) and the city centre, it covers an area of 45000 m². The site includes, in particular, a university campus of 40,000 students, Ibis hotel, banks, administrations and housing blocks. The shape of the mall is rectangular. Three main entrances serve the centre, each one is located on a different facade to ensure good accessibility on all sides of the centre. The levels of public use of the centre are organized on three floors around an atrium: the first two floors are devoted to the shops and the third to leisure and restauration.

To proceed with the analysis of the shopping centre Bab-Ezzouar, we started by coding the open space into zones according to their configurations and functions. Bab-Ezzouar shopping centre is composed of two parts: the hypermarket, an open space shopping zone in the south side and separated shops zone in the north side, the two parts are separated by the main circulation zone which links the two main gates (figure 1, table 1).

Table 1 Codes for the different zones in Bab-Ezzouar shopping centre

Zone	Code
• Zone C1	• Central circulation
• Zone C2, C3, C4, C5, C6, C7 and C8	• Circulation zone
• Zone H1, H2, H3 and H4	• Hypermarket exposition zone
• Zone M1, M2, M3 and M4	• Store zone
• Zone S1, S2, S3, S4, S5 and S6	• Service zone

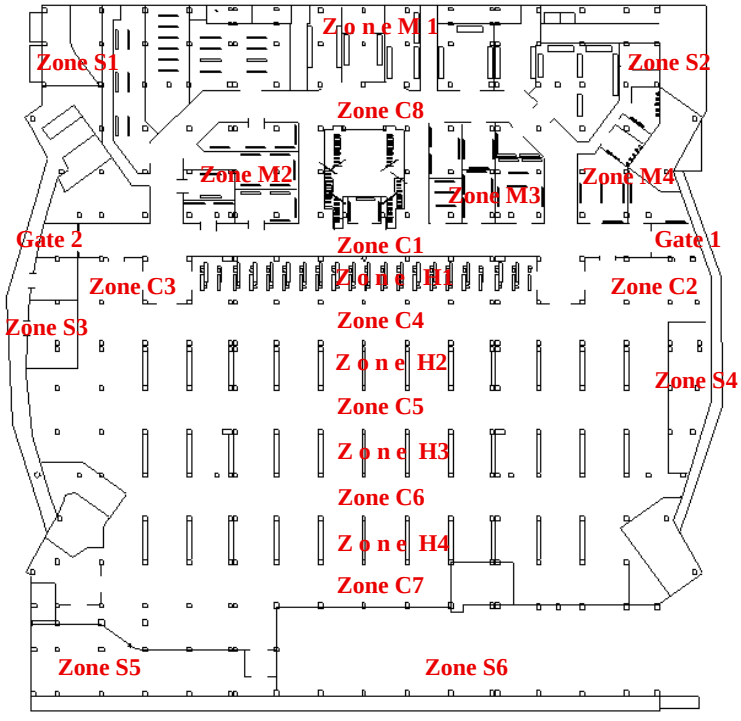


Figure 1 Coding Bab-Ezzouar shopping centre plan R.D.C

5. Analysis and Results

5.1. Fewest Line Axial Map Analysis

The axial maps (all lines map and fewest lines map) generated using UCL Depthmap for the purpose of analysing the physical accessibility of visitors, focusing on the syntactical measures of connectivity, integration, choice, and intelligibility. The fewest lines map is composed from 444 axes that vary between 0.025m and 118.60m.

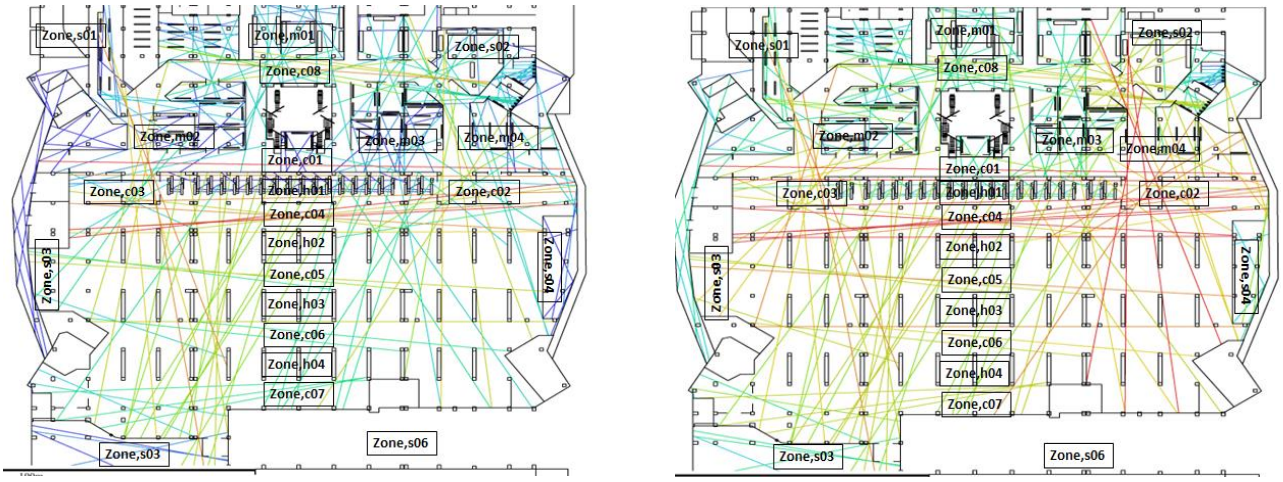


Figure 2 Fewest lines map, Bab-Ezzouar shopping centre, a. connectivity (left), b. integration (right).

The connectivity values range from 2 to 58 with an average of 11.61 which means that most spaces in the shopping centre tend towards disconnection. The most connected zone is C1 which represents the first circulation space, the main axis of the shopping centre. The zone c04 which represents the hypermarket circulation is moderately connected with average values, with low average values for merchandise exposure areas. Most zones of stores present low connection values.

The highest values of connectivity can be identified in the main access and the main distribution space of the hypermarket (figure 2a). The circulation zone in the hypermarket shows moderately high values followed by the exposition spaces. The distribution space to the stores has a moderately low connectivity value, which creates problems for visitors' navigation. Spaces that have low connectivity values are storage spaces and site workers spaces.

Global integration values vary between 1.0468 and 3.52163 with an average of 2.0027, which means that most spaces in the mall are balanced between integration and segregation. The zones presenting high integration values are the zone C1 of the main access and the central corridor (figure 2b), the zone C4 which is the main circulation axes in the hypermarket and the zone C8 at the top of the centre and it distributes to the stores. The zones: H2, H3, and H4 in the hypermarket; C5, C6, C7 (circulation) are the ones that have an average overall integration in the shopping centre. The other areas that include stores and services are increasingly segregated spaces.

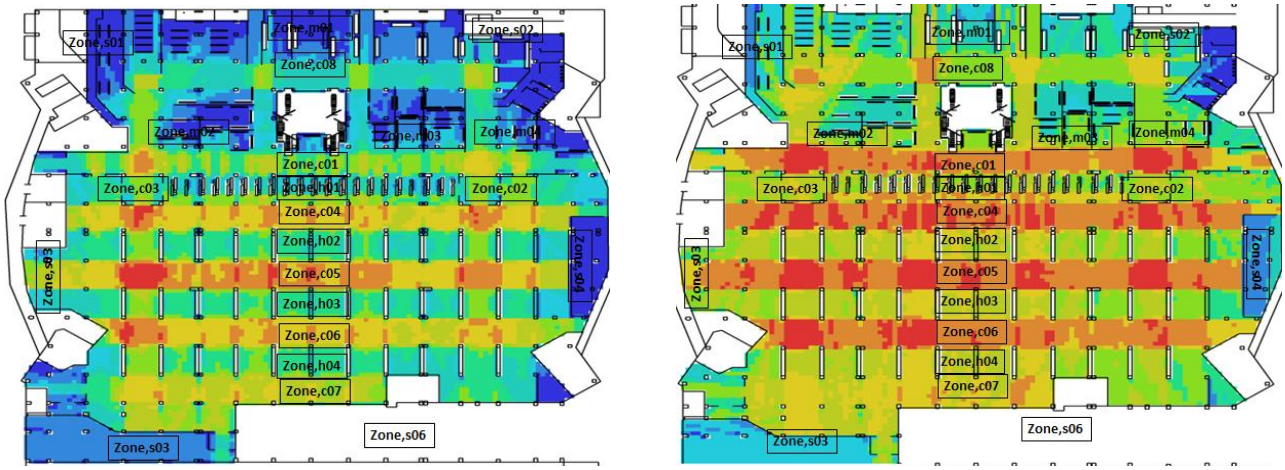
The main access and distribution space of the hypermarket have a high value of integration, they represent a high potential for use. The zones of the hypermarket (H2, H3, H4); and circulation (C5, C6, C7) that have an average integration are compatible with the potential use. In the zone C08, there is an anomaly between the low value of integration and the potential use that it must be strong because of the existence of an obstacle (the stairs). The low values of the integration of stores zone and services are recognized since the potential use of these spaces is influenced by other factors such as familiarity of the user and his experience.

5.2. Visual Graph Analysis

Visual connectivity values in the mall vary between 1 and 1953 with an average of 841,619; which shows that most spaces tend towards average visual connectivity. The visibility graph analysis (figure 3 a) shows that: the spaces that benefit from the greatest number of visual connections (in red colour) are the circulation spaces in the hypermarket, ordered as follows: (zone C5) then the (zone C4) and finally (zone C6). Spaces that have an average visual connection (in yellow colour) are the circulation spaces (zone C1) which represent the main access and circulation space in the centre. Spaces that have a weak visual connection (in blue-green colour) are the spaces reserved for exposure of goods in the hypermarket (H1, H2, H3, and H4). The lowest values of visual connections (in dark blue colour) are in the store spaces (M1, M2, M3, and M4) and spaces for site workers use or service (S1, S2, S3, S4, S5 and S6).

It is considered an aberration that, the weak visual connectivity values in this configuration are; the zone of the main access in the centre (zone C1) and the zones of exposition in the hypermarket (zone H1, H2, H3 and H4), despite their importance in the centre's function. Concerning visual integration (figure 3 b), the values in

the shopping centre vary between 2.47858 and 10.9386 with an average of 7.8033 which means that most spaces tend towards a strong visual integration. The visual integration graph shows that the most integrated spaces extend over the intersection of the circulation axes in the hypermarket classified in order as follows (zone C5) then (zone C4) and (zone C6) and finally the main access of the equipment (zone C 1). Spaces that have an average visual integration (in yellow colour) are the circulation spaces in the hypermarket (the C2, C3, and the C7 zone) and in the store zone (the C8 zone) and also the exposition spaces in the hypermarket (zone H1, H2, H3, and H4). Areas with low visual integration (in blue-green colour) are the store spaces (zone M1, M2, M3, and M4) and the other spaces for site workers use or service (zone S1, S2, S3, S4, S5, and S6).



(a) (b)

Figure 3 Visual graph analysis Bab-Ezzouar city centre. a. Visual connectivity (left), b. visual integration (right).

According to this analysis, spaces with a strong visual integration which represents the circulation zones in the free surface (Zone C4, C5, and C6) and the main access (Zone C1) offer high potential use and strong visual guidance. Spaces with low visual integration on the map and representing exposure areas in the hypermarket (Zone H1, H2, H3, and H4) and store area (M1, M2, M3 and M4) and service zones (S1, S2, S3, S4, S5 and S6) are spaces with low potential use and low visual guidance, then the configuration seems logical according to the functional requirements.

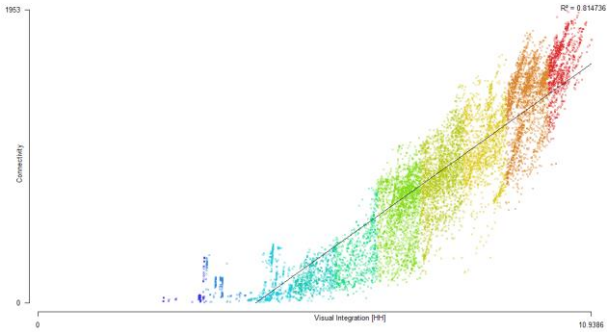


Figure 4 Visual intelligibility regression diagram; ground floor shopping centre BAB EZZOUAR

The diagram of visual intelligibility (Figure 4) shows a high correlation between visual connectivity and global integration with $R^2 = 0.81$. Therefore, the highly visual intelligibility of space means that navigation in the shopping centre is visually guided; space is clear while unfamiliar visitors can easily read the spatial composition of the centre.

5.2.1 Discussion

The VGA analysis technique allowed us to highlight some conclusions about the navigation and use of the ground-floor space in Bab-Ezzouar shopping centre. The open space and the transparency of the architectural elements such as the varnishing of the stores give visual possibilities than physical ones and consequently, make it possible to improve the intelligibility of the space by making the task of orientation easy. Thus, visibility

offered by transparency promotes visual accessibility and allows a clear view that gives the visitor the opportunity to control the entire system. This quality of space allows, subsequently, the visitor to find his way through a new environment as quickly as possible without feeling lost.

5.3 Data Collection And Analysis

Data collection in this analysis consists of two techniques: people following and the questionnaire survey.

5.3.1. People Tracking:

By analysing the maps obtained from the observation of the visitors' itineraries (figure 5), we can notice that the most crossed spaces are the main circulation corridor (zone C01) as well as the secondary corridor (zone C08). The different shops located around the secondary corridor are the most popular. The exposure zones in the hypermarket (zone H2, H3, H4) were also crossed by many visitors.

The observed visitors did not cross the other zones that represent the service areas (S01, S02, S03, and S04) except the area containing the sanitary (S2) (table 2). Most of visitors prefer in their itineraries that offer open spaces filed with the transparency of glazing (attraction factor).

Visitors tend to choose the most visually open spaces and that provide distant visual access. They also chose spaces with a configuration that presents fewer obstructions blocking the visual field as the main corridor

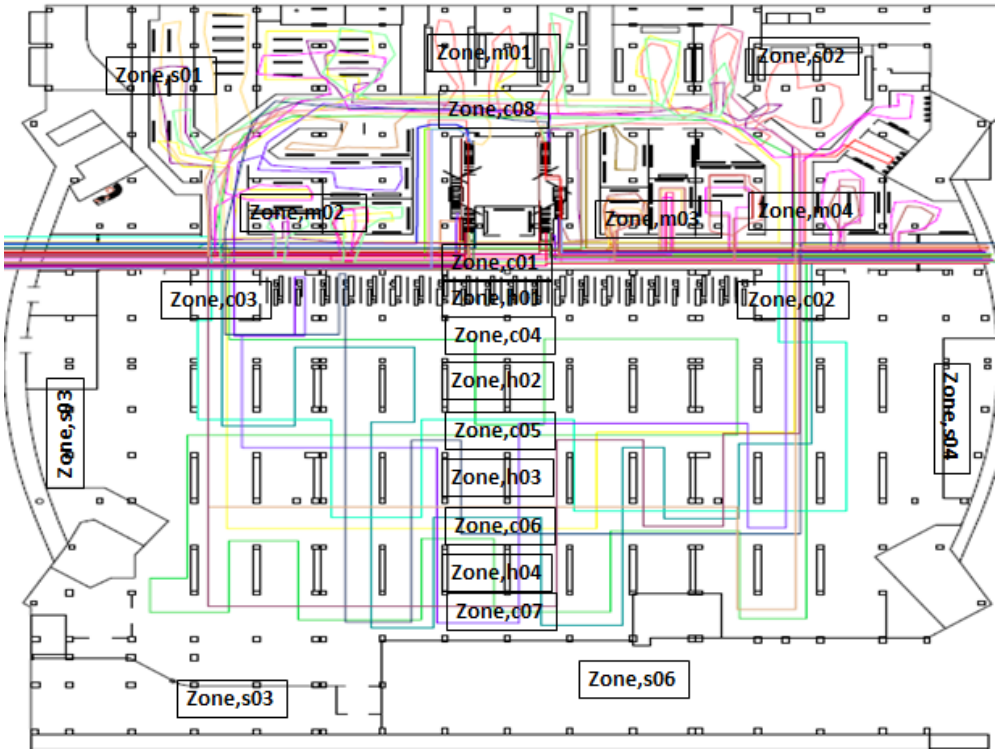


Figure 4 People tracking map for 30 visitors in Bab-Ezzouar shopping centre.

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Table 1 The use of each space in the shopping centre, following thirty visitors. Source (authors, 2019)

Zone	C1	C2	C3	C4	C5	C6	C7	C8	H1	H2	H3	H4	M1	M2	M3	M4	S1	S2	S3	S4	S5	S6
Visitors	30	08	08	08	08	08	08	13	02	08	08	06	07	07	08	03	00	02	00	00	00	00

5.3.2. Questionnaire Analysis

This questionnaire allowed us to know and analyse the influence of the architectural configuration on the navigation of visitors in Bab- Ezzouar shopping centre. It was handed according to a sampling that covers the different age groups as well as types of visitors of each space due to their familiarity and unfamiliarity with the space of the shopping centre. The survey sample is composed of 193 visitors including the 30 visitor subjects of people following. They were questioned individually to prevent bias.

Proposed questions are structured in two parts with multiple choices (three levels): The first part feats Weisman's method, which consists in seeking for information on an applicant's

wayfinding behaviour, it involves navigating and asking the visitors questions about their knowledge of the space, the frequency of visits, the most visited zones and the aim of the visit. The second part concerns the stated strategies for navigation in the shopping centre, if they are planning their visit and how they find their goals, if their visit plan is guided according to their shopping habit or according to the visual and spatial parameters.

Table 2 Results of the questionnaire, Source (authors, 2019)

Parameter	Choices	Percentage
Gender	male	34%
	female	66%
Purpose of the visit	shopping	35.75%
	discovery	37.30%
	not precise	26.94%
Familiarity with the shopping centre	good	42.48%
	average	36.26%
	weak	21.24%
Frequency of visit	daily	6.24%
	weekly	21.24%
	occasional	72,53%
preferred space / zone	stores	29,63%
	hypermarket	60,36%
	both	10.22%
type of itinerary	planned/precise	30.05%
	random	21.24%
	search	48.70%
Satisfaction (spatial clarity)	good	75.12%
	average	20.72%
	weak	4.14%
path influence	Spatial layout	58.54%
	shopping habit	41.45%
Using shortcuts to move	yes	55.96%
	no	44.04%

The results of the questionnaire (table 3) show that the mall is more visited by women than by men. Among the participants, 37.30% make a discovery visit, 35.75% have specific objectives to look for, against 26.94% who are looking for different objectives in the shopping centre.

It can be seen that most of the visitors go to the shopping centre for discovering the space (stroll) or seek their precise objectives. 42.48% of the visitors have a good knowledge, they judge that they are familiar with the shopping centre, 36.26% of the participants have a medium knowledge against 21.24% with weak knowledge of the space. The majority of visitors attend the shopping centre occasionally compared to 21.24% a weekly attendance, only 6.24% of visitors reported a frequent daily visit. Most of visitors attend the hypermarket zone, they represent 60.36% of participants, 29.63% go to the shops while 10.22 attend the two areas of the mall. Regarding their itineraries, 30.05% of visitors plan their visits and go directly to their needs against 48.70 who walk around looking for their needs. 21.24% of participants declare taking random routes. However, 75.12%, which represents a majority, think that they are well guided by spatial or visual cues and satisfied with the spatial organization, while 20.72% of the participants think that they are moderately guided by the space against 4.14% who are not satisfied with the spatial organization in their navigation.

The itineraries of the participants are much more influenced by the organization of the space rather than their shopping habits. 48.54% said they are heading into space according to what it offers as opportunities while 41.45% said their itineraries are usually the same according to their shopping habits. 55.96% use shortcuts to achieve their goals without being interrupted by the exposed goods against 44.04% who prefer looking at exposed products while walking towards their goals.

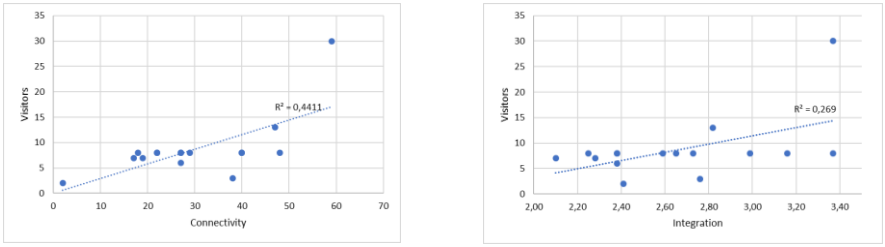
5.4. Overlapping Results

5.4.1. People Following And Axial Map

The most crossed spaces in the centre are those which have the highest values of connectivity and integration. However, the diagrams overlapping spatial syntactic values and people tracking data show moderately low values, R^2=0.441 for the correlation of visitor's behaviour with connectivity and very low with R^2=0.269 for the correlation of visitor's behaviour with

integration (figure 6). It seems that the main corridor (zone C1) is the most chosen by the visitors of the centre; It is characterized by its linearity, the generosity of its width and also the opening of the visual field. In addition, the main circulation corridor (zone C04) in the hypermarket is also one of the most chosen spaces by the observed visitors. It has the same architectural characteristics as the main corridor (zone C1).

Some zones have a weak integration and connection, but strongly chosen by the visitors as the exposure zones in the hypermarket (zone H1, H2, and H3) and the store areas (M1, M2, M3, and M4), other corridors are highly integrated and connected, but rarely chosen by the observed people, for example, the secondary circulation corridors in the hypermarket (C2 and C3 zones) due to the limited accessibility at that zone of the hypermarket with only one gate. The other circulation corridors and zones were chosen by only a few visitors. These spaces have at the same time the lowest syntactic values. They are characterized by their hidden location and their segregation from the main entrance. All the precedent results show that users' navigation in the shopping centre is influenced by other factors than the accessibility of spaces.

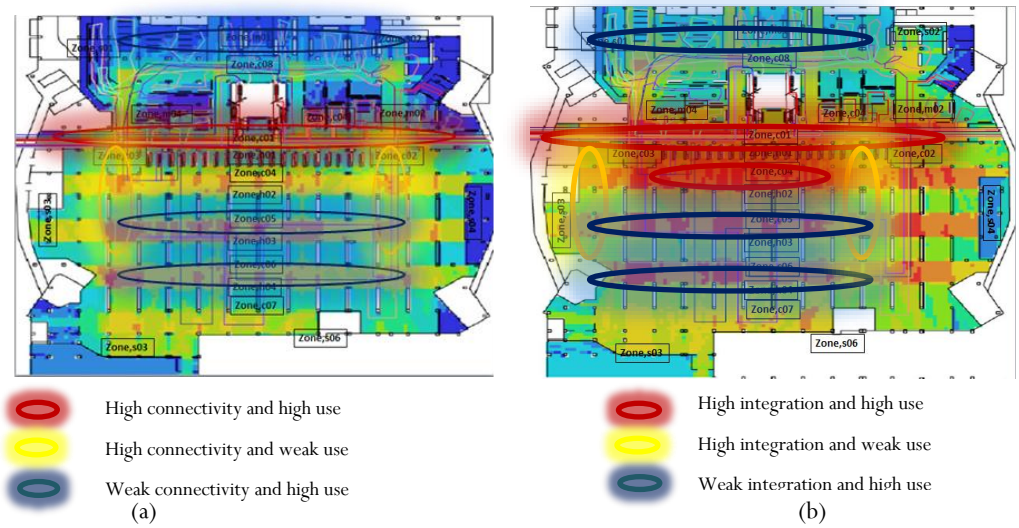


(a) (b)

Figure 6 Correlation of visitors use and syntactic measures, a. with connectivity (left), b. with integration (right).

5.4.2. People Following And Visual Map Analysis

The comparison of the results of the behavioural maps and the visual maps (figure 7) shows that the intersections of the distribution corridors have the highest values of visual integration and connectivity, simultaneously, observed visitors crossed them more than the other spaces. It seems that the main axis (zone C1) is the most chosen by the visitors in the shopping centre. It is characterized by its linearity, its wide width and a free visual field. In addition, the main circulation corridor (zone C04) at the hypermarket is also one of the most chosen areas for the observed users. It has the same architectural characteristics as the main corridor (zone C1).



(a) (b)

Figure 5 Correlation of the behavioural map and visual maps, a. connectivity (left), b. integration (right)

We can also note that some areas are weakly integrated and connected, but highly chosen by the observed visitors, as the exposure zone in the hypermarket (zones H1, H2, H3 of the hypermarket) and the stores zone (M1, M2, M3, M4) on the south-west side of the shopping centre, other corridors are highly integrated and connected, but not often crossed, for example, the secondary circulation corridors in the hypermarket (zones C2 and C3) this seems to be due to limited accessibility at the hypermarket level. Indeed, the access to the hypermarket is ensured only by a single entry, the other gates are reserved for the exit. The other circulation corridors and other zones were crossed by few visitors. These spaces have, at the same time the

lowest visual syntactic values. They are characterized by their hidden location and their segregation from the whole system.

5.4.3. Questionnaire And Syntactic Analysis

The results of the overlapping analysis showed moderately significant relations between accessibility and visitors' behaviour, a more significant relationship for visibility and visitors' behaviour. To test the influence of the shopping habit on the visitors' navigation, we applied a chi-square statistical analysis and tested the relationship between the familiarity of the visitors with space and their choices: The first test is for the relationship between visitors' familiarity and the planification of their visit (see table 4), the second one is interested in their itinerary influences whether it is the spatial layout or their shopping habit. The results show (See table 5):

Table 4 Chi-square analysis of independence (Knowledge and navigation type)

	good	Average	weak	Row Totals
planned	38 (24.64) [7.24]	19 (21.04) [0.20]	1 (12.32) [10.40]	58
search	26 (39.94) [4.86]	46 (34.09) [4.16]	22 (19.97) [0.21]	94
random	18 (17.42) [0.02]	5 (14.87) [6.55]	18 (8.71) [9.91]	41
Column Totals	82	70	41	193 (Grand Total)

A chi-square test of independence was performed to examine the relation between the familiarity of visitors and the type of navigation. The relation between these variables was significant (table 4), $X2$ (4, N =193) = 43.5491, p = .00001<.05. familiar visitors were more likely to plan their visits while unfamiliar visitors are more likely to search their objectives.

Table 5 Chi-square analysis of independence (Knowledge and navigation influences)

	good	Average	weak	Row Totals
Spatial layout	39 (48.01) [1.69]	40 (40.98) [0.02]	34 (24.01) [4.16]	113
Shopping habit	43 (33.99) [2.39]	30 (29.02) [0.03]	7 (16.99) [5.88]	80
Column Totals	82	70	41	193 (Grand Total)

The hypothesis was that both spatial layout and shopping habit influence the visitors' choices of wayfinding in shopping centres, with differences between familiar and unfamiliar visitors, the chi-square test of independence showed that there was significant association between the familiarity of visitors' (level of knowledge) and the influence of their shopping habit and the spatial layout, $X2$ (2, N =193) = 14.17, p = .00083. The more a visitor is familiar with space, the more he uses his shopping habit as a navigation aid (table 5). The need of spatial settings for guidance increases as the degree of familiarity decreases.

Comparing these results, we can confirm that the visitors' shopping habit and the visual patterns of space dominate their choices, they have a strong influence more than the spatial accessibility since the correlation values and the overlapping maps show weak relationships, connectivity is more influential than integration.

6. Conclusion

The purpose of this research is to define the effect of spatial parameters on visitor's navigation in shopping centres in Algeria. Shopping centres are taking their place in Algerian cities and in the citizens' daily life. This research allowed clarifying several points.

The case study, Bab-Ezzouar shopping centre was analysed through two techniques of space syntax: the axial map for accessibility patterns and visibility graphs "VGA" for visual patterns. The collected data on the real use of space through two methods: people following and the questionnaire survey allowed us to verify, in a first stage, the rate of use for each space then how the visitors are influenced by configurational parameters through the correlations of results. These analyses have confirmed that:

Navigation is difficult for unfamiliar visitors with a precise destination, but it encourages discovery for unfamiliar visitors who have the objective of discovering space. Navigation in the shopping space is strongly influenced by the level of knowledge of the visitor and the precision of their destination.

The results show a high correlation of syntactic measures, connectivity and integration in both axial and visual maps with the users' flow, however some anomalies were observed, which may be considered as design problems that could be enhanced in this example or considered in future designs

The most connected, integrated circulation corridors with the highest choice values are the most accessible. Stores that have a direct relationship with the most connected and integrated circulation spaces are more accessible compared to other medium-hidden stores.

Visitors tend to choose the most open spaces that offer maximum visual accessibility more than physical accessibility, avoiding spaces with obstacles blocking the visual field which can make the

task of orientation difficult. The stores and circulation spaces located in hidden areas are the least chosen by visitors.

The perception of shopping space differs for familiar and unfamiliar visitors. While familiar visitors navigate through a pre-planned itinerary based on their knowledge and known destinations, unfamiliar visitors use visual parameters to read space and choose their itinerary searching for their destinations. The confrontation confirmed the results of the spatial analysis; the majority of observed visitors tended to choose the most connected spaces. However, hidden spaces with low configuration values were the least chosen spaces. Thus, visitors prefer walking in a straight-line avoiding change of direction, they prefer, also, simple corridor stores and open spaces that do not require several choices in terms of direction to reach their destination. The confrontation has allowed us to highlight the different architectural features of the shopping space that can hinder an adequate quality of use in shopping centres. Using these features, designers can predicate the visitors' behaviour, so give the suitable solutions to improve navigation and comfort of the visitors.

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Property Price Attributable to Subdivision Neighbourhood Designs: Hedonic Pricing Model Approach in Bangkok Metropolitan Region, Thailand

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ABSTRACT

The purpose of this paper is to determine whether the property price is caused by the subdivision neighbourhood designs in the Bangkok Metropolitan Region (BMR), Thailand. A total price model is developed during the analysis process. The model provides a greater understanding of the significance of the subdivision neighbourhood designs that are related to property pricing. This paper is based on data collection from 50 subdivisions across the BMR area. The hedonic pricing approach is used to develop the models. The semi-log models are developed on 1,182 samples of property sales located in eight zones of the BMR. The independent variables include general bundles of property characteristics and the subdivision neighbourhood design items. There are two major findings in this study. First, this study provides a suitable property price model for subdivision development in the BMR. The model presents the high level of R^2 at 0.948. The model confirms that all classical hedonic variables are statistically significant to the property price. Furthermore, the additional alternative variables for the subdivision neighbourhood design items can improve the level of variation explained by the model. Second, this study finds that the average property price attributable to the subdivision neighbourhood design is about 20.24 % of the total property price. The components of the subdivision neighbourhood design items consist of project characteristics, recreation features, social facilities, and transportation system design. The model should support knowledge of the design's impact on the property price for the Government or policy makers on making appropriate policies for urban and environmental management. The model provides a guideline for developers on appropriate property selling-prices for subdivision development in the BMR. The new understanding of the property price attributable to the subdivision neighbourhood designs support suitable decision making on new subdivision development in the BMR.

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1. Introduction

The Bangkok Metropolitan Region (BMR) is the area that consists of the Bangkok Metropolitan Area (BMA), the capital city of Thailand, and its five adjacent provinces, which are Nontha Buri, Pathum Thani, Samut Prakan, Nakhon Pathom, and Samut Sakhon (REIC, 2009). The BMR is the centre of various activities in Thailand, including political, commercial, agriculture, and industrial. Consequently, the BMR has the highest population density in Thailand (Calhoun, 2002; Sheng, 2002).

At present, the highly competitive situation for single-family housing in the BMR influents the developers who are more concerned about their product designs. The subdivision product includes land, houses, and their neighbourhood amenities. The quality and quantity of the subdivision neighbourhood designs are important for competitive strategies for developers. However, there is still a lack of information on property prices caused by neighbourhood designs, but this highly influences the developers' investment decision (Suttiwongpan et al., 2019). Therefore, appropriate knowledge for guidance on the neighbourhood designs is required for industry practices (Tochaiwat et al., 2018).

For the BMR, there are a small number of articles on the effects of the subdivision neighbourhood designs on property prices. Those articles present the experience of developers and designers, which indicate that the neighbourhood features can add value to property prices for single-family subdivision projects (Piputsitee & Kittikunaporn, 2006; Tangmatitham, 2010). There is still no academic research on the relevant topic in the BMR, but it can be found in a number of studies from various locations (Benefield, 2009; Hui et al., 2007; Jones et al., 2009; Kauko, 2003).

Due to lacking essential knowledge for the BMR, this study aims to determine the property price attributable to the neighbourhood designs on subdivision development. This study first develops a total property price model that includes all possible related variables, and then focuses on the influence of the subdivision neighbourhood designs to the property price. In addition, several studies confirmed strong evidence of using a hedonic pricing approach for developing a property price model. Thus, the hedonic pricing approach is applied to develop the models in this study. The most appropriate model comes from the empirical method on a semi-log function. The semi-log models are developed on 1,182 samples of property sold in eight zones of the BMR. Sets of dependent and independent variables are also collected from the primary source. The dependent variable is actually the property-selling price, while the independent variables include the general property characteristics bundles and the subdivision neighbourhood design items.

The model expects to provide a guideline for developers on setting an appropriate property selling-price for subdivision development in the BMR. This new knowledge of the property price attributable to the subdivision neighbourhood designs could give information to support more suitable decision making on new subdivision development in the BMR.

The structure of this paper is as follows: section 2 provides the literature review, including the study area background. Then, section 3 presents the data and methodology. Section 4 indicates the results and interpretation of the empirical models. Finally, conclusions are offered in section 5.

2. Literature Review

This section provides a summary of the necessary existing information on related topics to the objective of this study. The first section presents literature on the subdivision neighbourhood design. Then, the relation between property selling-price and their design items are also reviewed for more understanding on the model development process. The last part of this section indicates a gap in the current situation that is significant for this study.

2.1 Neighbourhood Amenity Designs

The term neighbourhood has the meaning of the district or its local peoples or residents. A neighbourhood is the place that supports the social activity of the residents (Barton, 2000 p. 4; Choguill, 2008).

This broadly defines the "neighbourhood designs" as the design components of the community and residents for support, including project characteristics, recreation areas and social facilities, and the transportation system (Benefield, 2009; Warrick & Alexander, 1998). The appropriate neighbourhood design is important for sustainable subdivision development by increasing the level of social activities in the housing estate, which assists the creation of sustainability for development (Pasuthip & Panthasen, 2009).

Many previous studies on subdivision neighbourhood design have been done over the years. As started by Perry (2007) in a published monograph about neighbourhood unit design concept. The neighbourhood features include institutional, social, and physical designs, which provide neighbourhood residents opportunities to interact with those within their neighbourhood boundaries. This design concept focuses on the important neighbourhood centre, such as community school, which should be located at the centre of the community and could be accessed without crossing a main street. The density of residential units per neighbourhood area should be suitable for their social facilities, such as community centre, sport facilities, and playground. In addition, the design of the internal streets should consider both pedestrian safety and aesthetic purposes. Moreover, the neighbourhood should dedicate enough space for recreation in open space, such as parks, lakes and other community activity areas (Choguill, 2008; Lawhon, 2009; Perry, 2007).

Moreover, there are several publications that consider neighbourhood amenity designs. Those conclusive ideas demonstrate that there are four categories of neighbourhood

amenity designs: *neighbourhood characteristics*, *recreation features*, *social facilities,* and *transportation system designs* (Asabere & Huffman, 2009; Blair et al., 2004; Foltête & Piombini, 2007; Warrick & Alexander, 1998). More details of some selective variables will be explained in Section 3.3.

The authors conducted this study in Bangkok, the capital city of Thailand, and there is a considerable number of shop-houses located here. The study was conducted in four districts of Bangkok, which were Bangkokyai, Parsricharoean, Bangkae, and Nongklam. The districts are located along Petchkasem Road on the boundary of the Bangkok Metropolitan Administration. These four districts were selected due to their variability in the types of enterprises present (Figure 1). They offer a mix of enterprises, such as commerce, service, and manufacturing. The study areas exist along the main arterial highway of Petchkasem Road within the industrial areas in Samutsakorn Province. The selected study area represents a cross-sectional profile of the city. This area is one of the centers of commercial activities in Bangkok. In the current study, shop-house enterprises were stratified based on their types of activities.

2.2 Hedonic Pricing Model Approach

The hedonic pricing model is a powerful and appropriate research tool to assess the values of the implicit values of the products (Jim & Chen, 2006; Sirmans et al., 2005). The hedonic regression model has been broadly used to model property value (sell or rent) (Baranzini & Schaerer, 2007; Chongyosying, 2005). The model approach regressed the property price by various characteristics (Cho et al., 2008; Gao & Asami, 2007; Jim & Chen, 2009; Limsombunchai et al., 2004). The simple pricing model can be presented as a linear relationship between the property price (dependent variable) and its characteristics (independents variables) (Randeniya et al., 2017). There is no specific function form for a hedonic pricing model. The model can be presented in many functional forms, such as simple linear, semi-logarithm, double-logarithm (log-log), and Box-Cox (Jim & Chen, 2006). The most suitable model is usually determined by empirical methods (Palmquist et al., 2005). However, hedonic pricing models have been usually presented by using a semi-logarithmic (semi-log) model. The dependent variable is usually estimated in the form of a natural logarithm (ln), while the independent variable is left as simple. Then the coefficient estimates present the percent change of the predictor for a unit change in the given dependent variable (Baranzini & Schaerer, 2007; Chongyosying, 2005; Sirmans et al., 2005).

There are a number of studies on property price on various factors. Regarding the *neighbourhood characteristics*, Mohamed (2006) indicates the effect that higher-density development could have on residential privacy, followed by, Bosworth (2007) who supported this idea that the lower-density development is quieter, and then the higher-density development is negative to the property price. Several studies indicate the significant of the land-use diversity index (LUDI) to the property price (Baranzini & Schaerer, 2007; Geoghegan et al., 1997; Poudyal et al., 2009). The LUDI is the indicator to measure the variety of the land-use in the vicinity of the properties. The results from those studies conclude that LUDI can impact both positively and negatively on the property price. In addition, Song and Knaap (2004) analyzed the impact of the prices on single-family properties when mixed land uses are included in neighbourhoods. The study finds that the property prices increase with their proximity to or with increasing amount of community parks or neighbourhood commercial land uses, while the prices tended to decrease with proximity to multifamily residential units.

In cases of studies related to *recreation features*, Henry's (1999) contribution of landscape design quality to the property price. The result indicates that the selling price is 6 % - 7 % higher if the quality of the landscape is mark as excellent rather than good. In addition, the variations in the premium depend on the different property locations. Roberts (2007) presents details of the property prices in Aberdeen, Scotland, UK. The hedonic price model is developed from a relationship between the sale price to the urban park and open space. The results show that the distance from the boundary of a park and the perimeter of the open space to the property affects the property price premium. The price premium ranges between 0.44 % - 19.97 % depending on the type of residence and park. The premium will decrease if the residential area is in close proximity to the park area due to the effects of uncontrolled activities. Additionally, several studies from Baranzini and Schaerer (2007), Kong et al. (2007), and Cho et al. (2008) indicate that the size, location, configuration, and other design features of open spaces, such as community park, lake, sport field, and other recreation area create a positive impact to the property price.

In the case of *social facilities,* Hui et al. (2007) investigated the neighbouring and environmental characteristics of a residential property price in Hong Kong. The neighbourhood amenity independent variables including accessibility, clubhouse, and greenbelt area. The results show a positive impact for most of the variables, but only greenbelts are not significant to the property price. Benefield (2009) introduces the modelling of common neighbourhood amenity as a package using the hedonic pricing approach. The results indicate that tennis courts, clubhouses, boating facilities, and golf courses significantly impact the property price ranging from 8.3 % - 10.0 %.

Moreover, for *transportation system designs*, Matthews et al. (2007) evaluates the effect of street layout and interaction of accessibility to the property price. The study indicates that a more gridiron-like street pattern reduces the property value. In addition, this study introduces the connectivity index (CI) to represent the accessibility by a ratio of total street intersections to total street segments, thus the higher the CI trends to increase the property price. While, several studies support the idea that a cu-del-sac street pattern effects the positive impact to the property price due to the reasons of safety, liveable, and sense of the community form the design pattern (Asabere & Huffman, 2009; Bally, 2010; Ben-Joseph, 1995; Song & Knaap, 2003; Southworth & Ben-Joseph, 2004). Moreover, the width of the street and pavement on both main roads and sub roads are

also significant to the property price (Ben-Joseph, 2003; Clifton et al., 2008), while increasing the development cost and reducing the saleable area (Cannaday & Colwell, 1990; Johnson, 2008).

For the BMR, there are a small number of property price model studies using the hedonic pricing approach. Calhoun (2002) and Buranathanung et al. (2004) developed a property price model using the log-linear form. The dependent variable data is assessed by the Government Housing Bank (GHB) for mortgage evaluation processes. The independent variables mostly focus on the structure characteristics and their location. However, the price of properties from the mortgage evaluation process have been usually lower than the asking or selling price. Furthermore, the models need to be updated every five years.

2.3 Summary

The information above presents strong evidence to identify if there is no appropriate study on single-family property selling-price attributable to the neighbourhood designs of subdivision development in the BMR. Therefore, this study firstly applies the hedonic pricing approach to develop the total property price model. The models include a set of independent variables, including general property characteristics and their neighbourhood designs. The most suitable model from the empirical processing is used to examine the property price attributable to the neighbourhood designs. The model should support knowledge of the design impact on the property price for policy makers on making appropriate policies for urban and environmental management. Moreover, the models expect to provide guidelines for the developers on setting appropriate property selling-prices for subdivision development in the BMR. This new understanding of the property price premium attributable to neighbourhood designs could indicate support for more suitable decision making on new subdivision development in the BMR.

3. Data and Methodology

3.1 Data collection

This study collects data from a primary field survey of 50 private subdivision projects in the BMR. The sample size will follow the requirements determined by Yamane's formula, where the minimum requirement is 400 sets at 95 % confidence (1973, p. 1089). The total sample size, after extraction of the outliers, are 1,182 sales from different locations in the BMR. The dependent variable in this study is the actual property-selling price. Meanwhile, the independent variables are the set of property characteristic variables and neighbourhood design variables. Table 1 provides the variable names and their general statistic figures.

The actual property-selling and all property design variables are directly collected from the developers or project sale representatives. Meanwhile, the set of neighbourhood design variables are gathered from the drawings and their design documents. All the design drawings and their documents received permission from the developers and/or the Department of Land, Ministry of Interior. However, the selling-price and all designs are confidential, thus the names of the developers, project names, and specific locations cannot be published.

3.2 Methodology

This study applies a hedonic price model to develop the property pricing model. This study adopts the semi-logarithm function to develop the model with a variable set of general characteristics, structural characteristics, project location, lot location, and neighbourhood design. According to He et al. (2010), the semi-log function is the key situation function in the Hedonic pricing model, thus it will be adopted for use in this study. The property price model is estimated using the ordinary least squares estimation (OLS) technique. The function is presented in Equation 1.

$$Ln(P) = \beta_0 + \beta_G X_G + \beta_S X_S + \beta_{PL} X_{PL} + \beta_{LL} X_{LL} + \beta_{NAD} X_{NAD} + \varepsilon \quad [1]$$

Where *Ln(P)* is the natural logarithm of the property price, X_G corresponds to the general characteristic vector of the property, X_S corresponds to the structural characteristic vector of the property, X_{PL} corresponds to the project location vector of the property, X_{LL} corresponds to the lot location vector of the property, X_{NAD} corresponds to the neighbourhood amenity design vector of the property, β_0 is the constant term of the model, β_G, β_S, β_{PL}, β_{LL} and β_{NAD} correspond to the regression coefficient vectors of each independent variable, and ε is an error term reflecting the unobservable.

This study develops three property price models using different sets of independent variables; *Model 1* is a traditional model used for confirming the essential classical hedonic variables of the general characteristics, structural characteristics, and location characteristics. The result from *Model 1* will be used to classify the appropriate variables for the next step. Then, *Model 2* is the first alternative model that includes the neighbourhood design variables into the property price modelling experiment process. All likelihood independent variables from the existing literature will be included in the model. Finally, *Model 3* is a second alternative model that applies a stepwise regression to the development of the most appropriate property price model. *Model 3* will be used to indicate the property price attributable to the subdivision neighbourhood designs for the BMR. Names, definitions, descriptive statistics, and a brief description of the selected variables will be provided in the next section.

3.3 Selection of Model Variables

Table 1 provides the variable legends along with the definitions and the descriptive statistics. However, to avoid unnecessary repetition, only variables requiring further explanation than that provided in Table 1 will be discussed in this section.

However, this study focuses on the subdivision neighbourhood designs, but the other non-subdivision neighbourhood designs (general characteristics, structural characteristics, project location, and lot location) are included for model completion purposes.

Table 1 Legend, definition, and descriptive statistic

Variable	Definition	Mean	Standard deviation	Range
Independent Variable				
P	Total price (million Baht)	5.39	4.05	1.45–32.00
ln(P)	Natural logarithm of price	15.34	0.52	1.49-17.28
General characteristics				
SY	Sale year up to 2010	1.07	2.51	0-18
B	1 if property is developed by branded company, 0 otherwise	0.46	0.50	0,1
Structural characteristics				
LS	Land lot size (m^2)	276.19	134.38	70.80-1,112.00
DA	Dwelling area (m^2)	181.88	71.57	70.00-577.00
DP	1 if dwelling is Duplex, 0 otherwise	0.06	0.24	0,1
TH	1 if dwelling is Townhouse, 0 otherwise	0.07	0.25	0,1
Project location				
BUF	1 if property is located in BUF, 0 otherwise	0.57	0.50	0,1
BSA	1 if property is in BSA, 0 otherwise	0.08	0.27	0,1
NB	1 if property is in NB, 0 otherwise	0.08	0.27	0,1
SP	1 if property is in NP, 0 otherwise	0.02	0.13	0,1
PT	1 if property is in PT, 0 otherwise	0.15	0.35	0,1
SP	1 if property is in SP, 0 otherwise	0.03	0.16	0,1
SS	1 if property is in SS, 0 otherwise	0.05	0.22	0,1
WRP	Width of road in front of subdivision project (m)	16.04	13.92	5.20-89.00
Lot location				
LC	1 if property lot is located at corner of block, 0 otherwise	0.22	0.41	0,1
LMR	1 if property lot is located on main road, 0 otherwise	0.28	0.45	0,1
LLV	1 if property lot is located on lake-view, 0 otherwise	0.02	0.14	0,1
LPV	1 if property lot is located on park-view, 0 otherwise	0.14	0.34	0,1
Subdivision neighbourhood design				
Neighbourhood characteristics				
LN	Number of property lots	237.05	217.64	41-1,198
LUDI	Land-use diversity index	0.76	0.08	0.54-1.00
PUA	Property unit per subdivision area (PU/m^2) × 1,000	2.94	1.23	
NDT	Number of dwelling types	1.31	0.50	1-3
DPR	Ratio of duplexes in subdivision development			0.00-1.00
THR	Ratio of townhouses in subdivision development			0.00-1.00
NDD	Number of dwelling designs in subdivision	5.13	2.57	1-11
NPA	Number of public art in subdivision	1.20	1.71	0-15
NCR	Number of cultural and religion symbols in subdivision	0.97	0.48	0-2
UEL	1 if subdivision designed by underground electricity line,	0.03	0.16	0,1

Variable	Definition	Mean	Standard deviation	Range
	0 otherwise			
Recreation features				
PA	Park area (m^2) / 1,000	4.20	4.82	0.10-23.29
PS	1 if park shape is rectangular, 0 otherwise	0.68	0.47	0,1
PD	1 if park is centralised design type, 0 otherwise	0.77	0.42	0,1
PSA	Number of properties within radius of 300 m. to nearest park	202.55	198.12	40-1,000
PaF	Ratio of park area located in front part of project	0.39	0.44	0.00-1.00
PaM	Ratio of park area located in middle part of project	0.52	0.46	0.00-1.00
LA	Lake area (m^2) / 1,000	0.63	2.00	0.00-10.92
LaF	Ratio of lake area located in front part of project	0.04	0.18	0.00-1.00
LaM	Ratio of lake area located in middle part of project	0.10	0.27	0.00-1.00
MTN	Number of mature trees per neighbourhood area (MT/m^2) $\times 100$	0.04	0.02	
RNP	Ratio of native plants	0.81	0.04	0.75-0.90
Social facilities				
CH	1 if neighbourhood has clubhouse, 0 otherwise	0.62	0.49	0,1
SP	1 if neighbourhood has swimming pool, 0 otherwise	0.56	0.50	0,1
TC	1 if neighbourhood has tennis court, 0 otherwise	0.12	0.32	0,1
FF	1 if neighbourhood has football field, 0 otherwise	0.06	0.23	0,1
PG	1 if neighbourhood has playground, 0 otherwise	0.63	0.48	0,1
WTP	1 if neighbourhood has wastewater treatment plant, 0 otherwise	0.09	0.29	0,1
Transportation system designs				
CI	Connectivity index	1.29	0.26	0.50-1.75
GCR	Ratio of road circulation design as grid	0.37	0.37	0.00-1.00
CCR	Ratio of road circulation design as cul-de-sac	0.26	0.25	0.00-0.88
WMR	Width of main road	13.55	3.20	6.00-16.00
WSR	Width of sub road	9.37	1.36	5.00-11.00
WWM	Width of pavement at main road	1.73	0.32	1.00-2.50
WWS	Width of pavement at sub road	1.43	0.22	1.00-2.00

The sale year (SY) considers the different times of each sale. A property that was sold in 2010 is recorded as 0, one in 2009 is recorded as 1, and one in 2008 is recorded as 2.

While, brand (B) variable is a dummy variable to consider the influencing of the brand name of the property development firms in Thailand. The brand variable is recorded as 1 if the property is developed by a well-known listed company on the Stock Exchange of Thailand (SET) (SET, 2010), while recorded as 0 for the rest.

This study provides more explanation for the land-use diversity index (LUDI) and the connectivity index (CI). The LUDI variable in this study refers to the measurement of the land use variety in the subdivision. LUDI is the measurement of the land use variety in the subdivision, which is calculated by equation [2] below.

$$LUDI = -\sum_{k=1}^{K}(P_k)\ln(P_k) \quad [2]$$

Where P_k is the proportion of the area dedicated to land use k in the subdivision. There are three types of saleable area, recreation area, and infrastructure area. A larger value of LUDI indicates more diverse land use.

Next, CI is a measurement to quantify the roadway connectivity. The CI of this study follows that of Ewing (1996), which is the ratio of the segment numbers to the intersection numbers. A higher CI number means that travelers have increased the route choice.

To conclude, the models will be developed under the recognized method. The variables and sample size will be selected by strong academic support. The results of this study will be presented in the next section.

4. Results and Discussion

The results will be divided into two sections for the total property price model and the specific property price attributable to the subdivision neighbourhood designs.

4.1 Total property price model

Table 2 presents the results of the study including the coefficient parameter estimations obtained for the OLS of all three models.

Table 2 Regression results

Variable	Coefficient					
	Model-1		Model-2		Model-3	
Interception	13.587	***	12.959	***	13.016	***
General characteristics						
SY	- 0.025	***	- 0.025	***	- 0.029	***
B	0.126	***	0.136	***	0.117	***
Structural characteristics						
LS	0.004	***	0.002	***	0.003	***
DA	0.001	***	0.001	***	0.001	***
DP	- 0.355	***	- 0.316	***	- 0.292	***
TH	- 0.658	***	- 0.647	***	- 0.588	**
Project location						
BUF	- 0.200	***	- 0.210	**	- 0.312	***
BSA	- 0.320	***	- 0.341	**	- 0.368	***
NB	- 0.313	***	- 0.312	*	- 0.345	**
SP	- 0.576	***	-0.529	*	- 0.575	**
PT	- 0.644	***	- 0.678	***	- 0.605	***
SP	- 0.430	***	- 0.423	**	- 0.502	***
SS	- 0.530	***	0.542	***	- 0.550	***
WRP	0.006	***	0.005	*	0.003	**
Lot location						
LC	0.051	***	0.046	***	0.066	***
LMR	- 0.020		0.033	***	0.065	***
LLV	0.025		0.023		0.079	***
LPV	0.009	**	0.020	**	0.093	**
Subdivision neighbourhood design variables						
Project characteristics						
NL			- 0.002	***	- 0.004	***
LUDI			1.457	***	0.576	**
PUA			- 0.005		- 0.078	***
NDT			- 0.325	***	- 0.188	***
RDP			-0.210		-0.115	*
RTH			-0.325	*	-0.232	**
NDD			0.0007		0.014	***
NPA			0.026	***	0.022	***
NCR			- 0.247		NA	
UEL			- 0.288	*	0.254	***
Recreation features						

Variable	Coefficient		
	Model-1	Model-2	Model-3
PA		0.010 ***	0.009 ***
PS		- 0.007	- 0.169 ***
PD		- 0.254 ***	- 0.097 ***
PSA		- 0.001 **	0.002 ***
PaF		0.333 ***	NA
PaM		0.101 ***	0.093 ***
LA		0.043 ***	0.110 ***
LaF		1.089 ***	NA
LaM		- 0.556 ***	NA
MTL		0.033 ***	0.019 ***
RNP		0.424 *	0.391 ***
Social facilities			
CH		0.220 ***	0.105 **
SP		0.271 ***	0.102 ***
TC		0.061	0.045 ***
FF		0.573 ***	NA
PG		0.222 ***	0.048 *
WTP		0.237 **	0.239 ***
Transportation design			
CI		0.248 ***	0.201 ***
GCR		- 0.536 ***	- 0.152 ***
CCR		0.054 *	0.023 **
WMR		0.026 ***	0.025 ***
WSR		- 0.119	0.010 *
WWM		0.018 **	0.019 ***
WWS		0.011 **	0.017 ***
R^2	0.870	0.950	0.948
Adjusted R^2	0.868	0.946	0.945
F-statistic	389.708	554.059	417.156
F-significant	0.000	0.000	0.000

Note: * Significant at the 10 % level, ** significant at the 5 % level, *** significant at the 1 % level

The result in Table 2 indicates that all three models present high explanatory power: R^2 = 0.870 for *Model 1*, R^2 = 0.950 for *Model 2*, and R^2 = 0.948 for *Model 3*. The signs of all the independent variables are consistent with expectations. The comparison between the traditional model (*Model 1*) and the alternative models (*Model 2* and *Model 3*) shows that the R^2 of both alternative models are higher than the traditional model. Moreover, the R^2 of *Model 2* is slightly higher than that of *Model 3*, but some variables in *Model 2* are not significant at less than the 0.01 confidence level.

The results found that most of the coefficients of the non-subdivision neighbourhood designs are stable across the model. Meanwhile, some variables form the lot location category are not significant in Model 1 (*LMR* and *LLV*), while only LLV and DPT are not significant in Model 2, but all variables are significant in Model 3.

To conclude, the results strongly support all traditional variables being significant for the property price. The R^2 of Model 3 is slightly lower than the R^2 of Model 2, but all variables are significant. Thus, Model 3 is the most suitable model to predict the property price model for subdivision development in the BMR.

In Model 3, the coefficients of the classical variables show that the selling price rises by about 2.86 % annually; the price of the branded property increases by 12.41 % for similar structural

and location characteristics. In addition, the property price increases by about 0.30 % and 0.10 % per 1 m^2 increase in lot size and dwelling area, respectively. The result indicates that there are significant differences in the type of dwelling: duplexes and townhouses decrease the selling price by 25.32% and 44.46%, respectively. Next, the price of properties located out of the BIC reduced by 26.80 % for BUF, 30.79 % for BSA, 29.18 % for NB, 43.73 % for NP, 45.39 % for PT, 39.47 % for SP, and 42.31 % for SS, compared to similar properties located in the BIC. In addition, the property price increased by 0.30% for every 1 m the WRP increased. Moreover, the property price increased by 6.82 %, 6.72 %, 8.22 %, and 9.75 % in cases where the lot is LC, LMR, LLV, and LPV, respectively. Nevertheless, the price reduced by 0.03 % for every 1 m away from the nearest park.

Finally, this study focuses on the effect of neighbourhood amenity design on property price, so the result of the neighbourhood amenity design variable bundles will be explained in the next section.

4.2 Property Price Attributable To Neighbourhood Amenity Design

According to Model 3, after the extraction of non-neighbourhood amenity design items, the average property price attributable to the neighbourhood amenity design is 1,130,086.16 Baht, which is about 20.24 % of the total property price. The clear explanation of the neighbourhood amenity designs effect the property price in the subdivision development for the BMR. The results are divided into four categories of neighbourhood amenity design, as in the following.

4.2.1 Project Characteristics

The coefficient in Table 3 indicates that there are five negative variables that affect the property price, which include six positive variables and one insignificant variable. A unit increase for NL drops the price by 0.36 %, while more diverse land-use (LUDI) also increases the property price. However, an increase in the PUA decreases the property price; but an increase in the NAU raises the price. Moreover, the variety of dwelling type also reduces the price, in addition a one-unit change of RDP and RTH drops the property price by 10.86 % and 20.71 %, respectively. The number of dwelling designs and public art are also significant and positive to the house price, while the number of cultural and religious symbols is not significant. Furthermore, the model indicates that the underground electrical design also added to the property price by 28.92 %. Finally, the property price in projects developed under the EIA regulation is also higher than the others by about 27.00 %.

4.2.2 Recreation Features

The park area is the most important item for the recreation feature design. The result from Model 3 indicates that an increase of 1,000 m^2 in park area can raise the property price by 0.92 %. In the same direction, the result indicates that a unit increase in PSA will lead to an increase of 0.18 % in the property price. Additionally, a park in the middle of the subdivision also increased the property price by 9.75 %, but a park in the front is not significant. On the other hand, a park with a rectangular shape and central park design does not support the property price. The price decreases by 15.55 % and 9.24 % for parks with rectangular shape and central park design, respectively. Moreover, the lake area is a voluntary design item for subdivision development (except for EIA-involved projects in the form of a flood management reservoir). The result indicates that every 1,000 m^2 increase in lake area increases the property price by 11.63 %, while the location of the lake both in front and middle areas are not significant. Finally, the model supports the importance of greenery features; both of mature trees and native plants, which also increase the property price.

4.2.3 Social Facilities

The social facilities normally increase the property price. The result from Model 3 confirms that idea, most mot social facility variables are significant and have a positive impact on the property price, and only the FF variable was not significant. The price of the property increased by 11.11 %, 10.71 %, 4.64 %, and 4.91 % for the existence of a clubhouse, swimming pool, playground, and tennis court in the subdivision development, respectively.

4.2.4 Transport System Design

The model indicates that a higher level of route choices (CI) will increase the property price by 22.26 %. However, a gridiron street ratio reduces the property price by 14.10 %, on the other hand, a cu-de-sac street plan lifted the property price by 2.31 %. Moreover, the wider the road and pavement generally increased the property price, and only the width of the sub road is not significant to the price. The model shows that a one-unit increase in the main road width, main road pavement width, and sub road pavement width could increase the property price by 2.53 %, 1.01 %, 1.90 %, and 1.72 %, respectively.

5. Conclusion

The aim of this study was firstly to develop a property-selling price for subdivision development in the BMR, and then to identify the specific property price influencing factors in neighbourhood amenity designs. The independent variables consist of classical variables on sale year, brand value, structural and location characteristic variables, and bundles of alternative neighbourhood amenity design variables. There are three semi-log hedonic price models developed in this study. However, this study prefers to use the result form Model 3 for further analysis, because the R^2 is high, slightly different from the R^2 of Model 2, and all variables are significant to the property price. The major findings of this study are as follows.

Firstly, this study confirms that the classical variables are significant to the price model. Meanwhile, the comparison of each R^2 value concludes that Model 2 and Model 3 are slightly different, while both are greater than the R^2 of Model 1. This situation confirms that the additional neighbourhood amenity

design variables are necessary to improve the level of variables explainable by the model. Moreover, most of the selective alternative neighbourhood amenity design variables are significant to the property price. This situation confirms the importance of the different designs on the subdivision product. The knowledge supports information to encourage high quality neighbourhood amenity designs for the subdivision development industry for the BMR.

Secondly, this study found the ratio of property price that is influenced by the neighbourhood amenity design is about 20.24 %. This figure consists of project characteristics, recreation features, social facilities, and transportation system design. For project characteristics, the higher level of land-use diversity, number of dwelling designs, number of public art, underground electricity installation, and a project developed under the EIA-regulations have a statistically significant impact on the price. Meanwhile, the mix of dwelling types and the ratio of non-single detached houses can reduce the price. At the same time, the result finds that the larger the park and lake, along with a suitable location for the park, increase the price. Then, non-rectangular and decentralized park designs are appropriate designs to increase the property price. This study shows the strongly positive impact of all social facilities to the price. At the same time, higher level of travel choice, good proportion of traffic circulation, and wider road and pavement will support the property price.

To conclude, this study indicates that Model 3 can provide a guideline for developers on setting the appropriate property price for subdivision projects. Moreover, the proprty price attributable to neighbourhood amenity designs will be revealed to developers, designers, and other professionals, which relate to the subdivision development to understand the impact of the neighbourhood amenity design on the property price in the BMR. This study provides necessary information to support appropriate decision making on new subdivision development in the BMR.

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The Consumption of Tradition and Heritage Areas in the Grebeg Sudiro Event in Surakarta

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ABSTRACT

Cultural heritage cannot be separated from the traditions and identity of a society. However, heritage and tradition have become commodities for tourist consumption. They become interesting for tourists who look for 'authentic' experiences. Some of the so-called traditions commodified for tourism are intentionally made for a specific purpose. In this case it fits Hobsbawm's concept of 'invented tradition'. This paper focuses on the Grebeg Sudiro event, carried out by the Sudiroprajan community, in the city of Surakarta. This invented tradition has been held every Lunar New Year since 2008 in the Pasar Gede heritage area. The relationships between an invented tradition, tourism consumption, and place identity in a heritage area will be examined in this article. This article will highlight how heritage area as the venue for this event plays role in Grebeg Sudiro and how tourists can consume this tradition along with the heritage place as the venue. This research uses qualitative case study approach. Interviews conducted purposively and direct observations during the event were conducted to note and record the use of cultural heritage areas in the Grebeg Sudiro event, as well as to see how consumption of tradition takes place. Pasar Gede as a place of activity is considered as an interesting object and is considered to represent the identity of Sudiroprajan community. It can be said that invented traditions, cultural heritage identity, and tourism consumption are closely interrelated and complementary.

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1. Introduction

Grebeg is a tradition from Javanese culture. It is usually organised by Javanese royal courts in Surakarta and Yogyakarta whose dynasties still exist nowadays. In previous studies, Grebeg tradition was always considered something traditional but, in this case, we will discuss Grebeg as contemporary phenomenon in this modern world. This paper will also discuss Grebeg as invented tradition and will focus on the consumption of tradition and heritage place that take place in this event. This paper will discuss more about the contemporary tradition that uses heritage area and how that activity makes people consume the tradition, heritage area and everything shown at the venue. This study will be useful for people or agency (government, local community) to make tourism planning program that makes use of existing heritage site(s) to attract tourists. New traditions can be invented from existing cultural values to make what

Hobsbawm calls 'invented tradition'. Invented tradition always adopts the format of real or long-established tradition in order to make the new form of tradition appear as authentic. Invented traditions spread massively in Indonesia, especially in Surakarta after the 1999 Decentralization. One of those invented traditions is Grebeg Sudiro of Surakarta. This Grebeg is so successful as tourist attraction and has been popularly accepted as 'tradition' that it is held annually by the municipal government of Surakarta.

Originally, *Grebeg* is a ritual carried out by the royal court of Surakarta as a manifestation of the king's alms to his people. The implementation of Grebeg involved the royal family, royal apparatus, and all the people. The Grebeg has an attribute called Gunungan (figure 1), which is a mound of agricultural harvest and traditional snacks. This Gunungan is paraded around the Keraton (the royal palace) then stopped at The Great Mosque of Surakarta for some rituals before being distributed to the people. This ceremony is a symbol of the king's generosity as a legitimate regal effort (Purwani, 2014). Meanwhile, Grebeg Sudiro is an invented tradition of the royal court's Grebeg which shows a cultural integration between the Javanese and Chinese traditions. We use Grebeg Sudiro as case study for this research because this event is the first contemporary Grebeg in Surakarta and Indonesia. This event, which emerged in 2008, was initiated by the local community of Sudiroprajan urban kampong and is held in the cultural preservation area of Pasar Gede, a historical market place which dates back to 18th century. The aim of Grebeg Sudiro is to communicate and to promote the theme of cultural diversity (Widyaningsih & Purwasito, 2018). The Pasar Gede area has an important role as a source of identity and inspiration for Grebeg Sudiro. The area has long been a multicultural area inhabited by Chinese and Javanese people. This event highlights the identity of the region and represents harmony among ethnicities.

Pasar Gede has long been known as a historical traditional market in a multicultural setting. Grebeg Sudiro, then, can build its narrative through this historical place to make people believe that Grebeg Sudiro is an 'authentic' tradition despite the fact that it is a recent invention. Cultural heritage objects such as Pasar Gede are produced and consumed when an event takes places in it. The level of cultural consumption relates to and is informed by the demand profiles of heritage sites and services. During the event, several groups of local people sell souvenirs and snacks for tourists. At a different level the participants of Gebeg Sudiro become an attraction for tourists who want 'to consume' the tradition, the values it represents, as well as the snacks. Grebeg Sudiro consists of three activities, namely: a) Umbul Mantram, which is a procession held by local people internally, b) Pepe river boat tours: a local boat tour along Pepe River, a river located very close to Pasar Gede c) the Grebeg Sudiro cultural carnival as the highlight of the event. This annual event is massive, attracting many tourists not only from the city of Surakarta but also from other parts of Indonesia.

Consumption of traditions is unavoidable because of the globalisation era (Ashworth, 2010). Heritage, as part of a culture, is consumed by people who search for 'authenticity', even when some parts of it might be invented. Consumption of tradition is a manifestation of cultural demand. The production of cultural heritage sites ranks those sites as economic income land, and so many countries now actively apply for heritage recognition in order to earn income from tourists' visits (AlSayyad, 2001). This consumption relates to and defines how tourists who visit consume a destination, with that area in the city becoming a leisure product. Such a heritage element can be categorized as an activity place and leisure setting in the host city (Khairi et al., 2019). The commodification of cultural and heritage areas is closely related to consumption and tourism.

A heritage area is part of the development of cultural aspects in a region or country. Such an area is not only a memorial but also a source of value for a community. Cultural heritage objects as a source of identity can be packaged and transformed into new traditions to meet or satisfy certain interests. Cultural modification has become trends in Indonesia (Musthofa, 2017), as well as in other parts of Southeast Asia. One example of this is Malacca in Malaysia. Malaysia is a popular destination, with tourism becoming increasingly popular and significant (Ismail et al., 2014). Malacca is a port city that participated in over 600 years of trading in the Straits of Malacca. The ships and crews from other nations have caused Malacca to have a cultural mix of Malay, Chinese, Indian, English and Portuguese; a mix that influenced the architecture of the historical building that survive in Malacca (Fazil et al, 2014). In the same way, Sudiroprajan is a heritage area in Surakarta where people of Javanese and Chinese ethnic live together for decades. Their cultures mix and influence the building and the cuisine in Sudiroprajan. The types of heritage in Sudiroprajan and Malacca have cultural

Figure 1 Gunungan

diversity and heritage sites for tourism consumption.

This study has significance in building knowledge on invented tradition and the consumption related to that that includes heritage place as the venue of the invented tradition. We draw basic conclusions about the forms of production and consumption in the heritage areas, so that the findings can contribute to the efficient development of heritage festivals, especially in Surakarta. The results can be correlated with decisions to visit a heritage destination. They can also be correlated with the levels of perceived authenticity at the time when the event is held. Such data will be of interest and value to heritage managers, as well as the local people who want to create their own heritage festivals.

2. Theoretical Review

2.1 Invented Tradition and Places Identity

Tradition is shaped by the conditions and potentials of individuals in the interaction between the environment and socio-cultural variables (Soemardi, 1974). Invented tradition is a ritual activity that tries to embed certain values and norms in society through repetitive association with appropriate history (Hobsbawm, 2012). These associations can be made by using narratives. Cultural heritage can be used to build narratives for invented tradition as it has historical value to associate with. The value of cultural heritage is not only about the history of them but also about memories and values embodied in them. Those values are passed on from generation to generation. This heritage can appear in varied types such as: a) built environment, b) traditions, c) languages and d) places commemorating historical events. Some of them are tangible, such as building areas, while some others are intangible such as: a) dance, b) cultural norms and values, c) lifestyle dress and d) handicraft (Ismail et al., 2014). In addition, the heritage's existence reflects social system and activities that take the forms of intangible and tangible objects (Ginting & Rahman, 2016). Cultural heritage object is therefore important, as its existence reflects the patterns and social activities of a society and is therefore an interpretation of the inherited objects, tangible and intangible (Ginting & Wahid, 2015). Cultural heritage does not have fixed meaning. Its meaning is attached by its society to a heritage building or area. That meaning does not need to be permanent. It can change according to continuing economic and socio-political events, in association with collective memory, tradition and sense of belonging (Musthofa, 2017).

Another causative factor of invented tradition is bottom-up initiatives from community, which Sztompka calls "creative minorities". The concept of creative minorities is at the root of this phenomenon where local groups are motivated to achieve something (Sztompka, 2011). Tradition arises because the initiative stem from the community: a) can be widely accepted and adopted by the society, b) happen continuously rather than just once and c) is formalized. One form of the invented tradition is an event or activity that commemorates a certain date. Events are social phenomena found in human culture and realized through various activities such as: i) choreography, ii) dramatics and iii) dynamic aesthetics that are interpreted from the deep meanings that underlie a noteworthy event's historical roots (Fallasi, 1987). The heritage's existence is relevant to the historical value of community around. The local groups who live around or near to heritage environments try to preserve the object because the existence of heritage can help community and village to sustain (Aziz, 2017). On the other hand, local people create their 'new tradition' festival as a way to enable their community to sustain and to preserve the valuable heritage that exists in the community.

Invented tradition is the result of the metonymy of values in the history of a place. A place that has a certain history is a source of identity construction, not only of the specificity of the place but also the construction of meaning from the place (Grey & O'Toole, 2018). Place identity is then a significant factor in invented tradition because place can build the narratives background. The stronger the place identity, the easier for the narratives to be formalized by its wider community. A place can reflect the structure of identity; an entity that consists of a) the physical environment, b) memories, c) feelings, d) values and e) conceptions of human behaviour in the area. Identity can shape a place and gives meaning to the place through a) social interaction, b) symbolism and c) the history behind that place. Identity and place, then, have a very close relationship (Sukri & Radzuan, 2018). The relationships between people and places cause an area to be invested with symbolic meaning in the context of the community and to identify and engender emotions related to the scope of the local community (Lalli, 1992). Identity ownership is intrinsically related to the relationships with: i) the natural and social environment, ii) cultural heritage or iii) historical place for a personal collective view of the present and the future (Edwards, 1998). Moreover, heritage area as places have relationship with identity of people who live around the places. Historical places become source of identity and value of community and this important for commodification itself.

Here we examine the factors that influence place identity, such as: a) distinctiveness, b) continuity, c) self-esteem, d) self-efficacy (Breakwell, 1986). The four principles can be described as follows:

- *Distinctiveness*: the desire to maintain otherness or to be different from the characteristics of 'the other'.
- *Continuity*: continuity of one's self-concept.
- *Self-esteem*: evaluation of self-identification, formed from the perception of pride in a place.
- *Self-efficacy*: belief in one's ability to work successfully in a particular social environment.

The place's identity is maintained to reinforce and to strengthen feelings, a situation that can lead to the perception of authenticity. In this case, place identity is used in invented tradition because it delivers values to suggest authenticity.

2.2 Cultural Heritage and Tourist Consumption

Heritage is a subject of great interest in today's world. Cultural heritage tourism is increasingly on demand. This motivates the surrounding community to explore the potential of existing heritage sites and sources. Heritage, as a focus of tourism, may serve as powerful tools to promote the identity of community to wider society (Butler, Khoo-Lattimorea & Mura , 2014). A desired or looked-for cultural experience is one of the factors that make tourists come to a place, where something new is on offer (Urry, 2002). The 'tourist experience' is what drives cultural heritage promotion; not only the heritage area but also the issues of culture, leisure and social interactions which can cause visitors memorize and value their heritage related experiences (Teoa, Khanb & Rahima, 2014). As the demand for authentic cultural experiences increases, a well-framed cultural event will cause many tourists to visit. This can increase income opportunities for those who offer services to visitors (AlSayyad, 2001). The aim for this heritage tourism is to deliver quality experiences to tourists; with the primary element includes attractive, culturally authentic products that are available in urban heritage settings (Khairi, et al., 2019)

Cultural identity through its commodification represents cultural consumption (Valentina et al., 2015). This situation can be directly attributed to the invented tradition, called a 'remake' of a tradition carried out for a particular purpose. With invented traditions spreading across heritage areas, it is possible to make many of those areas highly popular and attractive to visitors. It is not only the heritage sites with their cultural connections that attract tourists; another factor that is important for tourism relates to the quality of the site's infrastructure and tourist services available (Teoa et al., 2014). This issue pushes the host to produce quality services and complementary activities to gain more consumption and therefore profit. The initial program offered by the host community can improve a visitor's cultural experience; whilst good facilities can most certainly increase visitation rates (Alberini & Longo, 2006).

Tourism is an industry that has the potential to be of great benefit to a country's economic sector; contributing to local communities by creating opportunities to develop their potential (Puah et al., 2018). Cultural heritage tourism will be increasingly linked to cultural production because performances have a high attraction value for tourists. Culture is packaged in a show with narrative stories and imagery made by the community with the producers, so that the culture can be more attractive as a consumer item (Pelly, 2015). The narrative that is formed is the result of people's interpretations of the physical culture and environment, including cultural heritage objects. However, the consequences of cultural commodification are forms of rituals that are often shortened and simplified so they appear magical: religions will be modified because the purpose is limited to entertaining the audience and experiencing secularization, even though this does not occur in all cases (Dharma, 2018). Cultural tourism is something beneficial to the providers as a result of current economic trends. Consumption of cultural tourism develops and creates markets where tourists are willing to spend money to look for various cultural products, the more authentic the better (Ashworth, 2010).

Figure 2 shows that heritage as a place can reflect the value of social and cultural values of a community. Those values can be used as narratives for invented traditions. The invented traditions will then affect the social identity of community by embedding the values in the invented tradition. At the same time, invented traditions are also related to economy in that the trend of cultural heritage tourism makes opportunities for invented tradition to develop. Invented traditions, then, can contribute more to the cultural heritage tourism by providing authentic experience to tourists.

3. Methodology

This study applies qualitative case study approach. As argued by

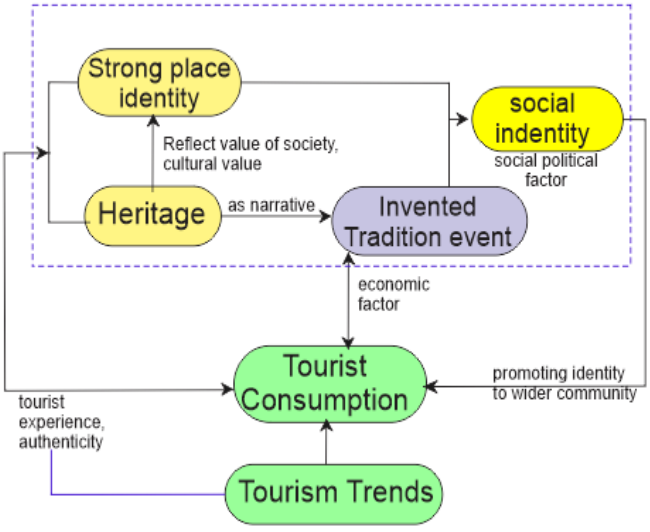

Figure 2 The Dynamic between Heritage, Invented Tradition and Tourist Consumption

Flyvbjerg, (2006), case study is not intended to make a generalization, but it is to be used as "a force of example" on the importance of the substance under investigation by using a very particular case. This research will investigate the consumption of traditions in the cultural heritage site along with the on-going activities in the area by using qualitative case study approach. Sudiroprajan is selected as the case study because that urban kampong has a heritage area, with Pasar Gede and Klenteng Tien Kok Sie as the icons. Its community is unique, multiethnic, with tradition held every lunar year to celebrate their tolerance and unity in diversity called Grebeg Sudiro.

This research is conducted at Pasar Gede Heritage Area where the Grebeg Sudiro event is held. In order to examine the consumption of tradition in heritage area in Grebeg Sudiro event, this research organizes the following steps: a) explore the background of the Grebeg Sudiro as invented tradition activities and its relationship with place identity, b) identify the forms of consumption when the event take places c) identify the importance of heritage area as an event venue, with interviews.

Before doing the interviews and field observation, a guideline is arranged by the following themes:

- History of heritage area that influence Grebeg Sudiro
- Values hold by community that influence Grebeg Sudiro
- The identity of the heritage area and the community
- The reason for Grebeg Sudiro to be held and what is invented from original tradition of Grebeg
- Expected outcome by the host
- Activities that show the production and consumption in heritage site when Grebeg Sudiro held (area in heritage site that is consumed by tourist)
- Spatial layout of the site and and facilities provided when Grebeg Sudiro is held
- Activities by local community

Respondents for interviews are categorized as follows (table 1):

Table 1 Respondent and Information

No	Position	Information
1	Official department of tourism	• The effect of tourism in Surakarta when Grebeg Sudiro held • Importance of Grebeg Sudiro
2	Department of Sudiroprajan urban kampong	• Legality of Grebeg Sudiro tradition • Explanation about committee formation and preparation • Facility fulfillment in Grebeg Sudiro • Importance of program Grebeg Sudiro • Grebeg Sudiro's background, why use Pasar Gede as venue • Route of Grebeg Sudiro • District and social identity
3	Tien Kok Sie Commite	• Ritual that happen in Grebeg Sudiro • History of Grebeg Sudiro • Role of Klenteng
4	Pasar Gede Commite	• Role of member of Pasar Gede • Increase of visitation in Pasar Gede when Grebeg Sudiro held
5	Grebeg Sudiro Founder	• History of Grebeg Sudiro • Background and purpose of Grebeg Sudiro • Importance of Heritage area Pasar Gede and Klenteng in Grebeg Sudiro • Route of Grebeg Sudiro and local people activity • Social identity of Sudiroprajan

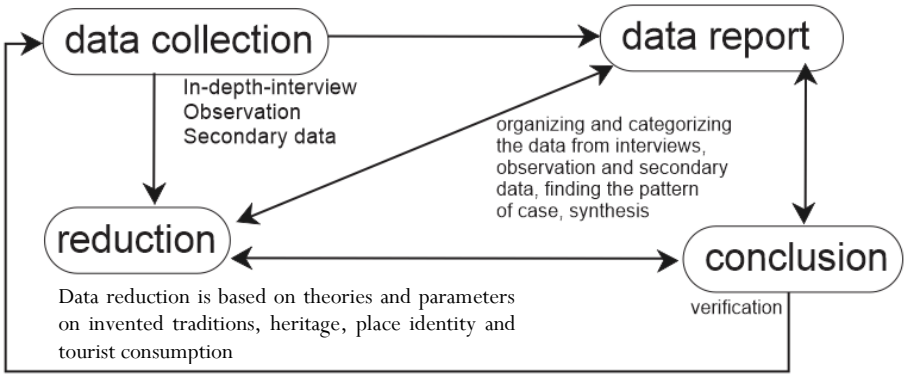

Figure 3 The process of analysis
Source: Modified from Miles and Huberman (1992)

The process of analysis is shown in Figure 3. After collecting data from in-depth interviews, observation, and secondary sources, we organize and categorize the data to find any patterns that might exist. It also includes the process of reduction, which is based on the theoretical framework, before going into conclusion. Qualitative research is based on categorization, concepts, and description on the development in field activities. Data collection and analysis are impossible to separate. Both processes happen simultaneously (Miles and Huberman, 1992).

Eight persons were interviewed in this research. In addition to that, we observe the activities in situ which includes the activities of the event, also the activities of the tourists. The observation also looks for the attribute and location, and the route of the event to find out the role of heritage area in the procession of Grebeg Sudiro. The secondary data is collected from documentation and report from the neighborhood office of Sudiroprajan. The documentation consists of the activities of local people and organizing committee, before and after the procession of Grebeg Sudiro. Other source of secondary data is previous research about Grebeg Sudiro and Pasar Gede heritage area. After data collection, the data is reduced by using the theoretical framework and decided parameter before being categorized to find any patterns that lead into conclusion.

4. Result and Findings

Sudiroprajan is an urban kampong with multi-ethnic population including Javanese and Chinese people (Rusdiyana, 2018). Sudiroprajan has Pasar Gede as the main market (figure 4), which has been carrying out its activities for almost three centuries. Its history began in 1745 in the era of Pakubuono II, at which time Chinese citizens were forbidden to live inside the Keraton of Surakarta. The official name of this market is Pasar Gede Hardjonegoro, the name being taken from a Chinese descendant who was given a royal title KRT Hardjonegoro by the royal court of Surakarta. Not far from the market, there is the Tien Kok Sie temple, which is a place of worship for Chinese people, and which has been acknowledged now as a heritage building. Near Pasar Gede, there is a 'Chinatown' known as Balong village, which now is not only occupied by residents of Chinese ethnicity but also by people from other ethnic groups. There is a good social interaction between the Chinese and Javanese communities in the area and its surrounding. Mixed-ethnic marriages are also common in those communities.

Through direct observation we find that Pasar Gede is a vital area for the Sudiroprjan people, so they make an event cantered on Pasar Gede, namely 'Grebeg Sudiro'. At first, this event appeared to enliven the anniversary of Pasar Gede, but gradually the program grew bigger and involved more and more people. Today it has grown not only of one single event, but a series of events in one period around the Chinese Lunar New Year. Pasar Gede occupies an important position in the creation of Grebeg Sudiro activities. Grebeg Sudiro as an invented tradition modifies Grebeg which is originally a ritual event of the royal court of Surakarta. Grebeg Sudiro has adopted components from the original tradition. New formations of traditions, with appropriate narrative, will be accepted by the community and formalized, according to Hobsbawm. Creating repetitive

Figure 4. Pasar Gede historical place

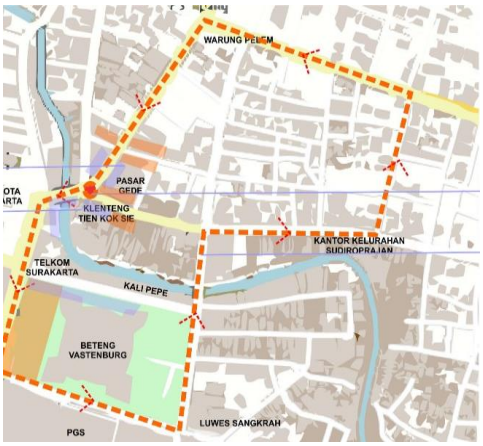

Figure 5 Grebeg Sudiro Route

activities and representing certain values that have a correlation with the past are practices of the invented tradition.

> "The aim of Grebeg Sudiro is for tourism. Local people hoped this event can attract many tourists and bring economic benefit to the locals. In addition, this event indicates the existence of the cultural attraction possessed by Sudiroprajan community who want to show that this neighbourhood has a history of acculturation between Chinese and Javanese communities and cultures"
> (Interview, 2018).

Although each ethnic group has their own cultural characteristics, they have blended together to create a unique regional identity (Ismail, et al., 2014)

And Malacca literally has the same role too; with its uniqueness of the cultural mixture of the people living in there that has built up over several centuries. Because of its ethnic diversity generated by Chinese, Malaysians, Portuguese, Dutch, English and Indians, various heritage sites make up the identity of that region. The acculturation between different ethnic groups grown naturally over hundreds of years and that process has built today's Malay national identity (Worden, 2003). In Malacca there are three traditional villages that are conserved in Malacca state: Kampung Morten riverine village, Kampung Chetti (Kampung of Peranakan Indians) and Kampung Portuguese. Those three groups believe that living heritage sites can help their communities sustain and advance their cultural pride and identity by creating cultural awareness of and by their own unique cultural aspects (Aziz, 2017). From the descriptions above we can expect that areas involved with or demonstrating cultural heritage and history are sources of identity for the Sudiroprajan community and the Malaysia/Malacca people too.

Grebeg Sudiro is communicated through four symbols, namely Gunungan, Jodang, art parades, and the annual thematic Grebeg Sudiro event which reflects the spirit of cultural diversity. Gunungan is one form of invention to resemble the element from the original Grebeg event.

> "The theme of Grebeg Sudiro is the result of the values found in the history of the Sudiroprajan urban kampong, which is based on the Chinese and Javanese communities. The theme cannot be separated from the cultural heritage area of Pasar Gede as a symbol and as a source of identity. The event, then, structures the identity and experience of the local community." (interview 2018)

Even before the inception of Grebeg Sudiro, Pasar Gede was already known as an icon of the Surakarta. Therefore, Grebeg Sudiro deliberately uses the Pasar Gede as a venue to make their event known well as part of local cultural heritage, so that the event can be elevated and become popular. The latter is an example of one of the production processes associated with Grebeg Sudiro. Pasar Gede is important for the local people to make an invented tradition event. The Sudiroprajan community deliberately makes the narrative of the event related to history, including its relationship to objects of cultural heritage. The market, which has a strong place identity, has taken its historical value and developed into the theme of the invented tradition of

Figure 6 Gate and Lampion Decoration Near Tugu Pemandengan

the Sudiroprajan community, which indirectly labelled itself as a community that has the tradition.

With a strong identity, unique places, and traditions that are displayed, the event will attract many visitors. The combination among them is a cultural production ready for consumption by tourists. The identity of the Pasar Gede as a place can also be accessed through the four principles of identity, namely: a) distinctiveness, b) continuity, c) self-esteem, and iv) self-efficacy. Distinctiveness is related to positive perceptions of the uniqueness of a place. In this event, Pasar Gede, Tien Kok Sie temple, Tugu Jam, Pemandengan, and Kali Pepe contribute as an interesting element because of their unique, historical difference from other places. Pasar Gede building is a landmark of the region that gives its impression both for the people who live around there and for visitors. Cultural attraction also becomes a positive value for people to remember a place, as shown in the Grebeg Sudiro event as a complementary element of an area with a strong identity. Self-esteem is defined as a positive self-evaluation or group by which a person identifies and produces pride.

The Pasar Gede area as a historic area and place is a source of pride for the surrounding community. It is said that Pasar Gede produces a particular identity among local people and that identity is expected to be accepted by wider society. The local community tries to show its identity more through events such as Grebeg Sudiro. There could be a problem when Pasar Gede, which is an iconic place, loses its identity, as it will eventually be abandoned; therefore, the sense of such iconic places must be conserved. This also happens in Malacca heritage area, in that the existence of heritage sites cannot be separated from the local community, that consists of several ethnic groups (as cited before). It can be said that local communities play the roles of actors doing things that affect heritage preservation through various activities. Self-efficacy is also important. This includes the provision of elements to make tourists more comfortable such as a) accessibility, b) markers, and c) public facilities. The availability of these facilities can increase the satisfaction of both locals and visitors. Tourists or visitor may expect appropriate standards of comfort facilities; therefore, the site must be set up to provide those facilities.

Grebeg Sudiro uses the heritage place and produces a show framed by cultural themes. Tourism production is carried out by citizens' initiatives, which creatively provide interesting background narratives in the Grebeg Sudiro event. Grebeg Sudiro is initiated by the district government, local community, Pasar Gede foundation, and Tien Kok Sie temple association. Furthermore, because the event is considered to have economic value, the Sudiroparjan urban kampong as stakeholders legalize and make it a potential tourism event. The Grebeg preparation area is not in Pasar Gede but the Sudiroprajan urban kampong office. In this case, the market plays a role as a stage and the village office as a backstage. The route of the Grebeg Sudiro event is also of some interest because it shows the heritage landscape in the Pasar Gede area.

> "The participants of Grebeg move from the market stage to the main street and go around to Balong Chinese village and then come back to Pasar Gede again. This carnival route (figure 5) has a purpose to show the people following the event about their territory and peculiarity of their region; as well as aiming to introduce their places as part of a cultural community." (interview, 2018)

The Pasar Gede area is transformed into a stage of cultural attraction. Lanterns and other Chinese ornaments decorate the market area starting from the front side of the Klenteng area (figure 6). The bridge is decorated, and there is also a gate placed on the side of the bridge. Moreover, the front area of the road leading to the fort is also decorated with zodiac-shaped lanterns. Another phenomenon that arises is the number of street vendors on the side of the Pasar Gede area, especially in the side of the bridge. All these activities are tourism productions. The community is ready to meet the needs of visitors ranging from snacks and souvenirs to parking service for visitors' vehicles. All of these interest public to come. They are also willing to spend their money for experiencing the events. In the same way in Malacca, the tourists consume according to the primary attractions in the heritage areas and consume the services provided, as well as spending their money on food beverages and souvenirs (Khairi et al., 2019). In Malacca tourists are interested to participate in cultural attraction. So, the governor of Malacca provides what the tourists want and made some festival for the tourists to participate. The ease of access to information also adds to the consumption of traditions in that area. The impact of publication in the mass media also 'blows up' the event and can encourage many tourists to consume the facilities and services provided by local people when the Grebeg Sudiro event takes place. Tourism consumption is massive in the area, especially when the peak event takes place, as the producers make the stage go right across the Pasar Gede.

5. Discussion

Grebeg Sudiro as a contemporary event and we can call it invented tradition. For an invented tradition to be recognized as traditional, it is important for it to use narratives. Historical value is very important to drive society to accept the invented tradition. Invented tradition consisting ritual practice with certain value in society trough repetition of ritual by linking with appropriate history (Hobsbawm, 1992). Grebeg Sudiro uses the history of Sudiroprajan urban kampong that has a long history on the peaceful interaction of Javanese and Chinese communities- as narratives to support the event to be considered 'traditional'. Grebeg Sudiro as an invented have specific purpose to make branding or to show local community identity -as an old and unique community that exist till now- and to highlight their cultural art through history. The community movement in Sudiroprajan is an important aspect to make Grebeg Sudiro have its own characteristic. The community known well the potency of Pasar Gede Heritage area and the uniqueness of acculturation there. Their movement also an activity to make the Heritage around Pasar Gede been preserved and popular in wider community. In Mellaca Heritage site local community also involve efforts to conserve their

heritage by cultural attraction and festival they had. Local people are having some purpose and do creative movement to achieve that (Sztompka, 2011). Local people live around heritage try to preserved the value of the heritage object (Aziz, 2017). Another aspect that contributes to the recognition of Grebeg Sudiro as a 'tradition' is institutional acknowledgment by the municipal government.

Pasar Gede plays an important role in this event. This heritage building is popular landmark in Surakarta city and it becomes the icon of Grebeg Sudiro. Heritage reflect tangible aspect like cultural norms and values in society (Ismail, Marson & Ahmad, 2014). Pasar Gede reflect ethinic diversity, that value used by Grebeg Sudiro as event theme. Pasar Gede area has built a strong identity in urban scope. In other side Melaka with multi ethinc acculturation among hundred years build identity from their ethnic traditional village in heritage site. Those diversities are pride and become Malay national identity. Identity ownership is relating with historical and cultural heritage (Edwards, 1998), relationshop between peoples and places cause an area invensted some symbolic meaning realed identity of local community (Lalli, 1992). From that we can conclude that identity, heritage and community have dynamic relation. Community can get identity from historical heritage and heritage places can get stronger identity from ethnic community.

Grebeg Sudiro takes an advantage from the situation to make the event noticed by people. Without Pasar Gede as its venue, Grebeg Sudiro might not be as successful and as popular today. Everything shown in Grebeg Sudiro is complex, and the event produces an attraction and (heritage) places to consume. Heritage area can be tourism object that promote community identity (Butleret al., 2014), beside that heritage as tourism has potential benefit to ecomomic sector (Puah et al., 2018).

Grebeg Sudiro involves not only cultural attraction, but also heritage place and legitimizing narratives. The interconnectedness of the three aspects makes Grebeg Sudiro a 'tradition', therefore it is considered to have traditional and cultural value. This makes it interesting for tourists who search for cultural experience as they always look for authentic symbolic experience as alternatives. Heritage tourism offer experience with cultural authentic products (Khairi, et al., 2019). Culture attracton and narrative history that produce can be goods for consumer (Pelly, 2015). The cultural program offered by local community can improve visitor experience and with additional facilities the visitor will increase (Alberini & Longo, 2006). The local community provide what visitor needs, they open parking area, snack and souvenir street vendor. And this happen in both Grebeg Sudiro and Melacca. The tourism authority plays an important role in the development of responsible tourism attraction, so that stakeholders focus on heritage and culture to create the consumption of tourism (Teoa et al., 2014). At the present-day Grebeg Sudiro, tourists come to the venue not only at the exact time when the ritual was conducted but also days before or after the event, only to consume the decorated spaces and the food sold in the Pasar Gede area.

6. Conclusion

The Grebeg Sudiro event is a cultural production that reflects the identity of the Sudiroprajan community. That value is lifted from the heritage and community uniqueness. The Pasar Gede area, as a cultural preserve located in Sudiroparjan urban kampong, is the place where the event takes place because it is considered to promote the event's message. Cultural production is carried out by the community and institutionalized to elevate Sudiroprajan's cultural identity. Pasar Gede, as the main performance venue, was chosen because it is an iconic historical place and has a strong identity of its own as well as with the community. This identity strengthening through the specificity of a region encourages and attracts tourists to come and feel the atmosphere that is different from other places. Heritage plays important role to the attraction and this not only happen in Grebeg Sudiro but also in Melaka Heritage site. Tourism is the reason for the creation of traditions, because such initiatives are profitable; tourists provide income by bringing spending power to an area or event. Cultural heritage that is unique will certainly attract attention and be used to meet and satisfy tourism consumption. Consumption of traditions and cultural heritage has a close relationship. Heritage offers a unique experience with a strong identity, it is easy to make a demonstration of the values and symbols, but it also depends on the initiator and stakeholders as the main actors in tourism production.

This research can still be developed with a variety of other cases, with different approaches and methods. The study of tourism and its relationship to cultural heritage is something that is currently being discussed because, at present, the growth of massive tourism. It is expected that further research will be more detailed in nature, in order to examine cultural heritage from other perspectives.

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A Preliminary Implementation Framework of Building Information Modelling (BIM) in the Algerian AEC Industry

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ABSTRACT

The construction industry is one of the most growing sectors worldwide, it plays a great role in boosting the economy. The construction sector in Algeria has recently witnessed an upward growth, due to the Algerian government's vision to develop economic activity and boost the residential construction market. On the other hand, the Algerian construction market is suffering from the lack of efficiency; projects delay and less quality of projects delivery. It becomes very necessary to find a way to improve these inefficiencies by adopting new approaches and technologies. Building Information Modelling (BIM) is becoming a widespread and common approach in the design, construction and maintenance of building facilities as BIM reduces waste, improves construction quality and enhance collaboration among the construction stakeholders. Hence, it becomes necessary to start gradually introducing BIM to the Algerian construction industry in order to improve its productivity. This paper addresses BIM implementation in the Algerian AEC industry and proposes a preliminary framework towards its implementation. Through a questionnaire survey, we explored the BIM capabilities, BIM awareness and BIM maturity of the Algerian AEC players. Based on the questionnaire findings and literature review, this paper proposes an effective BIM implementation based on both levels of macro-adoption and micro-adoption. The framework developed is based on three main aspects comprise of technology, process and policy. This study is considered as the first implementation framework of Building information modelling in the Algerian AEC industry. The framework proposed will be used as a reference for the Algerian researchers and professionals.

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1. Introduction

Construction is at the highest impact in North African countries. It has seen significant growth and offers interesting opportunities for all players in the industry (African Review, 2017). Governments are focusing on different sectors such as urban construction to strengthen their economics, especially in Algeria, where there is an increasing demand for infrastructure and housing (Panzeri, 2016). Governments around the world have recognised the inefficiencies affecting the construction industry in

general and have recommended and mandated the practice of Building Information Modelling (BIM). Several factors for better BIM implementation have been discussed in previous research.

A number of authors discussed BIM implementation as a technology and a combination between software knowledge and skills (Miettinen & Paavola, 2014) while others see that investing in IT infrastructure with education and training is a key factor (Lindblad & Vass, 2015). On the other hand, some researchers see change management and elaborating new business models as critical factors for BIM adoption (Lizhu, 2017; Miettinen & Paavola, 2014). People have been identified as one of the important factors for successful BIM implementation such as individual's awareness and willingness (Chen & Li, 2015). Succar et al. (2013) in his research discussed the individual competency and identified it as a key role for successful BIM implementation and the researcher defined individual competency as 'way to put in practice some knowledge, know-how and also attitudes, inside a specific context'. Miettinen and Paavola (2014) defined trust, transparency, effective collaboration, open information sharing, and shared risks and rewards between individuals as fundamental for successful BIM implementation. Furthermore, other researchers see the BIM as a policy aspect that includes mandates, standards and a clear government strategy (Lindblad & Vass, 2015; Miettinen & Paavola, 2014; Yang & Chou, 2018). Government should consider developing BIM education and programs in order to increase the individual competencies, awareness and knowledge (Yang & Chou, 2018).

Several researchers consider encouragement from top management having a positive impact on BIM implementation (Kullathamyothin, 2006). Hence, this study investigates the necessary steps and the key factors for successful BIM adoption. This research introduces a preliminary framework for BIM implementation in the Algerian AEC industry and can be used as a reference for the developing countries that have the identical construction industry environment. This research represents the first initiative of developing a BIM implementation framework for the Algerian AEC industry based on mixed approaches of government-driven and industry-driven.

2. Literature Review

2.1 Applications of BIM

To achieve better BIM implementation, it is vital to demonstrate the use of BIM on a construction project. Rowlinson and Yates (2003) identify that multi-dimensional CAD can be the change agent that drives the construction industry towards relational contract procurement systems and facilitates roles changes toward collaborative design, construction and facility management. They claim that such technology has the potential to integrate client, designers and contractors at the early stage of a project, which improve the decision-making.
Won et al. (2013) demonstrate that BIM adoption can bring more clear benefits and advantages with complex projects. BIM has been adopted for a variety of functions through the project lifecycle. The level of BIM implementation is based on the characteristics of the project, support of management and involvement of different professionals. BIM moves well beyond 2D CAD, ultimately entailing a multi-dimensional process. Various dimensions of BIM use have been categorized according to the implementing process. Dimensions of BIM can be divided into:

- The 3rd dimension is space;
- The 4th dimension is time, i.e. scheduling and sequencing;
- The 5th dimension is cost estimation;
- The 6th dimension is facility management.

3D BIM is regarding geometry position, which allows people to detect clashes and coordinate effectively. Geometrical representation could expose the misalignment of drawings of different trades. 4D BIM combines time with geometry information. It could determine when a component can be in a particular position according to schedule. 5D BIM adds cost on 4D BIM. It could identify the cost of any components of the model. Combining space and time, 5D BIM could demonstrate the cost of any object at a position at a particular time. 6D BIM is about the lifecycle of the building. It is about how the building impacts its surroundings and other aspects, which have an impact on the building.
BIM can be used as a tool, a platform and environment (C. Eastman et al., 2011). As a tool, BIM is a task-specific application. It is used for model generation, automatically checking the design for the satisfaction of building specification and customised requirements, and identifying conflicts and clashes by checking the multi-disciplinary model before construction.

2.2 Overview of BIM Implementation

Developed countries such as the USA, UK and Singapore have realised the critical role of BIM to provide improvements in productivity and cost-saving through all phases of the AEC industry (Chew & Riley, 2013; Kaneta et al., 2016; Khosrowshahi & Arayici, 2012).

Table 1 Overview of BIM in developed countries

Country	Revolution in BIM Adoption
The United States of America	• Leader of BIM implementation technology (Chew & Riley, 2013); • 1990's establishment of buildingSMART, formerly called the International Alliance for Interoperability (Edirisinghe & London, 2015); • The National BIM policy program was introduced in 2003, and later in 2007 BIM was mandated in the USA.
United Kingdom	• In the UK, BIM is used in the design and construction fields over the past 20 years; • UK government in 2011 published The Government Construction Strategy and announced its intention to require collaborative 3D BIM on its projects under asset information, documentation and data being electronic by 2016 (Khosrowshahi & Arayici, 2012); • UK has the vision to computerise the construction process through the use of technologies, for this purpose they adopt the UK Digital Built Britain (Eadie et al., 2015).
Singapore	• Singapore has been promoting the usage of BIM since 1997 in the different construction departments and approvals such as building plan and fire safety certifications (Wong et al., 2010); • Singapore wants to establish the world's first BIM electronic submission (e-submission) through The Building and Construction Authority (BCA) (Edirisinghe & London, 2015); • Singapore is putting Mandatory BIM e-submission via Coronet for new building projects over 5,000 m^2 (Kaneta et al., 2016); • It is obliged for architects and consulting engineers to use BIM for design. However, the quality and density of the design drawings as the output of BIM are not always enough (Kaneta et al., 2016).
Australia	• Building information modelling (C. Eastman et al., 2011) has emerged in Australia, particularly in 2011, after the UK Government recognised the tangible benefits of using BIM; • In February 2016, Infrastructure Australia recommended that the Australian government should make the use of BIM as mandatory for the design of large-scale complex infrastructure projects (Bimcrunch, 2016); • The Department of Planning, Transport and Infrastructure (DPTI) have developed BIM guidelines for government agencies, consultants and contractors (McAuley et al., 2017); • The Department of Defence recognises BIM benefits and plans to integrate BIM and IPD into its projects soon (McAuley et al., 2017).
Japan	• BIM implementation in Japan is not always encouraged with top-down consensus (Kaneta et al., 2016); • MLIT (Ministry of Land, Infrastructure, Transport and Tourism) published BIM Guideline in 2014 after MLIT selected three pilot projects from the public sector in 2010 (Kaneta et al., 2016).

Several efforts have been made through programs and policy mandating BIM adoption. It is necessary to understand the different efforts developed worldwide in order to learn from the past experiences and acquire a global knowledge about the steps that have been taken and the necessary transformation that should be adopted in order to implement BIM successfully. Table 1 illustrates a global overview of BIM implementation in developed countries and defines the approaches and technology adoptions strategies that have been developed in order to achieve efficiency, economic benefits and unification of practices (Lindblad & Vass, 2015; Miettinen & Paavola, 2014)

2.3 BIM Frameworks

Several frameworks have been developed worldwide in order to facilitate BIM implementation. This study proposes a preliminary BIM implementation framework based on three main aspects, technology, process and policy. This section represents a review of the different frameworks developed worldwide.

The framework presented by Succar (2009) describes the domains of BIM knowledge and their interrelationships. These domains are 'BIM fields', 'BIM maturity stages' and 'BIM lenses' where 'BIM fields' identifying domain 'players' and their 'deliverables', 'BIM stages' identifying the implementation maturity level, and 'BIM lenses' to investigate the depth and breadth to identify, assess and qualify BIM fields and BIM stages. Bin Zakaria et al. (2013) in his research has developed the concept of BIM implementation based on four main components which are: organisational culture (organisational readiness to change and

adopt new technology), people (knowledge and experience), technology (adopting new technology) and finally, government recognition (national BIM standards).

Succar and Kassem (2015) developed the five conceptual macro-BIM adoption models that help policymakers to assess an existing policy effort or develop a new one. The models consist of Diffusion Areas Model; Macro Maturity Components Model; Macro Diffusion Dynamics Model; Policy Actions Model and Macro Diffusion Responsibilities Model. Furthermore, Kassem and Succar (2017) validated the five models with the participation of 99 experts from 21 countries and (Riitta & Hirvensalo) applied the five models in assessing and comparing the national BIM policies across 21 countries. As the data revealed, the five models enjoy high levels of 'clarity', 'accuracy' and 'usefulness'. The concepts, models and decision proposed support tools for macro-BIM adoption assessment and planning.

Alreshidi et al. (2017) have developed a framework for BIM governance based on 3 main factors 1- Socio-organizational factor, discussing the actors and the team values; 2- Data management and ICT, which is highlighting the security and availability of the information and the ICT usage; 3- process and policy, discussing the policies and process needed for better BIM governance.
The reviewed frameworks will help to develop the preliminary framework for the Algerian construction industry by taking into consideration of the local environment and the current BIM application.

3. Research Methodology

To implement BIM successfully in the Algerian AEC industry, it is essential to investigate the BIM awareness, BIM maturity, BIM readiness and BIM capabilities. Thus, this study carried out a critical literature review about BIM implementation in the construction industry and the BIM implementation framework proposed by previous studies worldwide as presented in Section 2. Furthermore, a survey among architects, engineers and contractors was carried out in order to investigate BIM capabilities, awareness, maturity and readiness. The questionnaire has been distributed and collected in a period of 3 months, by both online questionnaire using Google Form and manually by visiting the respondents in their places.
After identifying the challenges and the best practices of BIM implementation in previous research (Khalid et al., 2020), and investigating the level of awareness, capabilities, maturity and readiness of the Algerian construction industry; the findings from this research form a ground towards developing and proposing a preliminary framework of BIM implementation in the Algerian AEC industry.

The sampling of the respondents was selected based on the Krejcie and Morgan's formula which is stated as follow (Chuan & Penyelidikan, 2006):

$$s = X\ 2NP\ (1-P) \div d\ 2\ (N-1) + X\ 2P\ (1-P) \qquad (1)$$

The architects' sample was 230, contractor's 180 and engineer's 143. The responses were 110 among architects, 44 among contractors and 66 among engineers with respondent's rates of 47.83%, 24.44% and 46.15% respectively (Figure 1).

4. Results and Discussion

4.1 Survey Finding

The questionnaire has been designed based on four sections: background, current practices, the challenges and the best practices. The questionnaire has been validated after a pilot survey conducted. The questionnaire showed consistent content, adequate sampling and compelling content (Khalid et al., 2019).

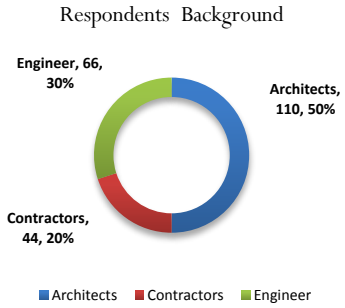

Figure 1 Respondents backgrounds

Figure 2 illustrates the software usage among architects, engineers and contractors during their works. The most used software by architects is CAD (98 users); Revit (72 users); Sketchup (58 users); then ArchiCAD (40 users) and other software such as Tekla, SAP2000, and Navisworks.

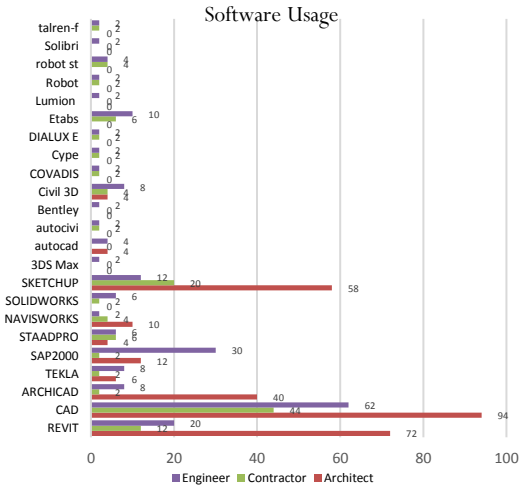

Figure 2 Type of Software usage

The most used software by engineers is CAD (62 users); SAP2000 (30 users); Revit (20 users); SketchUp (12 users); Etabs (10

users); Civil 3D (8 users); Tekla (8 users) and other software such as Solidworks and Navisworks. The most used software by Contractors is CAD (44 users); SketchUp (20 users); Revit (12 users) Staadpro, Etabs (6 users) and other software. Based on the results, the Algerian practitioners are still adopting AutoCAD and SketchUp (traditional method of project delivery) as a tool of design and delivering the project while there is some BIM software usage such as Revit, ArchiCAD and Tekla.

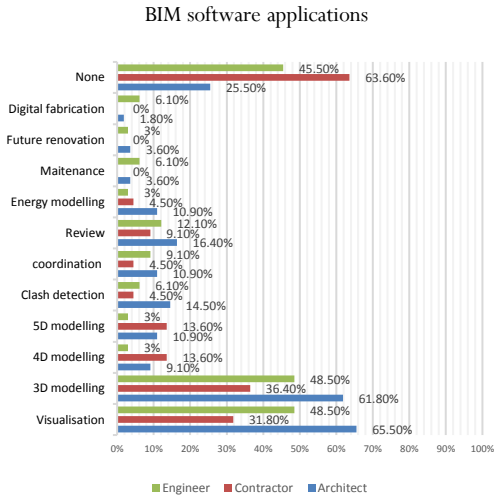

Figure 3 BIM software application

The respondents have been asked about their BIM application and in which stage they use it in order to investigate the exact usage of BIM software (Figure 3). It is observed that the most BIM application among architects are 65.5% for project visualisation; 61.8% for 3D modelling; 9.1% for 4D modelling; 10.9% for 5D modelling; 14.5% for clash detection; 10.9% for coordination; 16.4% for construction review; 10.9% for energy modelling; 3.6% for maintenance; 3.6 % renovation; 1.8% for digital fabrication. Furthermore, the most BIM application among engineers are: 48.5% for project visualisation; 48.5% for 3D modelling; 3% for 4D modelling; 3% for 5D modelling; 6.10% for clash detection; 9.10% for coordination; 12.10% for construction review; 3% for energy modelling; 6.10% for maintenance; 3% for renovation; 6.1% for digital fabrication. Finally, the most BIM application among contractors are: 48.50% for project visualisation; 48.50% for 3D modelling; 3% for 4D modelling; 3% for 5D modelling; 6.10% for clash detection; 9.10% for coordination; 12.10% for construction review; 3% for energy modelling; 6.10% for maintenance; 3% for renovation; 6.1% for digital fabrication.

Figure 4 shows the BIM usage stages among architects, engineers and contractors. The most usage of BIM among architects is in concept design (50.9%); technical design (43.6%); developed design (41.8%). Other usages such as preparation and brief (25.5%); 21.8% in construction and 9.1% in handover and operation. Moreover, the most usage of BIM among engineers (36.4%) is on technical design; 30.3% in concept design; 27.3% in construction; 24.2% in developed design; BIM in the other stages is less used such as preparation and brief (18.2%), handover and closeout (9.1%); operation (6.1%). Furthermore, the most usage of BIM among contractors is in construction and concept design (36.4%); developed design (31.8%); technical design (27.3%) on the other hand BIM among contractors is less used in the rest of the stages such as handover and closeout (22.7%) preparation and brief (4.5%).

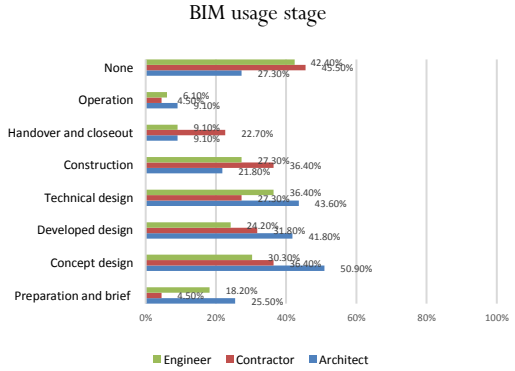

Figure 4 BIM usage in the construction project stage

The results shown previously could summarise that the usage of BIM software in the Algerian construction industry is more on the 3D modelling and 3D visualisation since the BIM software tools are timesaving in terms of generating the 3D models and able to visualise the design and present it to the client, and with few usages in the other application such as 4D, 5D modelling and clash detection.

At this stage it may be concluded that the Algerian market has a mixed combination of usage; some respondents are still in Pre-BIM stage (BIM level 0) where they are relying on CAD and sketches drawing, the information at this stage is generated manually (Succar et al., 2012; Tekla, 2019). On the other hand, other respondents use BIM software for modelling and visualisation, at this stage (BIM stage 1/ BIM Level 1) each discipline uses their own software to generate their own deliverables (3D geometries, 2D out of these 3D geometries, quantities, specifications, and analytic models) (Succar et al., 2012; Tekla, 2019). Very few respondents use BIM software for other dimensions of modelling (4D/5D/Clash detection) which could be assumed more as individual initiatives. Regarding the usage of BIM software in the building life-cycle, it may be concluded that the usage is still at the design stage and less usage at the construction stage and very few in the facilities management.

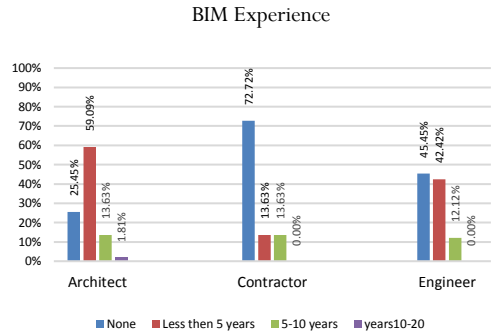

Figure 5 BIM experience

Figure 5 illustrates the experience of using BIM from different respondents in order to measure the BIM novelty in the Algerian market. Based on the results it can clearly be observed that BIM experience among the majority of the architects (59.09%) is less than 5 years, 13.63% of architects have between 5 to 10 years of experience, 1.81% among them have between 10 to 20 years of experience. In the context of BIM experience among the majority of the engineers (42.42%) is less than 5 years; 12.12% among them have between 5 to 10 years of experience. BIM experience among 13.63% of contractors is less than 5 years; 13.63% among them have between 5 to 10 years of experience. As a conclusion, the BIM usage in the Algerian construction market is still at an infancy stage, with most of the respondents have less than 5 years of experience.

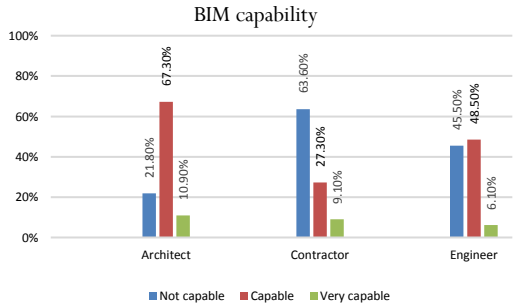

Figure 6 BIM capability

Figure 6 illustrates the BIM capabilities and the respondents have been asked about their points of view (very capable, capable and not capable) in order to investigate their levels of readiness. Twenty one point eight percent (21.80%) of architects see themselves are not capable; 67.30% of them consider themselves capable; while 10.90% claim that they are very capable. Fourty five point five percent (45.50%) of engineers see themselves are not capable; 48.50% of them consider themselves capable; while 6.10% claim that they are very capable. Sixty three point six percent (63.60%) of contractors see themselves are not capable; 27.30% of them consider themselves capable; while 9.10% claim that they are very capable. This result could illustrate that architects and engineers have more capabilities to implement BIM than the contractors, because of the nature of work, architects and engineers used to use BIM software for design and calculations while contractors based on printed paper and 2D drawings to perform the construction tasks.

In this section (Figure 7), the architects, engineers and contractors' BIM awareness were measured. The respondents showed a good BIM awareness since most of them have read some research about BIM (22% for architects, 34% for contractors and 30% of engineers) or have a good idea about its concept (14% for architects, and 13% of engineers) or differentiate between BIM software and BIM technology (23% for architects, 20% for contractors and 22% of engineers) or master BIM software (35% for architects, 23% for contractors and 25% of engineers). The findings from the survey illustrate in general the current practices of BIM implementation in the Algerian construction industry; the findings provide an overall understanding of the BIM capabilities, BIM maturity and BIM awareness. In order to achieve a better understanding and develop the adequate BIM implementation framework for the Algerian AEC industry, it is necessary to relate the challenges of BIM implementation with its current practices. The challenges and the best practices have been discussed in previous research based on the three aspects of technology, process and policy. The technology and process aspects covered the micro-adoption (organisation level) while the policy aspect covered both the macro-adoption (industry level) and micro-adoption; the macro-adoption was carried in order to investigate the role of the government in promoting the BIM implementation at the industry level (Khalid et al., 2020).

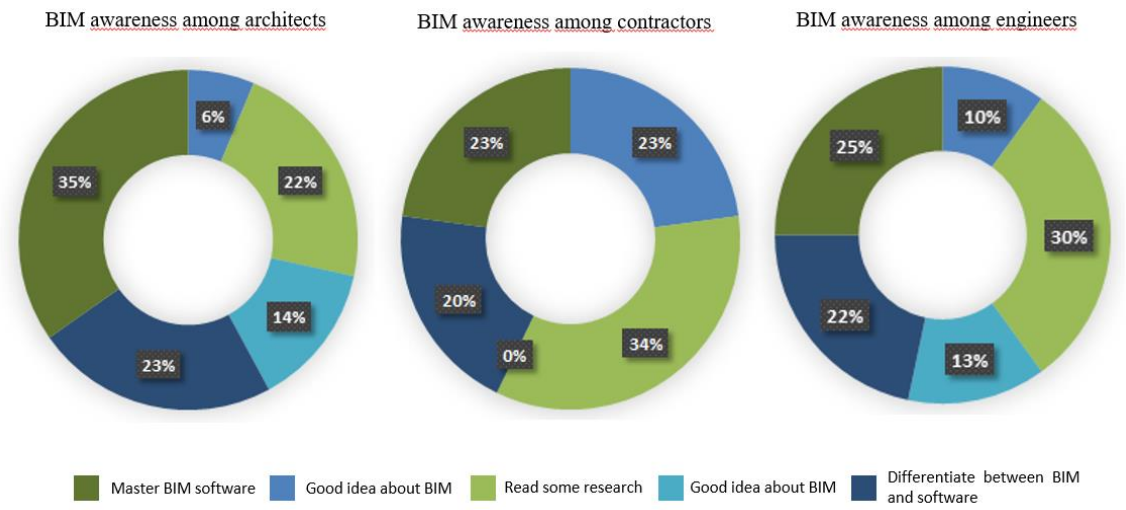

Figure 7 BIM awareness.

4.2 Developing the Framework

Several frameworks have been developed worldwide focusing on promoting and improving BIM implementation in the construction industry based on three main pillars (technology, process and policy). These frameworks have properly addressed the necessary BIM variables. Hence, in this research, a preliminary framework has been developed based on the main BIM pillars (technology, process and policy). In this study, the framework covers both the macro-adoption and the micro-adoption in order to understand the current construction environment and to identify the push-pull relationship between the government and the construction players. The factors of BIM implementation differ from a market to another. It is crucial to investigate in-depth the nature of the Algerian construction environment in order to ensure an efficient combination between the three main pillars of BIM implementation. Hence, the findings from the questionnaire survey, literature review and previous research (Khalid et al., 2020) serve as a guideline to develop the BIM implementation framework within the Algerian market.

Previous research has discussed the various factors affecting the BIM implementation worldwide, as it was agreed by many of them that technology aspect remains the basis. Mastering BIM as a technology requires training and awareness as a start since it helps to increase the technical know-how (C. M. Eastman et al., 2011; Rotimi et al., 2019; Zhao et al., 2015). Training and awareness remain essential for Algerian architects, engineers and contractors due to the lack of knowledge about BIM as a whole process. Through the data from the questionnaire survey, it has been noticed that there is a variety of software being used in the Algerian market, such as Revit, ArchiCAD and Tekla but its usage remains restricted to the 3D modelling and visualisation. On the other hand, the Algerian practitioners claim that they are aware and capable of BIM as a whole process. This explains the misunderstanding of the BIM concept as BIM is about mastering the technology, process and policy. Training and awareness are considered as the key factor for a start of BIM implementation as previous researchers suggest (Rotimi et al., 2019).

BIM process is considered as the second pillar of BIM implementation. Based on the survey findings, the Algerian players are still based on the traditional method of work process and there is a need to shift for BIM level 1 work process as a preliminary step. BIM level 1 needs a usage of standards such as BS 1192:2007 and adopting a common data environment (NBS, 2014) in order to ensure a smooth information production and a better projects coordination. Furthermore, in order to implement BIM as a process there is a need to establish an effective change management strategy, enhancing communication and collaboration and identifying the roles and responsibilities. As Soh and Markus (1995) further suggest in their IT implementation model to internal process and practices, a thoughtful review of the process change strategy is demanded. In the implementation of BIM, some case studies recorded the importance of changing the delivery process, justifying the need to incorporate the activity to produce/author 3D BIM model and 3D model-oriented process flows as evidenced in (C. M. Eastman et al., 2011; Matthews et al., 2018; Olatunji, 2011). Furthermore, in order to ensure effective communication between the different disciplines and team members, the current methods of communication and collaboration should be analysed to produce flow diagrams. This methodology will lead to prescribing the work modelling techniques such as communication flow modelling, physical environment modelling and culture modelling to examine and understand the current practices (Ahmed & Kassem, 2018; Arayici et al., 2011). The flow diagram will form a good basis for discussion among the team members at the organisational level or the industry level. Moreover, to adopt BIM successfully it's important to identify the key roles and responsibilities of the team. According to Wilkins and Kiviniemi (2008) and Alreshidi et al. (2017), the implementation of BIM requires a definition of team roles and responsibilities. The definition depends on overall team relationships, the level of BIM implementation and the types of

BIM tools that are used. As a BIM process it's essential to consider all the factors. Moreover, the Algerian practitioners are facing several challenges related to BIM process such as the challenges to establishing a new workflow to move from the CAD process to BIM process (Khalid et al., 2020). Tackling these aspects will firmly lead to a smooth BIM implementation in the Algerian market.

BIM policy is considered as the third pillar of BIM implementation. As mentioned before, based on the current practices and the survey findings, the Algerian construction market is still based on the traditional method of work process where there is a lack of introducing BIM in the contractual environment, and lack of government initiatives and support to start implementing BIM gradually. It is necessary to establish a well-defined policy at both macro and micro adoption in order to insure a complete BIM implementation. In this research, the policy aspect has been categorised into two main levels, macro-level which consist of the government vision and role to push the BIM implementation and the micro-level which consist of changing the contractual environment. Succar and Kassem (2015) suggest that establishing national BIM policy, standards, guidelines, mandates and regulatory bodies are crucial for a better BIM implementation. Hore and Thomas (2011) added that top management support and awareness is a critical factor that should be taking since it is considered as the main driver for BIM implementation. Moreover, introducing gradually BIM in the contractual environment is crucial as mentioned by C. M. Eastman et al. (2011), Deutsch (2011) and Dao and Chen (2020). Several project delivery methods are suitable for BIM implementation but the use of Design and Build is seen as important to exploit BIM benefits to the fullest. The flexibility of the Design and Build approach offers a changing process flow and enables the integration of construction information earlier in the design process. In Algeria, there is a lack of government efforts and lack of the adequate contractual environment to promote the BIM implementation. Furthermore, there is a lack of research and frameworks about the effective way to implement BIM in the Algerian market. Hence, this research's objective is to propose a preliminary BIM implementation framework.

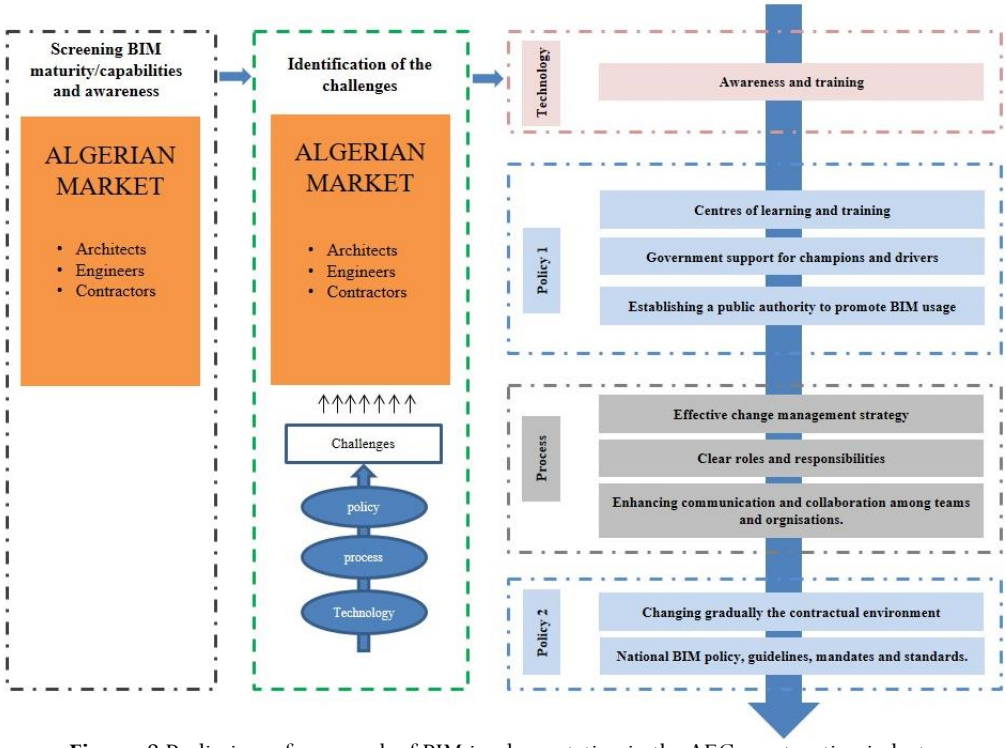

Figure 8 Preliminary framework of BIM implementation in the AEC construction industry

In this research the questionnaire survey illustrates the BIM maturity, BIM capability, BIM awareness and BIM experience of the Algerian practitioners; by combining these factors with the findings from the literature review and the previous research published by the author that highlights the challenges and the best practices (Khalid et al., 2020), this study comes up with the necessary steps of BIM implementation as illustrated in figure 8. Starting with a general screening of the BIM maturity level; BIM capability and level of BIM awareness, then identifying the challenges and the best practices, and finally proposing the necessary steps to implement BIM effectively.

There are two major approaches for promoting BIM applications in different countries, government-driven (government issue a series of policies to lead the BIM implementation) and industry-driven (the industry players are active in BIM implementation and government take limit actions)(Yang & Chou, 2018). This study proposes a mixed approach where the industry and government will work in parallel in order to promote the BIM

implementation. This approach is the most convenient for the current Algerian construction environment. These steps are as followed:

- **Technology:** Awareness and training in order to increase the knowledge in terms of BIM benefits, and impact on the project's cost, time and quality. Furthermore, increase the BIM competency of the Algerian architecture, engineering and construction industry. This could be done by the private centres of training such as software and BIM learning centres.

- **Policy 1:** This includes government support for champions and drivers and establishing a public authority to promote BIM usage at the market level. These steps take place in order to spread and ease the awareness and the learning process. The necessary support for individuals and organisation who are motivated and enthusiastic to implement BIM plays an enormous role in leading and spreading the BIM. These steps will lead the organisations and individuals to acquire the necessary knowledge and prepare for the next step related to the process. This step will lead to ease of the transition procedure and help the organisations for their change strategy.

- **Process:** At this level, the organisations should start an effective change management strategy, elaborate a clear communication and collaboration plan, and identify the key responsibilities and roles. All the team members should have a clear vision about the required change and the new method of sharing the information with an effective collaboration and communication plan, it is all about the individual and team members personal transition, they should embrace and learn the new way in order to deliver the expected results. The change will be successful if the required guides and steps are clear and the necessary actions are defined. At this level of maturity and implementation, the government could start mandating and oblige all the construction players to implement BIM within their organisations.

- **Policy 2:** At this stage, after the efforts made through spreading the BIM knowledge, education and training and the change management, it becomes necessary to start changing gradually the contractual environment, elaborating a national BIM policy, draw effective guidelines to mandate and standardise the usage of BIM implementation in the Algerian AEC industry. Introducing BIM in the contractual environment will push forward the different players to start implementing BIM. It helps to identify the BIM requirements and documentation, risk allocation, insurance due to any potential failures and identify intellectual property and ownership. Finally, establishing national guidelines and a clear strategy towards BIM implementation, it will serve as a guideline and a government driver for BIM implementation since the adequate environment have been already set. Furthermore, it will function as a reference for all the construction players.

5. Conclusion

The BIM concept and technology have been applied in practice worldwide and the great benefits of BIM application in the AEC industry are gradually being revealed. In order to effectively implement BIM in a construction market, it is necessary to assess the BIM maturity and capabilities of its players, this will give an insight about the readiness and the level of competency among the different stakeholders in order to know in depth their strength, weaknesses, opportunities and threats.

This paper illustrated in-depth the current BIM maturity and investigated the BIM capabilities and awareness of the Algerian market. The finding proposes a preliminary framework towards BIM implementation based on previous theories and questionnaire survey findings, starting with the technology aspect such as training and awareness, then policy aspect such as BIM drivers support and motivation, followed by process aspects such as change management and finally, changing the contractual environment and elaborating a national BIM policy and mandating BIM usage.

The preliminary framework illustrates the general steps towards BIM implementation, besides, other aspects need to be considered and discussed in details such as people and educational programs. The reliability of the framework is based on previous theories and models adopted based on the surveying findings to be adequate to the local environment. The proposed framework shall be further validated by the Algerian BIM players and it can be adapted for other countries with the similar context and construction environment.

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Effects of Behavioural Uncertainties In Property Valuation

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ABSTRACT

Psychological and behavioural dimensions play a vital role in influencing Valuers' valuation judgements, thus affecting the validity, accuracy and discrepancy (reliability) of property values. However, behavioural uncertainty research, specifically within the discipline of property valuation among property Valuers, is still limited, particularly in developing countries with their unique property valuation systems, and has been so far conducted in an independent, separate manner, which looks into the behavioural uncertainties non-connectedly. Therefore, this study aims to examine the behavioural uncertainties of local Valuers in property valuation, vitally addressing the questions of behaviours involved and how a behavioural uncertainty is associated with other behavioural issues. This study adopted a phenomenological design, where a session of focus group discussions with 10 public-private Valuers from Johor Bahru, Malaysia was conducted. Results show that local Valuers were subject to various, simultaneous interwoven behavioural uncertainties, which ultimately form a behavioural framework of associations, including biases, client influences, heuristics, professional ethics, and opportunistic behaviours in making their valuation judgement. Biases (subjective preference) and professional ethics (negligence and carelessness) are the two most dominant behaviours involved in local property valuation. These findings provide policy insights to both public and private Valuers, academicians, and the market about the importance of understanding behavioural property economics, that crucially enables them to collectively create a sustainable property valuation environment.

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1. Introduction

Traditionally, property disciplines are inescapable from applying the rationalist approach and the expected utility theory, where both repose on three fundamental assumptions (Mullainathan and Thaler, 2000). People are assumed to act independently based on full and relevant information, have rational and correct preferences among outcomes that can be identified and associated with a value, and firms are assumed to optimise decisions by profit maximising, while individuals seek to maximise their utility. However, particularly in property valuation and investment, it appears to negate these assumptions; studies demonstrate that judgements can be sub-optimal and is involving an irrational behaviour (MacCowan and Orr, 2008; Kucharska-Stasiak, 2013; Warren-Myers, 2015). Hard information, especially in fluctuating, illiquid markets of developing countries like Johor Bahru, Malaysia where property data/information transparency and sharing, is still an issue, and on a property's heterogeneous legal and physical characteristics are imperfect, asymmetric, not up-to-date, inaccurate, unreliable, inadequate and unavailable; thus, high transaction costs on searching information have resulted. There is evidence suggesting that property Valuers are

exposed to various assumptions/speculation, emotional uncertainty, bounded/non rationality, heuristics and cognitive biases and errors, negligence (misconduct), client's influence and other behavioural issues, in making valuation decision (Iroham et al., 2014). Thus, research into such problems of behavioural uncertainty and subjectivity, signifying symptoms of errors is indicative of the emergence of new trends in property valuation.

Such compounded behavioural uncertainties (biases) problems that lead to systematic errors are imperative to be tackled as they result in loss of investment and confidence of clients (Ayuthaya and Fredric, 2014; Baffour Awuah et al., 2017). The posed inaccuracy, unconvincing, and discrepancy issues of property valuation due to some of the above behavioural subjectivities and uncertainties are not foreign to Malaysia (Achu, 2013; Nasir, 2006), therefore leading to strong criticism that national valuation is claimed to be of poor quality and illogical (Ismail and Buyong 1998). Kucharska-Stasiak (2013) asserted that behavioural valuation issues are inevitable because mathematical calculation will eventually rely on subjective interpretations and other behavioural uncertainties of Valuers, making appropriate adjustments and assumptions in the valuation models (Crosby, 2000). Thus, one must accept that valuation (estimation) is not pure science; the value is predominately derived from the art aspect (Warren-Myers, 2015), which has a potential for variation, and biases.

While there is substantial and growing research on the 'science' aspect of the methodological model, covering the systematic selection and mathematical analysis of comparables and parameters in ensuring property valuation validity, the descriptive 'art' behavioural property valuation uncertainty is often neglected, particularly on how property Valuers' subjective decision-making process contributes to the inaccuracy and uncertainty of valuation. Studies by Klamer et al., (2017), Kucharska-Stasiak (2013), Lowies et al., (2013), Whittle et al., (2014), Iroham et al., (2014) and Warren-Myers (2015) acknowledge this gap, and they recommend further research into the need of behavioural uncertainties of Valuers in property valuation.

Such knowledge lacuna is particularly true and relevant for the local property context (i.e., the city of Johor Bahru, Malaysia) because by far there is no single empirical behavioural valuation research undertaken. Thus, learning that conventional normative valuation alone will never suffice for the local valuation status quo, this exploratory-descriptive paper aims to revise the notions embedded in the neo-classical theory as well as to transcend the "science" aspects of valuation. The study introduces a more comprehensive set of behavioural economics and psychological dimensions to the local property valuation decision-making processes, after considering the fact that only a few, limited types of cognitive biases anchoring, and adjustment heuristics have been studied in earlier research (see Gallimore, 2004; Gallimore et al., 2000; Gallimore and Gray, 2002; Diaz, 1997; Diaz et al., 2002, 2007; Iroham et al., 2014).

By delving into the area of behavioural valuation of property, this qualitative study formulates a behavioural model by investigating the local Valuers' behavioural uncertainties and their influences on property valuation. More specifically, the study seeks to answer the following questions:

(i) What are the behavioural uncertainties influencing the Valuers' property valuation decision-making? and
(ii) How uncertainties (behavioural components) influence the Valuers' decision-making in property valuation? or under what circumstances/conditions that the Valuers are to be subject to behavioural uncertainties?

The paper is structured as follows. Section 2 begins with a literature review, where it analyses behavioural economics theories and psychological literature, serving as a theoretical underpinning. This covers various types of behavioural uncertainties and their application to property valuation process and final figure decision. Next, in Section 3, it continues with a full description of the qualitative research methodology used to gather and analyse the sampled respondents' data on their perceptions, experiences and facts for the posed research questions. While a detailed set of results and findings are presented in Section 4, discussions of the results are shown in Section 5. Finally, section 6 presents the conclusions, implications and recommendations of the research.

2. Behavioural Uncertainties In Property Valuation

This paper conceptualises psychology and behavioural economics in a property valuation discipline, where its literature mainly adopted from behavioural finance and investment of property and stock markets as well as little from property valuation (see Whittle et al., 2014). The literature also spans the recent short review by Mohammad et al., (2018) on six main behavioural factors influencing Valuers' judgement in property valuation, an empirical case study of property valuation variance in Nigeria by Atilola et al., (2019), MacCowan and Orr's (2008) fund management and property disposal and other types of property transactions instances associated with behavioural disciplines, Gallimore's et al., (2000) small company's property investment, Salzman and Zwinkels' (2013) corporate and household housing investment and valuation, Ayuthaya and Fredric's (2014) property valuation and investment confidence, and Baum's et al., (2000) valuation bias and client influences on commercial property. Succinctly, despite the various scopes of properties, the main behavioural uncertainties discovered confirm Diaz and Hanz's (2007) four lines of inquiry in behavioural valuation, which emphasise (i) departures from normative models, (ii) comparable sales selection, (iii) valuation biases (Sherin, 2002), and (iv) agency-related impacts or feedback.

2.1 Biases and Heuristics

The issue of a Valuer's misjudgement has often been attributed to the adoption of a cognitive heuristics habit (Diaz, 1997; Gallimore, 1996). A heuristic is the use of simplifying cognitive shortcuts in solving complex problems or making a decision (Simon 1978). As the complexity and detailed information increase, people prefer to use a heuristic to eliminate alternatives, often with just a limited amount of information search and

evaluation (Gallimore et al., 2000). This heuristic rule can ease Valuers' time and effort, i.e., less transaction cost of searching and information needed in making a valuation decision. There are various types of heuristics or biases, namely representative heuristic, availability heuristic, anchoring and adjustment heuristic (Tversky and Kahnemann, 1974), and positivity/confirmation heuristic (Evans, 1989).

For example, Tversky and Kahneman (1973) indicate that a person evaluates the frequency or probability of events by availability. Quan and Quigley (1991) show that Valuers make use of their memory, past successful and unsuccessful experience, lesson, belief/philosophy, principles, preferences, perception, intuition, sentiments, interpretation, and human capital (prior knowledge/expertise), when valuing a property. Information via metacognition is more readily and easily available and retrieved compared with macroeconomic, market and property specific data. Valuers will prefer and choose the most recent information or the information that is most vividly recalled and easily obtained (Baum et al., 2000; Diaz et al., 2002). This recency bias/anchoring is based on 1 or 2 examples, rather than by how frequently the event has occurred. The availability heuristic is closely related to confirmation/positivity bias and anchoring, and other types of behavioural biases as presented in the following sections.

The representative heuristic is similar to stereotyping. A Valuer classifies an event with others of a type that they are familiar with. As contented by McCowan and Orr (2008), it is suggested that valuation decisions are biased towards the markets that the Valuers are more familiar with and hold good-quality data. Stereotyping also applies to the herding behaviour or cascade effect. It induces one Valuer to follow the herd (majority of Valuers) by relying on their valuation information, rather than on rigorous independent analysis and private information. Such behaviour occurs because Valuers are concerned with what others think of their valuation decisions; imitating other Valuers' decision makes them felt that their valuation is more validly acceptable and correct. This tendency is accentuated in the case of decisions, involving high uncertainty, regarding pricing of heterogeneous assets in land and commercial/industrial assets or technical knowledge in the valuation process.

The third heuristic involves an anchoring and adjustment bias. Valuers tend to solve problems by forming a-priori value estimates as a reference to what the answer/standard might be (Iroham et al., 2014). Aside from a Valuer's knowledge and experiences (see the availability bias), this anchoring/benchmarking process can be performed through a personal contact of experts' opinions (e.g., based on other Valuers (colleagues)/property agents, negotiators as informers) (Yiu et al., 2006), via a price asking technique (see Diaz et al. 1999). Also, relying on the uncompleted contract price of a comparable property, sensationalist news media or advertisement, which are deemed as 'noise trading' (see Shiller, 2002; Salzman and Zwinkels, 2013), as well as anchored onto their previously appraised values/transacted price for a similar property (Clayton et al., 2001) are considered as part of the anchoring bias. For instance, a semi-rational model shows that property Valuers are often over-confident by overreacting when the informer's private information is confirmed (Salzman and Zwinkels, 2013). This ease of recall also adds a false impression of the importance or frequency for that information, giving an erroneous interpretation of the market (Gallimore et al., 2000). Another instance is that at times, media or public's urges may exaggeratedly intensify the recent property price hikes or market boom, which consequently induces irrational decision of some Valuers to overreact by following the current, trendy property price increase.

The fourth heuristic, the positivity/confirmation bias, was identified when Evans (1989) noted that humans have a fundamental tendency to seek information that is consistent with their current presupposition, beliefs, principles or philosophy, and avoid the collection of potentially falsifying evidence, although the latter is valid. In this regard, it is suggested that Valuers look for ways of confirming their perceptions of valuation. In general, people tend not to adjust their expectations easily because they look around for a logic which explains and reinforces their beliefs. Gallimore (1994) and Baum et al., (2000) argue that Valuers tend to eliminate or underreact to contrary evidence than to evidence that supports their existing views. This bias may also lead Valuers to manipulation and adjustment of existing information just to fit in and confirm their ways (Havard, 2000) (see the opportunism concept of Williamson, 1975). Besides, Valuers are also subject to the satisficing effect. It is a process by which a Valuer in selecting a course of action takes the first opportunity, that meets the minimum criteria. The search for alternatives then ceases, even though there is no time pressure or strict deadline imposed by a client (Gallimore et al., 2000). Such behaviour can be associated with the conservatism bias, where conservative Valuers are found to be unwilling to change their valuation opinion and decisions. This bias can also be applied to senior Valuers who may be unwilling to incorporate new information which is relevant to the current market. Most of them view that the decisions made in the past (experience) were the major, sufficient basis of the decision-making process by the senior Valuers.

Next, over-confidence is, likened to over-optimism, a bias that originates from a mental illusion of control and knowledge, and possibly from other forms of above biases (herding bias, and personal internal anchoring). Over-confidence includes the hindsight bias, which is considered as part of the availability bias. That is, Valuers may think they knew specific events (property prices) in advance. Such oversimplifying behaviour refers to an underestimation of risks. Due to an arbitrary reference point obtained from the speculative perceptions and vast experience (past decisions) and reputational establishment, sophisticated and experienced Valuers are likely to be overconfident and believe in their own ability to judge asset values by ignoring current information in their analysis (Salzman and Zwinkels, 2013).

As emphasised, the selection of data from the same database source for valuation is not a mathematical exercise, but a heuristic process of Valuers' subjective preference or professional intuition and gut feeling (Klein and Kahneman, 2009). The subjective selection of market and comparables input is inevitably associated with the above biases (systematic errors, e.g., herding, anchoring

and availability), random deviations and/or client's influences (Mallinson and French, 2000; French and Gabrielli, 2003). For example, a significant discrepancy or variation of valuation may result not only from the choices of different markets and comparables (property) input data (e.g., its location), but also from different valuation principles/assumptions and methodological analysis and calculation techniques used (Havard, 2000).

2.2 Negligence, Professionalism, and Misalignment of Interest

The above heuristics and biases could also ensue in negligence. At times, a Valuer, in arriving at his valuation, may have miscalculated and wrongly reported the area/size of the property or failed to make a thorough site/property inspection, therefore overlooking essential comparables features and market data to be included in the valuation report. Such negligent behaviour of Valuers will eventually result in an over or under valuation of a property (see Mallinson and French, 2000; Crosby, 2000 on the case laws of valuation negligence). Such carelessness or negligence, especially the mala fide one, is deemed as unethical or unprofessional behaviour of a Valuer (Levy and Schuck, 1999). Atilola's et al., (2019) descriptive statistical findings asserted that negligence and unprofessionalism of a Valuer are among the significant factors causing distortion to the property values. Unethical/unprofessional valuation is also related to the issue of the misalignment of interest (perverse incentives) that causes moral hazard (Cho and Megbolugbe, 1996). Also, as Levitt and Dubner (2005) explain the roots of misalignment, it could be partly due to information asymmetry.

Oftentimes, Valuers, considered as experts, are better informed and more knowledgeable than their clients who are laypersons; thus, the former tend to opportunistically overstate the value of a property because of their incentive to set the appraised value to be equal to or greater than the transaction price, which that increases their revenues. Moral hazard could be resulted due to undue institutional and political intervention (regulatory requirements) surrounding the property appraisals, which imposes a heavy burden of proof for low appraised values on public Valuers (Baum et al., 2000). Such political information, which favours the government and public Valuers, for low values (or undervaluation) is unfair to their clients who are not aware of the internal political decision (see the issue of information asymmetry). For opportunistic (unprofessional) public Valuers have no position to reject their top management's decision of the government, while they wish to safeguard their valuation job, albeit ethically it could be right to do so if the call for undervaluation is mala fide, this phenomenon is considered a conflict of interest (see social dilemma). Besides, unethical conduct and moral hazard in valuation also involve the Valuers in accommodating the requirements of a specific client, instead of being an impartial, objective and independent Valuer (Amidu and Aluko, 2007).

2.3 Client Influences

Client influence or pressure is another behavioural uncertainty, concerning whether a Valuer subjects himself to principal-agent moral hazard. The following is a summary of client influence characteristics and circumstances affecting the valuation outcome, which include: (i) client types- sophisticated, individual/ institution client; (ii) procedural (methodological) influence; (iii) integrity of Valuers; (iv) age and experience of Valuers; (v) size of valuation firm; (vi) client size (firm and income generation) and their relationship with Valuers (see Levy and Schuck, 1998, 2005; Achu, 2013). The above agency issue arises because it provides the 'mutuality of interests' in terms of economic dependence and/or the provision of non-auditing services by the valuation firm (a win-win situation) between a Valuer and a client (Baum et al., 2000). Generally, various clients (developer, bankers, and chargor) pressure Valuers by requesting or forcing them to alter the value estimates in order to meet the clients' expectation (Kinnard et al. 1997; Wolverton and Gallimore, 1999), even without supporting documentation.

As Gallimore and Wolverton (1997) asserted, rather than independently assessing the property value, Valuers are merely to validate the pending price provided by their clients. Levy and Schuck (1999) found that both sophisticated pressure, involving the use of property and market knowledge and information, the process of valuation including changing the valuation purpose, addition and omission of input parameters or comparables and other transaction data and unsophisticated pressure, using the threat of withholding and delaying fee payments or future assignments, are faced by Valuers. Typically, a client's size matters; the bigger the client in terms of the firm and amount of fees given, the more likely are Valuers to revise their initial value to fit their client's demand. Valuers may think it is an acceptable practice and is rational to safeguard business relationship and for future instructions. However, there are instances where neither the client size nor the level of value adjustment influences Valuers' decisions. Such resistance of influence is not impossible and is lesser, if below conditions, namely (i) firm integrity and high professionalism of Valuers, and (ii) large-size and multi-service valuation firms with less economic dependence on clients, are observed (Achu, 2013).

Moreover, it is also illustrated that the client's influence, ethical issues, heuristics, and negligence are linked to biases, due to their adverse selections made. All these biases/moral hazards can ultimately be associated with the self-interest or opportunism concept (Williamson, 1975; see also Ling et al., 2019). By virtue of the personal interest, incurring less transaction cost in terms of time and effort required, Valuers may rather be subject to unprofessionalism by choosing to dwell in their conveniently quick subjective experiential and opinionated assumptions, or even by succumbing to a client's undue influence, instead of seeking for mathematical evidence in justifying the property's value.

3. Methodology

The primary research strategy adopted by this qualitative research was phenomenological, and the data collection method used was a one-day focus group discussion. While such research strategy was suitable, especially to study in depth the experiences, perceptions or opinions of experts as well as facts pertaining to the above research questions, the discussion technique used is to understand the meanings and interpretations of the group people towards specific issues from their perspectives. This discussion is likened to group interviews, in which it involved both registered and non-registered ten (10) Valuers who are considered as experts from the Johor Bahru district, Malaysia. Those expert Valuers were identified from The Board of Valuers, Appraisers, Estate Agents and Property Managers Malaysia and the Malaysian Institute of Professional Property Managers. Prior to data collection, the respondents were contacted via invitational emails and phone calls to enquire their willingness to undertake in the discussion.

The Johor Bahru city of Malaysia, within the active, fast-paced economic region of Iskandar Malaysia, was selected as the study area. Aside from the local property valuation issues highlighted above, another key reason is that the emerging and fast-growing city has major and active/diverse property valuation operations, resulted from rapid property development and transactions, and significant local and international investments. The sampled Valuers were comprised of both government (public) and private sectors. They have involved in various property valuation activities for heterogeneous properties, encompassing various uses of commercial, residential, industrial, agricultural and vacant land, and the scopes of valuation work, be it corporate or individual valuation, covering loan, sales, rental, mortgages/charges, investment, acquisition, which ultimately can be categorised into two types of valuation in Malaysia: statutory valuation (e.g., stamp duty, property gain tax, compensation, land and rating tax) and non-statutory valuation (e.g., sale and purchase of a property) (see Suriatini and Buyong 1998). In addition, all the sampled respondents are considered as highly experienced, qualified expert Valuers due to their educational background, professional affiliations, and positions held in their organisations, namely senior managers, and branch managers or directors. The qualifications of Valuers above were strictly observed, ensuring that they are indeed the experts in local property valuation, because dealing with the topic of behavioural uncertainties involving multi-stakeholders, it is complicated.

As for the instrument of research, altogether six main questions posed were in a semi-structured form. A review of the literature identified the topic areas to be probed and the questions to be asked during the discussion (see content validity). Also, face validity (validated by peers) on the interview questions was carried out. The discussion was chaired and facilitated by the two authors (as moderators), in which the discussion was voice recorded and field noted for the transcribing purpose. Although there is no rule of thumb (magic number) for qualitative non-probabilistic sampling, the optimum size for a focus group is six to eight participants (excluding moderators). This number is consistent with Bryman's (2008) and Guest's et al., (2006) argument that ten experts are considered acceptable, since themes concerning common views and experiences were garnered among relatively homogeneous individuals (in this case, all were Valuers). The respondents (Valuers) were sampled via purposive expert samplings, i.e., after a few experts' agreed to take part in the discussion, they were then asked to recommend other relevant respondents (colleagues).

All in all, based on the content coding analysis, using the total 15 themes/codes related to the above literature and four categories (namely biases, heuristics, ethics/professionalism, and client influence) derived abductively (see Figure 1 below), the following section selectively reports the main results and interpretations (findings). Along with the respective findings, two types of results presentations, namely textual and diagrammatic mind-mapping forms of the codes and categories, are illustrated accordingly. To ensure the study's credibility, especially in dealing with the large and complex dataset, the Atlas.Ti software has been used during the processes of transcribing, coding and results generation.

4. Results and Findings

There are various uncertainties of Valuers' psychological and behavioural biases and heuristics involved in property valuation. Also, Valuers' decision may likely be subject to various institutional and political settings (government intervention) that bring about the issue of conflict of interest against the clients. Carelessness/ negligence, as well as biases regarding personal selection, are the two most adopted behaviours mentioned by local Valuers during the discussion.

Respondent 4 responded:

"Valuers are subject to various subjectivity, bias, client influence, negligence, and other various behavioural issues that may lead to inaccurate and imprecise valuation."

This is also agreed by **Respondent 2** who frivolously responded as follows who believes that ultimately it boils down to a Valuer's decision/discretion who is governed by subjectivity:

"…quoting a professor from one institution that valuers themselves are the "culprit" who may render the inaccurate market value of a property…"

Local Valuers tend to ask around to obtain the current market values of a property predominately from public Valuers (as a significant market regulator) and some their colleagues (private Valuers, bankers, and real-estate agents), to use them as references and benchmarks. Based on the retrieved values, some subjective adjustments are performed. Such anchoring or following-other-Valuers behaviour (herding issue) makes some private Valuers feel more confident about their assumption in their valuation, since most of the Valuers arrive at similar values.

Respondent 5 responded:

"Based on the income method, make some adjustment…overly dependent on the information by the broker or real-estate agents who can know much information on a property value, instead of doing their own independent market search and value on the property…Those agents are very close to

the bankers (for the loan purpose). They can influence the valuers."

Respondent 3 affirmed:

"…the client may offer some values as references to the valuers by simply quoting a value…private valuers may always anchor or seek the advice from the public valuer (local government) on what is the current value of the property. Use or follow it as a reference/benchmark and make some adjustments. For instance, how much did the government value the property?"

Also, although it is not rampant, the issue of the recency bias occurred, whereby local Valuers are biased to follow the current unique market trend, stimulated by foreign investment, instead of anchoring onto the overall and historical market of the property. Some Valuers are overly engrossed in the recent, specialised market that suddenly booms and have based on it to justify the nearby local residential valuation. Apparently, such a biased estimation may not truly reflect the local property market value.

Respondent 10 attested to:

"…the market value for the property is around RM200,000 but it has recently been raised to RM400,000 (the market has been pushed)…"

Respondent 8 further confirmed and questioned on this recency effect in valuation:

"…some special conditions for big developers with the recent high or overvalued property, how exactly the valuer go about it (how to value the property which is just next door to those overvalued properties)?"

Most of the local property valuations involve one conventional technique, i.e., a typical comparison method. Due to the little application of other techniques on specific properties (vacant land) such as an investment or discounted cash flow method, most of the Valuers subjectively choose this (comparison) method, which is less complicated and is more convenient to be employed on residential properties. Property valuation based on the standard comparables (parameters inputs) and procedures/practice is considered sufficient or 'good enough', so long as the value estimate is justifiable and logical. For that reason, the satisfied Valuers may not attempt to search other relevant, unique data or comparables for the similar property valuation. In addition to the subjective selection and preference issue, Valuers' choices on methodology and inclusion of parameters (comparables) are highly biased. Despite the national governing bodies (see the Royal Institution of Surveyor Malaysia, the National Institute of Valuation and the Department of Property Valuation and Sevices, Malaysia, JPPH), the national valuation Act, common practices and some general standards guidelines (see the Capital Markets and Services Act 2007) on valuation (see also the Board of Valuers, Estate Agents and Appraisals through the Valuers, Appraisers and Estate Agents Act 1981), since valuation ultimately requires the discretion and judgement of a Valuer, subjectiveness is unavoidable; thus, the selection and inclusion of data and methodology can be rather widespread among Valuers. Such subjectiveness is permissible as long as it does not go against the norm or practice of valuation; so far, no specific guidelines or laws and policies are enforced to address the issue. For instance, with a similar methodology using a comparison method, two different Valuers still included quite a different types and number of parameters (comparables) for the property value estimation, in which both can justify their selection. Thus, such uncertainty (subjectiveness) also leads to inconsistency and discrepancy of valuation.

Respondent 5 verified:

"For instance, one property uses a comparison method, while the other similar property used an investment method, why? Both the principles of existing use and the highest and best use are valid… There is no law to dictate which principle to be used for the valuation."

It is also found that Valuers (both public and private) inevitably establish their valuation judgement based on the following behavioural uncertainties: various and diverse opinions, memory, understanding (knowledge), perception, experience (successful and unsuccessful) and feeling about the property valuation. The value of the similar property will be valued differently, especially when it comes to the different understanding and inputs of the legal planning and land requirements (tenure system, planning guidelines) and the market's opinion and views. Thus, questions on which Valuer's valuation is correct and which one is wrong are never being straightforward. However, the inconsistency of value arises when a Valuer is overly dependent on adopting the behaviours above. The biased and heuristic behaviour exposes them to the issues of inaccuracy and credibility of valuation, since ultimately, in the eye of the court, proper and hard evidence as testaments are still necessarily prioritised.

Respondent 5 succinctly responded:

"Most of the valuers use their own perception…it is powerful…These diverse conditions introduce their subjectivity and choices, understanding, preference, bias in it…if the next door sells this much of value, then the similar properties around it should have the similar value (stereotyping issue)."

Another behavioural uncertainty is human errors. Due to certain reasons, Valuers are unavoidably subject to carelessness or negligence (not being cautious) in their property valuation decision. The carelessness/negligence issues include typographical errors, miscalculation of area or value of a property, wrong insertion/assignation or omission of a number, overlooking some comparables/parameters input during the search/ inspection, and inappropriate methodology selection.

Respondents 5 confirmed:

"…sometimes unintentional carelessness is committed by a valuer, e.g., assigning wrong figure/number of the area of a property, probably due to typographical error…"

It is also discovered that the local Valuers are highly vulnerable to client influence. The influence or pressure by clients (buyers or sellers of property, bankers and developers) can come in various forms, mostly influencing the final valuation figure and methodology selection on the valuation. Interestingly, there are

two types of client's influence found, namely the unsophisticated and sophisticated clients. The former is more frequently encountered by the local Valuer. The question on whether or not the Valuers are influenced by clients is not fully disclosed; however, some Valuers are found to be resistant to the client's unethical request by declining the offer of their clients. For instance, an unsophisticated client typically attempts to influence a Valuer by giving high fees and more businesses in order to change the final value of a property. Also they (clients) may quote/offer their desired property value to the Valuers for confirmation or validation, rather than evaluation; if the Valuers decline their requests then they may suffer the loss of business and delay of payment. While, as for the sophisticated clients, their influence is indirect, which their ultimate intention is to alter the final figure. The client may not fully reveal necessary information or supply misinformation that distorts/lowers the property value. Also, some of them may intervene by urging their Valuers to change the techniques or principles in arriving at the final valuation figure.

Respondent 5 affirmed:

"There are many cases, e.g., the client has fixed the value of the property and coerce the Valuer to follow their intention, i.e., by forcing the valuer to maintain the value which was sort of undervalued…"

Respondent 3 responded:

"Client influence is still unavoidable on the property value, e.g., the client may offer a figure as a reference to the valuers. Have a conflict of interest with the client to overvalue or undervalue."

Respondent 2 further supported:

"… some clients try to persuade the valuer to use the highest and best use principle which creates a court case."

It is also found that property valuation is subject to political (governmental) intervention. Although this is not rampant, it is rather influential and critical. Public Valuers particularly, due to the uncertain (dynamic) condition of the local political setting, they are compelled to follow the instruction and discretion imposed by the top management (governments). This has suggested that the conflict of interest/moral hazard occurs as the Valuers' professional position and the decision can no longer stand impartially. For instance, due to the government's authority, Valuers must apply certain imposed valuation method and principle (i.e., adoption of existing land use assumption) on a certain property (vacant land and low-cost housing) that may eventually disbenefit or compromise the interest of sellers, as it produces much lower value compared to the market value.

Respondent 4 attested:

"…one seller was forced to sell at a lower price compared to the market value due to the government/institutional setting. The value must follow the existing use: low-cost housing instructed by the government, although the general and highest and best use of the land can be residential or building…".

Furthermore, the results do not only suggest that Valuers are subject to the above behavioural uncertainties individually and independently but rather, all the above behavioural issues are interconnected with each other. This study shows that many heuristics (e.g., memory and experience) and biased behaviours (e.g., herding, anchoring and adjusting, and gut feeling) and subjective selection of Valuers' are associated with (lead to) the carelessness and negligence (overlooking) issue. Valuers may not realise that when they heavily relied on their personal preference, assumption, memory, gut feeling, and 'so-called' vast experience frequently, leading them to commit stereotyping and satisficing issues, establish evidence and comparables from the inaccurate, misleading information of clients and a recent (specialised) market without doing independent and exhaustive search/and analysis, they have in fact been directly and indirectly subject to carelessness or negligence. Valuers may overlook some relevant, updated comparables, either by omitting or without including them in the calculation. This situation is particularly true, when dealing with legal, planning, and land matters of properties in terms of the exact location, area, status and category of land use, which are often uncertain due to the high cost of information searching.

It is also suggested that the above subjective preferences and the selection of comparables and methodology in valuation are associated with those biased and heuristic behaviours described above. For instance, based on the past experiences, which have made some Valuers subject to stereotyping (generalising) and the satisficing issue, they have shaped the Valuers to be predisposed to a particular set of methodology and input parameters selection. Aside from suggesting that biases are the most rampant, common behaviour presented by local Valuers in property valuation, more intriguingly, biases are also the most relatable element with other behaviours (client influence, heuristics and ethics). All of the above textual findings and results can succinctly be illustrated in the graphical result below (Figure 1). The 15 coloured boxes are indicated as codes, while the four white boxes are the categories/families of the respective codes which are linked with the red-dotted lines.

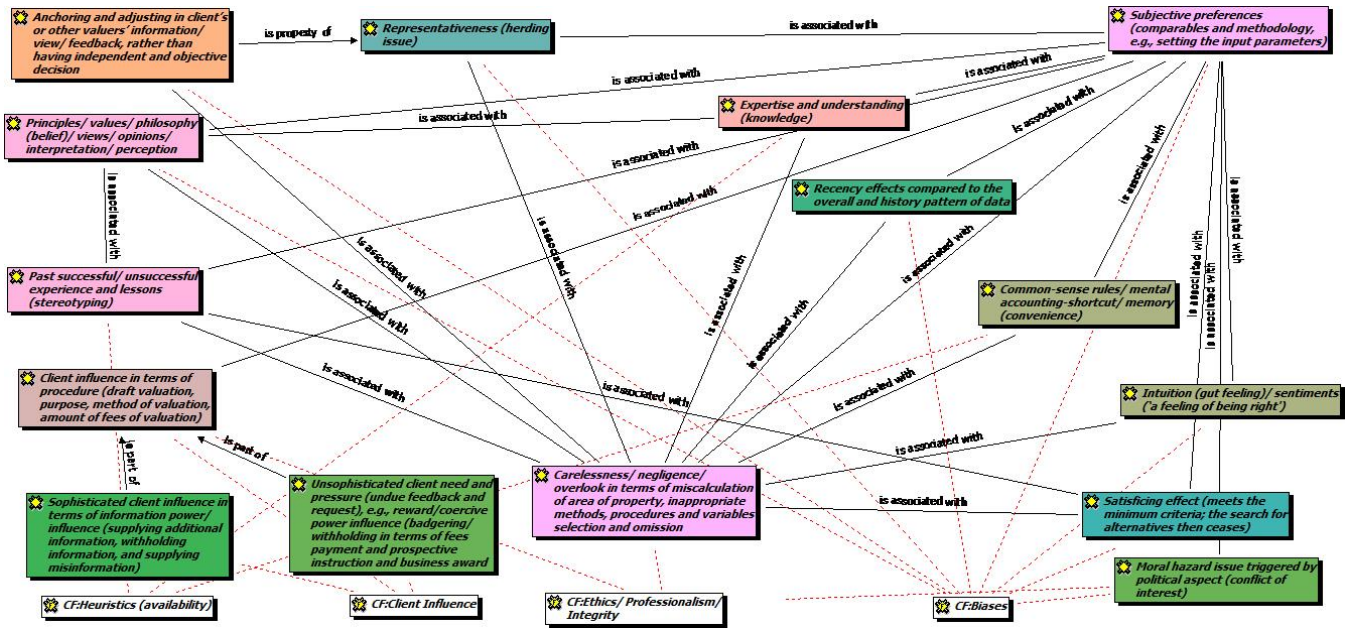

Figure 1 Behavioural Uncertainties of local Valuers in Property Valuation

5. Discussion

The above findings suffice to demonstrate the local public and private Valuers' inevitably behavioural biases and irrationality in their valuation decision; thus, the value of the same property will be valued differently (see availability biases, Quan and Quigley, 1991). The theory of behavioural economics is proven relevant and practical in this context (Warren-Myers 2015).

The local private Valuers are likely to benchmark the previous transacted prices by asking price opinion and the final valuation figure from their reliable colleagues (private and public Valuers) (Diaz et al., 1999) for both the confirming purpose (see confirmation/positivity bias) (see Havard, 2000) and the enquiring purpose, particularly when they are unsure about the property's features. Aside from their own availability heuristics (valuation experiences and knowledge), such valuation is also subject to biases (i.e., anchoring and adjustment and herding). This situation can be argued from the necessity of information cascade, in which the private Valuers are likely to forgo or ignore their own value estimation (even though they are true, accurate and evidence-based) and mainly succumb to public Valuers' valuation. This behaviour is necessarily invoked because the Valuers feel more confident about their assumption in their valuation (less deviation from other Valuers); thus, less rejection will be resulted by the public Valuers (market regulator- JPPH) whose decision is deemed standard, final and conclusive. Also, this behaviour of Valuers is crucial, ensuing in the low rejection rate, to boost their clients' confidence in them.

Another reason for Valuers to be biased is that the story provided by their personal contact of market information is more memorable, that eases recalling process (see availability heuristics). The anchoring and adjustment and herding biases in local valuation have been ensued by the current unique/specialised property market trend, stimulated by the foreign investment (or mega developers), which booms the nearby housing property. Instead of looking into the historical and frequency data and the suitability of the context (including the location and types and other features of property market), this tendency is likely because some less objective Valuers are easily influenced by 'noise tradings' on the recent price hikes (Shiller 2002) or the momentum effects of the herd majority of Valuers) on the current, popular property boom.

Despite the general local practice and guidelines on valuation procedures, keeping the above biases as low as possible, questions of whether it is a systematic error or random deviation is still difficult to determine. Eventually, Valuers' choices on methodology and inclusion of input parameters (comparables) are still highly subjective. Choosing between the highest and best use and existing use principles (see Havard, 2000) is dependent on the Valuers' subjectiveness. Moreover, the local Valuers admitted that negligence ranging from typographical errors to inappropriate methodology selection in a property valuation process which affects the final figure is sometimes inevitable. Regardless of the question of whether such negligence is intentional or not, the local Valuers' negligence is inherently associated with heuristics and biases (Crosby, 2000). Albeit it is to suggest that client pressure or influence from buyers or sellers of property, bankers and developers occurs in the local property valuation process and final figure (Levy and Schuck 1998, 2005), which can bring the 'mutuality of interests' (win-win situation) (Baum et al., 2000), some Valuers admitted that they have successfully resisted the influence by declining the offer to adjust the value without any valid justifications.

This is possible, when the firm integrity and high professionalism of local Valuers, and large-size (established), multi-service valuation company with less economic dependence on clients are met. Despite that, local valuation is still subject to unsophisticated big clients, especially who provide high fees and regular business,

to revise the final figure of value or offer their desired property value to the Valuers for confirmation or validation, rather than proper evaluation. Coercion in terms of losing future business and late/no payment is also resulted in the local condition due to incompliance with clients' needs (see Levy and Schuck, 1999). Also, the rarely sophisticated clients with valuation knowledge are encountered as well that they may attempt to withhold negative information and emphasise positive attributes (see information asymmetry) via some advertisement of media. They force their Valuers to change the principles or techniques of valuation, i.e., from the assumption of an existing use to the highest and best use of property which the latter can give a higher value.

All the above-mentioned biases, heuristics, negligence and client influence have signified that the professionalism and integrity of local property Valuers are questionable and have been compromised. Moreover, the ethics of valuation extends to the undue political influence, subject to moral hazard (conflict of interest) (Cho and Megbolugbe, 1996). Due to information asymmetry, public Valuers particularly, who are more informed with government's decision compared to layman clients, the former are compelled to follow the instruction and discretion imposed by the top management (governments) to apply certain, imposed valuation methods and principles (i.e., based on existing land use), which this may disbenefit the interest of sellers as it creates much lower value compared to market value (Baum et al., 2000). Imposing such undue obligation on local Valuers has subjected themselves to a dilemma between their prospective job and client interest/valuation accuracy. Evidently, local Valuers rather choose the former over the latter. As Williamson (1975) asserted, most of the behavioural uncertainties, if not all, in local property valuation are inherently associated with opportunistic behaviour of a Valuer (see Ling et al., 2019). For their own sake (in terms of gaining more and faster profit and fees), convenience, less macroeconomic information searching costs, Valuers may rather disregard their clients' interest and valuation accuracy.

6. Conclusion and Recommendations

The study applies the theory of behavioural economics and psychology insights in property valuation. In sum, these are the main theoretical findings: behavioural uncertainties of local valuation embrace the following interrelated biases and heuristics (e.g., availability, stereotyping/representative, herding, anchoring and adjusting, confirmation, overconfidence, subjective choice, satisficing and recency effect), negligence, moral hazard, opportunism, and client (both sophisticated and unsophisticated) influences. Thus, the above-mentioned empirical discoveries have achieved our set objectives. However, a methodological limitation is posed. This paper's findings may preclude us to draw a conclusive and representative causal-effect inference, especially with one focus group discussion session with only a group of Valuer experts. A longitudinal behavioural study via a more rigorous methodology (e.g., explanatory mixed method research with a combination of in-depth personal interviews and questionnaires surveys with quantitative structural modelling) is necessary, especially involving other stakeholders (developers, bankers, estate agents and buyers and sellers) for validation and evaluation. Due to data and time unavailability, although the sample of respondents was homogenised (at least all of them are experienced, highly qualified and knowledgeable and from property valuation and management background), we did not manage to ensure well-rounded distribution of the number of private and public Valuers as for the current study, the number of the latter prevails. Such different sectors with wide-ranging, generic scopes, experience/exposure and knowledge have contributed to broad and diverse yet rather superficial results on certain, specific instances. Therefore, more systematic results which are executable via the categorisation of the background, specific sectors and scopes of Valuers are suggested because they could be influential in behavioural valuation where different responses may be observed.

Despite the limitations, this study addresses the literature lacuna on behavioural uncertainties in property valuation, particularly describing extensive behavioural economics components in a real-estate discipline. At least three contributions are achieved by this study. First, this study provides evidence that behavioural uncertainties (e.g., heuristics and biases) and their effects on local property valuation are also occurring in Malaysia. Second, among the behavioural uncertainties, this paper has identified the most widespread and influential behavioural uncertainties (i.e., biases and professional ethics), which local Valuers are subject to. And lastly, this paper showcases and contributes an interrelationship framework of the behavioural uncertainties, i.e., how one behavioural uncertainty (e.g., a satisficing effect under the bias category) is associated with another (e.g., stereotyping effect under the heuristic category). This study has indeed proven Warren-Myers' (2015) commentary on the significance and needs for such study on the behavioural uncertainties in property valuation because human-property interconnection is always varying in different contexts and circumstances.

Lastly, the findings with practical implications offer in-depth, fundamental understanding to local policy-makers, that the often-neglected behavioural study is a sine qua non in determining the property valuation outcome. This paper discovers rationales behind the complex ways of how Valuers make their decision and hence suggests that the current local property valuation system appears adversarial. Therefore, more comprehensive behavioural valuation research, including the identification and formulation of potential countermeasures to curb psychological and behavioural uncertainties in property valuation, should be carried out to produce a sustainable property valuation environment. This is of particular significance in emerging markets of developing countries, where objectivisation, via information availability and comparison methods, seems to be more difficult.

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The Role of Phase Change Materials for Lifetime Heating of Buildings in Cold Climatic Conditions

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ABSTRACT

The study focuses on utilization of the solar insulation in buildings by means of thermal storage materials. During months of April to October, a significant part of solar gain was noticed in outer walls as well as in roof of the structure. Light weight modern construction materials have low thermal inertia so it stores less energy. The study focuses on the utilization of Phase Change Materials (PCM) for harnessing solar thermal energy for heating buildings. Various researches that show the effect of implementing PCMs in different parts of buildings like in walls, roof, windows, doors, floor etc. has been shown in the paper. The PCMs are helpful especially for those buildings which are located in cold climatic condition. Effective solutions are still required for harnessing maximum possible solar energy for heating buildings by storing heat energy by means of thermal storage materials like PCMs in hot days and to liberate it in cold night.

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1. Introduction

The entire world population and economy are rising speedily that has led to enormous growth in the world's energy demand and consumption, thus playing a massive role in causing severe eco-friendly impressions(Du K, Calautit J, Wang Z et al.2018) According to data published by Eurostat, EU member states have seen a significant increase in their final energy demand that reached approximately 1084 million tonnes of oil equivalent (MOTE) in 2015, of which 422 MTOs correspond to building-related sectors Were. 39% of total demand (Olivieri L, Tenorio JA, Revuelta D et al.2018) The Building sector, being the largest energy-consuming sector, accounts for more than 33.33% of final energy consumption on a global basis and is considered an equally important source of CO2 emissions (Devaux P, Farid MM. 2017) In addition, it was discovered that half of the energy consumption in buildings is due to heating, ventilating and air-conditioning (HVAC) systems (Young BA, Falzone G, Wei Z.2018); Another research said that the value is 60% (Akeiber H, et al.2016) Integration of thermal energy storage (TES) technologies into buildings contributes to reducing peak load,Meeting the energy demand by its availability, allowing integration of renewable energy sources, and providing efficient management of thermal energy, thus improving energy efficiency in buildings. (Olivieri L, Tenorio JA, Revuelta D et al.2018)

Phase Change Materials (PCMs) works on the principle of releasing or absorbing heat by changing their phase. These can be used to store the thermal energy of sun which can be further used for heating the buildings especially during night time. This reduces the need of electricity for running heating appliances.

Electricity is mostly generated using fossil fuels, which is not only polluting the environment but also depleting at the faster rate. The world is switching towards the renewable sources of energy for electricity generation. Among these renewable sources, solar energy is one of the best sources for fulfilling energy demand in form of heat and electric power. Solar energy has one limitation that it cannot be utilized during night time. But the solar thermal energy during day time can be stored and used during the night time. This has been tried to achieve by using thermal energy storage materials like rock bed, pebbles, sand, wax, PCMs etc. PCMs are the best alternative among these as they are capable of absorbing large amount of heat during transition of phase from liquid to solid. It releases its stored heat, during solidification process (Hu, He, Ji, & Zhang, 2017). Temperature of PCM cannot increase as energy is stored in it as latent heat materials for heating purpose in building were proposed by Telkes and Lane in 1980 (Solar Energy, Pergamon Press 1978), (Lane, 1981) and (Zhou, Zhao, & Tian, 2012) . Since 1980s, with continuous development of building technology in China, increasing attention has been paid to wall insulation, its insulation property and construction technology(Benkel et al., 2017).

During energy crisis of late 1970's and early 1980's PCMs were widely researched for their use in solar heating systems. Role of PCMs in buildings are increasing in order to maintain the thermal comfort inside the building. PCM based building not only maintains the thermal comfort in all seasons but also reduces CO2 emission through building (Pasupathy & Velraj, 2006a).In terms of building applications, only PCMs have a property of phase transition close to human thermal comfort, ranging from 20°C to 28°C (Pasupathy & Velraj, 2006b).

According to chemical composition phase change materials can be classified into three categories namely organic compounds, inorganic compounds and inorganic eutectics or eutectic mixtures(Baetens, R., Jelle, B. P., & Gustavsen, 2018). The organic compounds can be further categorized into paraffin's and non-paraffin. The detailed classification of PCM is shown by Figure 1. Organic PCMs like wax, paraffin etc. are costlier, inflammable and produces harmful gases during combustion. While the salt hydrated inorganic phase change materials (PCMs) are inflammable, cheap and their latent heat capacity is very high. But these also have some disadvantages like high corrosiveness, instability, tendency towards incomplete re-solidification and sometimes effects of super cooling (Pasupathy and Velraj 2006a).

The paper presents the researches that show the utilization of PCM's in different parts of the buildings. In cold climate area, the heating electrical appliances become the essential part for the persons residing there. The solar energy can be used as an alternative for fulfilling this need. But it has limitation that it can be used in day time only. This limitation can be overcome by using PCM's or other thermal energy storage material that store solar thermal energy during day time and can be used during night time. The studies that had been carried out in this field are presented in the paper. This paper shows the utilization of PCMs in building and study about heating and cooling application in building. Previous study shows that in day time PCM absorb heat from solar radiation and this radiation stored in form of thermal energy and at night time PCM change our phase due to temperature difference and release the heat inside the room this cycle in done every day. This paper shows thermal performance of PCM in different climate condition and different building structure. The main motive of this paper is to present the PCM's thermal performance in the winter season. This paper concludes that the thermal comfort inside the room is dependent upon the quality of the PCM, melting point of PCM and position of PCM layer in building like roof, wall and windows. PCM integrated building is the best way to save the energy consumption and reduces carbon emission.

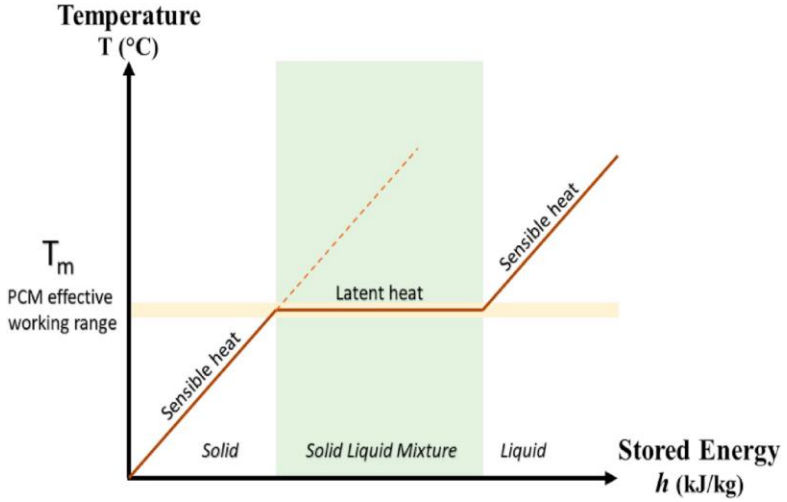


Figure 1 LES by PCM Vs. temperature change (Amaral C, Vicente R, Marques PAAP et al.2017)

2. Background

In 1996, by the United Nations made a protocol on Climate Change named Kyoto Protocol, many tricks and plans were made to reduce carbon emissions in this protocol and several serious steps have been taken under the Kyoto Protocol, under which all countries were instructed to reduce carbon emissions to protect the earth. The European Union fully supported the Kyoto Protocol, reducing emissions of its greenhouse gas. In 1999, 1780 million tons of energy was consumed, in which 35% of the energy was consumed in the residential and commercial area. To save energy consumption by the buildings, several measures began to be found to prevent the impact of the building on the green house. As energy accessibility and demand often does not match, thermal energy storage plays a crucial role to take advantage of solar radiation in buildings. In Europe, cold weather lasts for a longer period of time, for this, the large amount of oil and heaters are burnt for keep the building warm, due to which the energy consumption is increased and as a result the greenhouse gas emits those which contaminate our environment. Therefore, many researches will be done to keep the beings naturally warm, which can be used to heat the room both day and night using the energy of the sun. Therefore, the use of PCM is increasing rapidly, PCM changes its phase by absorbing heat energy from the sun, if it is solid then convert in liquid and if in liquid than convert in solid, At the time of day, PCM kept inside the solar energy in the form of thermal energy, then by changing its phase at night it loose the heat energy in building, which can also keep the building warm while using natural energy at night. (Baetens, R., Jelle, B. P., & Gustavsen, 2018). Several studies have demonstrated that the use of PCMs in well-insulated buildings can reduce heating and cooling energy in residential buildings by as much as 25% and obtain similar reductions in the peak power required for air conditioning.PCM reduce the load of heater in winter season and also reduce the AC (Air conditioner) load in summer. It just doesn't only reduce energy consumption but also reduce the carbon emission from the building, because when we are using the air conditioner (AC) than it release CO2 gas in atmosphere. (Umair, Zhang, Iqbal, Zhang, & Tang, 2019) There are many types of PCM available in the market such as Paraffin-Wax, Micronal DS 5000, Fatty acids, Polyethylene glycol 600 (PEG 600), Micronal PCM, Inorganic salt hydrate (48% CaCl2 + 4.3% NaCl + 0.4% KCl + 47.3% H2O), n-Eicosane, Rubitherm GR27. The main function of PCM is that it maintains the thermal comfort of the building using latent heat, PCM is not only used as building material but it is used everywhere that comes with energy storage. , As the solar distillation is done to increase water production capacity. , Even during the night, without the help of Sun, distillation would continue to be achieved. , PCM have been used in hospital for heat therapy, PCM is also used to heat tank water (Zhou et al., 2012). Based on the previous studies, it can be seen that the performance of the PCM and insulation material hinge on the weather, and the installation of these materials predominantly managed to reduce heat ventilation & air Conditioning (HVAC's) load. As the human's comfort level is increasing, the energy consumption rate is also increasing in the building. ; Humans are ruining the environment for their comfort. PCM based building is being built to reduce energy consumption. Natural energy is used more in this type of building such as solar radiation to heat the water, and the sun's ray for providing natural light in the daytime, In order to give thermal comfort in the room; PCM is installed on roof, wall, window and floor. , Phase change material (PCM) maintains the thermal comfort inside the room by absorbing the sun's heat energy (Nazi, Wang, Chen, Zhang, & Paul Roskilly, 2017).

3. Concept Of PCM Heat Storage

PCM is a material that uses latent heat during the change of phase process to control the temperature within a specific range (Jelle BP, Kalnæs SE.2017). The phase change process can change the state between liquid and gas by condensation and evaporation, known as liquid-gaseous LHTES; Or changing the phase between two solid states, known as solid-solid LHTES; Or a change in the state between solid and liquid by melting or freezing, known as solid liquid LHTES. Inferable from certain specialized impediments of the strong and fluid vaporous classifications of inactive warmth methodologies, just strong fluid PCMs are viewed as appropriate for building warming and cooling applications (Akeiber H, et al.2016) .At the point when the temperature of the PCM's encompassing ascents to such an extent that the PCM arrives at its liquefying point, the compound bonds starts its breakage with an endothermic procedure permitting the PCM to assimilate vitality, while the material melts changing its state from strong to fluid. This is the charging procedure of PCM. Next, when the temperature diminishes to arrive at the point of solidification of the PCM, securities will recover and warmth will be discharged exothermally while the PCM is recaptures its strong state. PCM along these lines is depicted to be a warm store. (Wang Q, Wu R, Wu Y et al.2018) The entire procedure of charging and releasing is went with a little volume change, under 10% of its underlying volume (Amaral C, Vicente R, Marques PAAP et al. 2017) A delineation of the procedure is introduced in Figure 1. Truth be told, PCMs experience reasonable and inert warmth forms dependent on the quick PCM temperature contrasted with the liquefying/freezing range. At the point when the adjustment in temperature happens underneath or over the scope of stage progress, for example at a particular (fluid or strong), the reasonable vitality put away is given as (Navarro L, et al.2016)

$$Q = mC_p\Delta T$$

Where C_p is the specific heat of phase change materials at constant pressure in J/KgK.

m is the mass of phase change material in Kg

ΔT is the Temperature Difference in Kelvin

When due to stored latent heat phase change of material occur at constant temperature, which is function of Enthalpy Change is denoted by

$$Q = \Delta h$$

Where Δh is the enthalpy of phase change in KJ/Kg

Total Thermal Energy Stored in phase change material of MP tm is then evaluated as (Zeinelabdein R, Omer S, Gan G. 2017)

$$Q = \int_{t_i}^{t_m} mC_{pi}\,dT + ma_m\Delta h_m + \int_{t_m}^{t_f} mc_{ps}\,\Delta T$$

C_{pi} is the average specific heat at constant pressure between t_m and t_i.

c_{ps} is the average specific heat at constant pressure between t_f and t_m.

3.1 PCM Classification

Phase change materials that have their charging/releasing procedure inside strong fluid progress classification are arranged into three primary classes: Organic, inorganic, and eutectic PCM (Jelle BP, Kalnæs SE.2017). These classes are partitioned further into sub-classifications. Natural PCMs covers paraffin and non-paraffin materials by which the last contains unsaturated fats, sugar alcohols, and glycols as regions. Inorganic PCMs are named salt-hydrates, liquid salts, or metals. Also, eutectic PCMs are gotten by blending at least two organics, inorganics, or natural with inorganic PCMs (Zeinelabdein R, Omer S, Gan G.2017). Figure 2 sums up the TES grouping regarding the arrangements of PCMs. Natural PCMs are materials found in nature that for the most part comprise of carbon-hydrogen chains. The upsides of natural PCMs are a few, with specific downsides that constrain their adequacy. Natural PCMs are fit for having persistent softening and freezing without stage disengagement or corruption. They are artificially steady, don't have super-cooling, are non-destructive, and recyclable. Be that as it may, they have low warm conductivity (Pandey AK, Hossain MS, V Tyagi V et al.2016) and are combustible. Inorganic PCMs are materials that offer the benefits of exceptionally high dormant warmth stockpiling limit, non-inflammability and more keen stage changes, anyway their principle downsides are in effect normally destructive, highlighted with stage isolation and super-cooling (Chandel SS, Agarwal T 2017). Eutectics are accessible as compounds of organics and additionally inorganics and generally (inorganic salt-hydrates) that highlight compatible softening/freezing with no stage isolation (Luo L, Tatsidjodoung P, Le Pierres N 2013).

PCMs with their various classes and classifications have a wide scope of liquefying temperatures whereby each has a predetermined inert warmth limit of dissolving (Figure 3). This is the primary variable to be considered while picking an appropriate PCM for a predetermined application. Truth be told, a few properties are required to guarantee most extreme warm execution. These properties are canteen physical, dynamic, concoction, practical, and ecological; and the rundown of these properties is given in Figure 4.

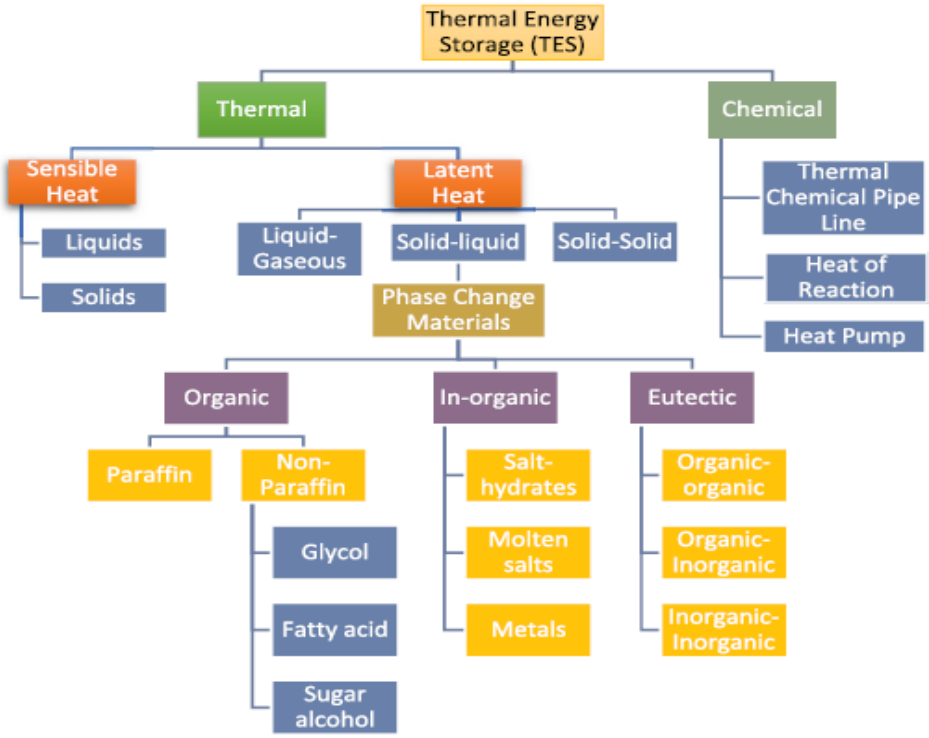


Figure 2 Classification of Phase Change Materials

4. Researches On Utilization Of Pcms For Building Heating Purpose

For getting used in buildings, phase change materials must fulfil some specific thermal, physical, chemical and kinetic properties (Tyagi and Buddhi 2007).

i) Thermal properties: high latent heat of fusion, suitable phase change temperature range and good heat transfer.
ii) Physical properties: high density, small volume and suitable phase equilibrium.
iii) Chemical properties: long term chemical stability, compatibility with construction materials, no flammability and non-toxicity (De Gracia, Oró, Farid, & Cabeza, 2011).
iv) Kinetic properties: suitable crystallization rate and no super cooling.
v)

The PCMs have been implemented at various parts of the buildings for storing and releasing the thermal energy at suitable time. The former usually uses the daily storage/release cycles, whilst the latter work on a season basis .In other words ,for short time storages we can consider the heat storage during the night-time and its release in the day time or vice versa. For annual storage, the heat is stored during the summer for its release in colder seasons or vice versa. The researches that had been taken place regarding heating of building by using PCMs are categorized into following sub-topics:

4.1. PCM as Middle Layer

The PCMs have been tested as the layer provided between the walls or between wall and plaster. The various PCMs have been developed and used in this way by researchers for testing their effect in term of thermal comfort of the building. In this type of wall, PCM is placed between two layers. , The thermal efficiency of the building can be improved by placing PCM in the middle of material like plaster and cement, such a cold, cold and warm summer gives better performance in both the seasons. In this type of building, PCM is installed in the side wall, The advantage of putting it in the side wall is that if the sun rays fall on the wall, then the radiation is absorbed by PCM-based wall. The thermal comfort inside the building depends on the PCM's quality and location the PCM where it has been installed. There is a difference of 10 to 34 degree temperature in this type of building. This means that when the summer season arrives, the temperature of the room will be lower than the temperature of atmosphere and the temperature of the room in colder weather will be higher than the outside. The researches showing the use of PCMs in this way are listed in Table 1.

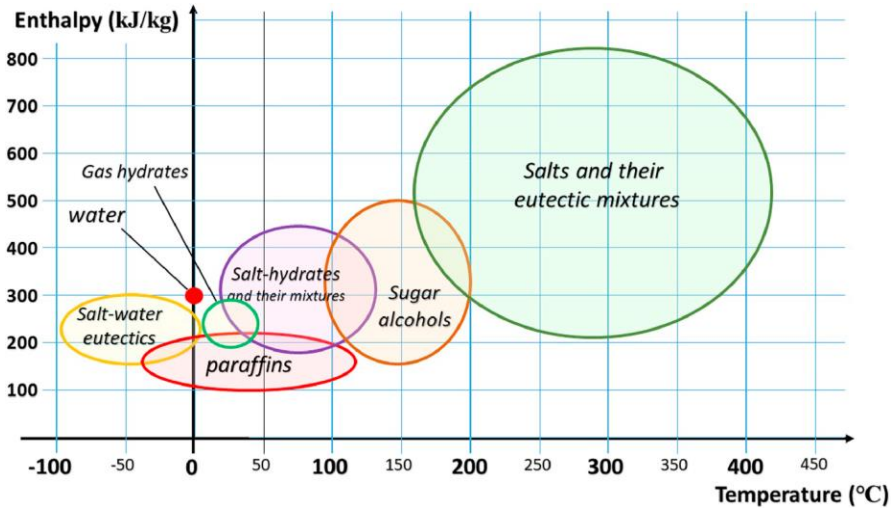


Figure 3 Melting range and melting enthalpy for different PCM types (Baetens R, Petter B, Gustavsen A.2010).

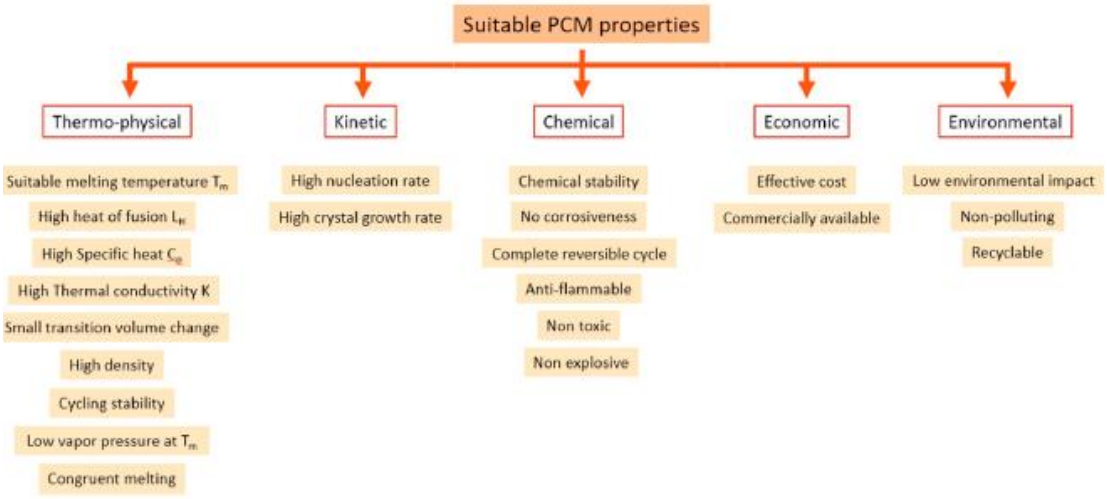
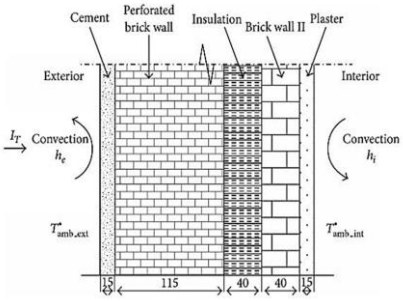
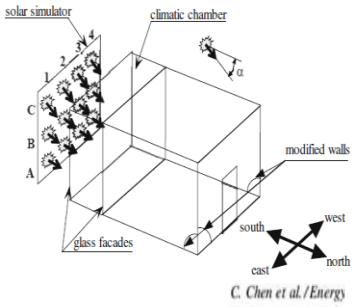
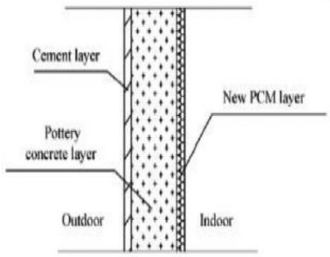
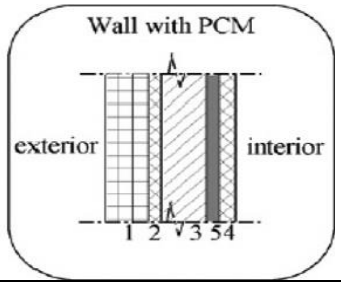


Figure 4 Thermo physical property of PCMs

Table 1 Study on the use of PCMs as middle layer

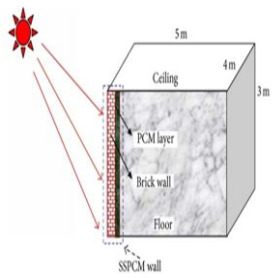
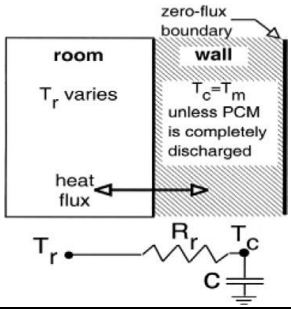
Image	Authors (Years)	Type of PCM used	Remarks
	**Izquierdo-Barrientos et al. (2012)**	GR from Rubitherm	In case study, no optimum temperature were found as it varies from 5° to 35°C, depending upon the wall location, season like winter, summer and PCM layer position in the wall. Due to high thermal inertia of building wall, the heat loss during day time reduces while during night time increases for winter season and opposite for summer season. When PCM are used than it provides thermal comfort because PCM reduce the thermal effect on the constructed HVAC system.
	**Kuznik & Virgone (2009)**	ENERGAIN (Composite of 60% micro-encapsulated paraffin in copolymer)	The effect of manufactured PCM on the test room was studied with and without composite wallboard in three seasons namely summer, winter and mid-season. PCM keeps the room temperature 4.2°C below the outside atmosphere temperature and enhances the natural convection inside the room.
	**Romero-Sánchez et al. (2012)**	Micronal DS 5000 (Water based solution)	A pilot house had been built using stones treated with PCM. Also the effect on the thermal comfort without PCM has been observed. Results shows that PCM rises the thermal mass and inertia of the walls that results in better thermal comfort.

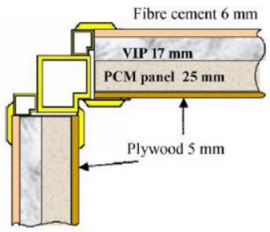
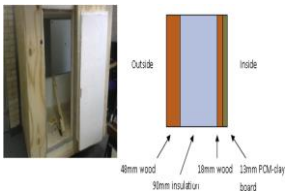
	**Chan (2011)**	Energain	Constructed a PCM integrated based building, PCM integrated in Bedroom wall and Living room wall and study the energy analysis. The maximum of 4.4% decrement in room temperature was noticed during west orientation of the living room. PCM save the energy by 2.9% annually.

4.2. PCM used in Internal Layer of Wall

The PCMs have been tested as the layer integrated with internal layer of wall as it gives better thermal comfort in all seasons. In building applications, in various field PCMs can be integrated into building covering materials such as concrete, gypsum wallboard, plaster, etc., as part of building structures for light-weight or even heavy-weight buildings to increase the thermal comfort & thermal mass. When PCM is installed in the internal layer of wall, it was found that PCM gives better performance when it is applied in the south direction wall in compare to another direction. This happens because the sun remains in the south direction for longer period, so that the radiation is obtained for longer period in that direction and the other reason is that the sun is closer to the earth in this direction. As the technology is increasing, the violence is also progressing in the field of our energy building, as it can now know about the construction and thermal performance before the building formation. Through B.L. Gowreesunker CFD analysis has been done on an Energy Build in which they have analyzed the thermal changes in the building with the help of CFD to find from which place air is coming into the building and from which place is the supply of thermal energy more. With the help of CFD, we can reduce the cost of building and also save time. , If CFD is not used, then a prototype building will have to be made, then there will be a lot of changes in prototype buildings that will waste both time and money. In this way, we can use a technology to prepare a good building ahead of time at a lower cost (Gowreesunker & Tassou, 2013). Figure 3 shows the PCM layer is located in the side wall and few of the related researches are written in Table 2.

Table 2 Observations from various modern buildings

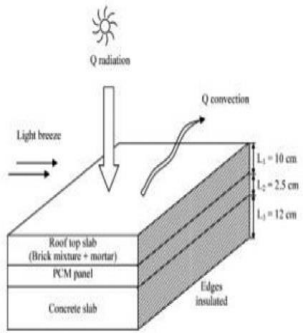
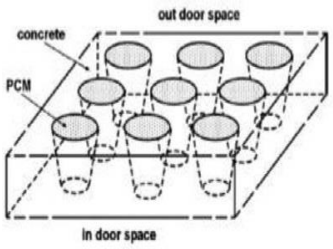
Image	Authors (Years)	Type of PCM used	Remarks
	**Zhu et al. (2010)**	Paraffin as dispersed PCM and high-density poly-ethylene (HDPE)	A PCM integrated based model are constructed it is a physical dynamic model in which shape-stabilized PCM are used. This model consists of three wall resistance, two capacitances and the PCM layer represented by four resistances and two capacitances (Figure 2). Parameter identification is the key issue of this model. A few PCM models with detailed physics and thermodynamic behavior of building structures were united with PCM layers are simulating with good accuracy. Experimental results manifested that the comprehensible model can perfectly represent the light walls and intermediate walls integrated with SSPCM.
	**Neeper (2000)**	Fatty acids and paraffin waxes	Gypsum wallboard constructed by mixing of PCM. Aim of the paper is provide guideline; a) how to use PCM and benefits of PCM in building architecture; b) Latent heat storage capacity of wallboard per unit area; c) Melting point temperature of PCM. The maximum daytime energy storage occurs at a value of the PCM melt temperature that is close to the average room temperature in most circumstances The thermal energy stored by the gypsum wallboard during practice by the constructed building may be limited to the 2 range 300–400 kJ/m, even it possible if the wallboard has a greater latent capacity.

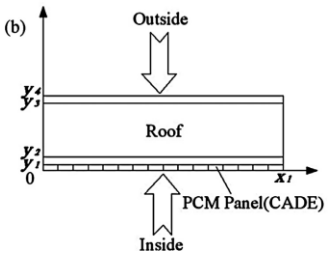
	**Ahmad et al. (2006)**	Polyethylene glycol 600 (PEG 600)	Comparison the performance of A new structure of test-cell which is light waits wallboard with PCM integrated and test-cell without PCM. In summer season 20°C temperature reduces inside the structure or cell, This structure are integrated with PCM. It prevents the negative indoor temperature without PCM until the temperature of the cell is -9°C and that the outside temperature is below -6°C in winter. Significant heat storage and release showed by the PCM structure.
	**Gowreesunker and Tassou (2013)**	Micronal PCM	Study the effect of 1) PCM integrated wall board and it how to reduce high indoor temperature. 2) CFD analysis of air flow and temperature of indoor space. PCM integrated wall board reduce the high temperature of indoor space by 3K in compare to conventional plaster boards and this construction prevents the room from overheating in month of May to July. In winter season it provides heat inside the room space. Performance of Clay wall boards dependent upon PCM quality.

4.3. PCMs with Roof System

It's a very effective technique to maintain the thermal performance inside the room, the PCMs have been tested as the layer provided between the roof and concrete slab or one side of the roof slab. The various PCMs have been developed and used in this way by researchers for testing their effect on the thermal comfort and energy consumption of the building. The University of South Australia has created a solar-based roof integrated solar heater and heat storage to heat the air in which corrugate iron has been used like a roof sheet, and this work as a solar collector. Planting PCM in the roof receives sufficient thermal energy, thereby increasing the energy efficiency of the building without thermal comfort lost. PCM Integrated Based Roof becomes more effective when PCM takes place in the wall apart from the roof. Building with PCM-based roofs is more beneficial for places where the winter season is much longer. The researches showing the use of PCMs in this way is listed in Table 3.

Table 3 Study on the use of PCMs in buildign roof

Image	Authors (Years)	Type of PCM used	Remarks
	**Pasupathy and Velraj (2008)**	Inorganic salt hydrate (48% CaCl2 + 4.3% NaCl + 0.4% KCl + 47.3% H2O)	Experiment on two model of room has been carried out; one is with PCM another is without PCM. In the month of January, roof top temperature is 27°C which is 4°C higher than the non-PCM model room. However, in month of July, inner side wall of the PCM room temperature is 38.8°C, which is lower than the non-PCM room temperature. If double layer PCM is integrated with roof than the model is shows better performance.
	**Alawadhi and Alqallaf (2011)**	n-Eicosane	Cone frustum hole was constructed in the concrete roof and was filled with n-Eicosane PCM. The application of PCM in wall in this way reduces the transfer of heat through the wall. This results in lower room temperature in day time and higher temperature during night time than ambient temperature. During summer season the room temperature was reduced by 35% than ambient temperature and results in higher room temperature during winter.

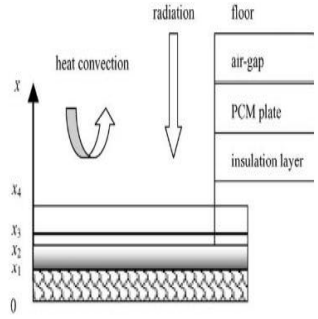
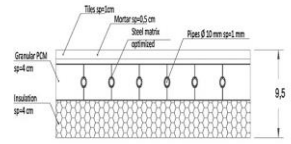
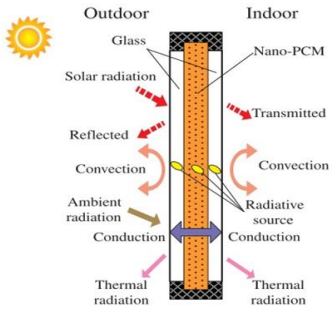
	**Pasupathy, Athanasius, and Velraj (2008)**	In-organic eutectic PCM (48% CaCl2 + 4.3% NaCl + 0.4% KCl + 47.3% H2O)	Studied the thermal performance of in-organic eutectic PCM provided on building top roof slab for cooling and heating purpose. Effect of PCM layer thickness on building temperature was also studied and found that with increase in PCM thickness, the room temperature also increases during winter. Water flow through the pipe inside the PCM panel reduces the temperature inside the room during summer season. But it has one limitation that large amount of water is required for maintaining the thermal comfort during summer season.
	**Kong et al. (2014)**	Capric acid & Capric acid +1-dodecanol	Constructed a model house in which two different PCM were integrated at two different location; roof and wall. Aim of this model is increase the thermal energy inside the room, absorbed heat energy in day time by the PCM and utilizes this energy at night for thermal comfort and it saves energy consumption. Constructed model is shown better performance in the winter season

4.4. PCM At Other Part Of Building

For improving the thermal comfort and to reduce the energy consumption of buildings, PCMs have been tested in some other parts of building like floor and windows. Nano-PCM increases the thermal efficiency of the building and decrease energy consumption. According to the European Union (EU), buildings are responsible for 36% carbon emissions and 43% energy consumption (Beltrán and Martínez-Gómez, 2019). PCM layers were placed on the interior surface of the wall room facing a large window of the test room and were tested in different indoor and simulated outdoor conditions (Guarino et al., 2014). PCM can be used in many places in the building and every use has the same purpose to reduce the energy consumption load in the building. Therefore, keeping the PCM in the window, roof, wall and floor, keep the thermal comfort inside the room. One such building has been where PCM has been used in the floor, in which the water is supplied from the bottom of the PCM layer with the help of pipes. It has the advantage that heat absorbed by PCM from room transfer into the cold water, thereby, maintained the thermal comfort of the room and the water also gets heated, which we can use in many other works. If this kind of setup is discussed in the cold weather, hot water is supplied in the pipeline which is heated with a solar water heater. , Hot water heat is absorbed by PCM and then PCM releases this thermal energy inside the room. The temperature inside the room is also favorable in the winter season.

For reducing the carbon emission and energy consumption, PCMs are used at different locations in the building like floor and windows. PCMs in this way are listed in Table 4.

Table 4 Studies on PCMs used at other part of building

Image	Auhtor (Year)	Position of PCM in building	Type of PCM	Remark
	**Xu et al. (2005)**	Floor	70% paraffin and15% polyethylene	Provided the layer of PCM with air gap in the floor of the building. Result shows that the PCM used gives better thermal comfort that wood and tiles. For acieving better thermal comfort, the thickness of PCM layer should be less than 20mm and air gap must be tried to keep minimum as possible. Also the thermal conductivity of PCM and heat of fusion should be greater than 0.5W/mK and 120 kJ/kg respectively.
	**Ansuini et al. (2011)**	Floor	Rubitherm GR27	Constructed the prototype with radiant floor integrated with PCM and water pipe. This prototype save 25% of water which is wasted in cooling the room during summer. In winter also it did not affect the heating behaviour of room thus maintaing the thermal comfort during all seasons.
	**Li et al. (2016)**	Window	Paraffin MG29	Tested the effect of PCM in three conditions namely tripel pane window with PCM, double pane window with PCM and tripal pane window without PCM. Results shows that triple pane window with PCM shows better performance in all the seasons. During summer season it allows 16.6% and 28% less heat as compared to double pane with PCM and triple pane without PCM windows respectively. During rainy season also, it maintains the inside temperature 0.74°C and 1.65°C less than double pane with PCM and triple pane without PCM windows respectively.
	**D. Li et al. (2018)**	Window	Paraffin wax	The PCM was mixed with nano particles and applied over the window panes. The nano particles increases the thermal capacity of the PCM and improves the performance. Result shows that the inner temperature of nano-PCM glazed window increases with increase in nano particle size and its concentration. This model reduces the energy consumption by 1.5%, 2% and 4% during summer, autumn and winter season respectively. 1)Temperature of inner side glass surface is depending upon concentration and nanoparticle size, when the concentration increase 1% and diameter of Nano-particles of 100nm than inner glass surface temperature is increased.

5. Researches On Utilization Of Pcms For Building Cooling Purpose

PCMs applications are appropriate for both new structures and the retrofitting of existing ones (Jelle BP, Kalnæs SE.2017). The method of consolidation, dissolving range, and wanted utility describe the working method of the utilized PCM–TES framework. PCM–TES can be utilized for warming, cooling, or for both warming and cooling, which are alluded to as cross breed frameworks. The basics behind cooling applications utilizing PCM states that: when the considered warm zone is exposed to an expansion in encompassing temperature that may pass the solace run gave by the American Society of Heating, Refrigeration and Air-Conditioning Engineers, during hot condition (24 degree Celsius for a stickiness not exactly or equivalent half) (McQuiston F, Parker J, Spitler J.2005), at that point PCMs play their job in putting away the abundance heat through their steady temperature retention capacities. Figure 6 outline the stage change marvels during cooling use of the PCM. The softening scope of PCM is then reliant on the arrangement of the PCM in the zone, kind of utilization using the PCM, and wanted cooling set point. Every mode is partitioned into inactive and dynamic classifications. (Heier et al.2015) states that the contrast among dynamic and latent frameworks is the main impetus of charging and releasing the capacity where dynamic stockpiling uses siphons or fans while detached capacity relies just upon the temperature distinction between the capacity and environmental factors. As indicated by (Suayfane et al.2016), the cooling request in the structure area has expanded quickly attributable to: (1) high necessity for tenants' solace, (2) ascent of structures inward warmth increases, (3) effect of urban warmth island experienced in stuffed urban communities, and (4) decreased expense of cooling hardware. Coordinating PCM into structures can diminish the cooling cost and improve the warm solace during hot seasons.

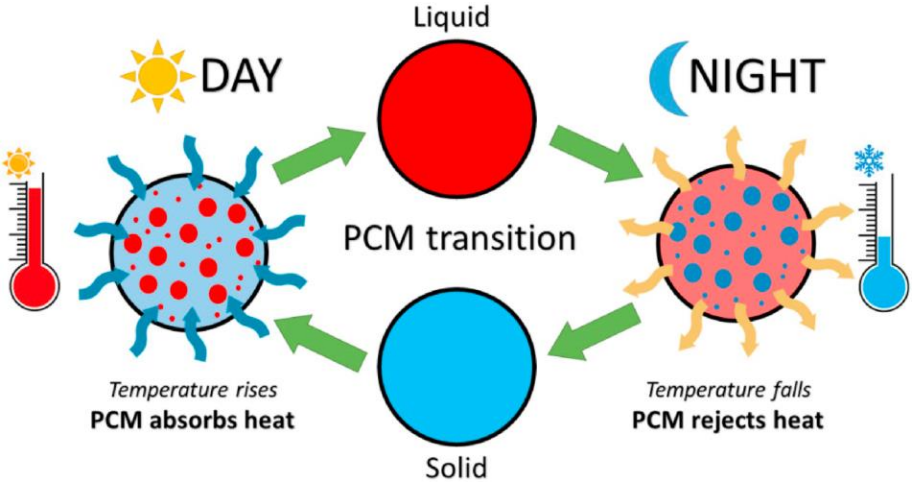
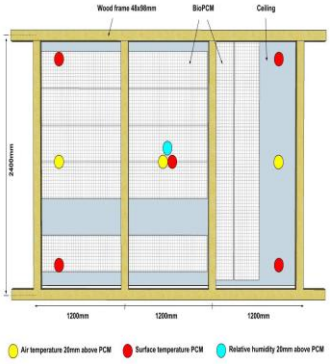
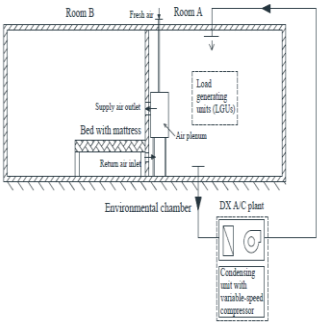
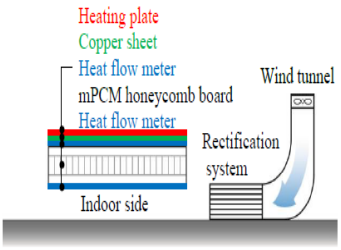
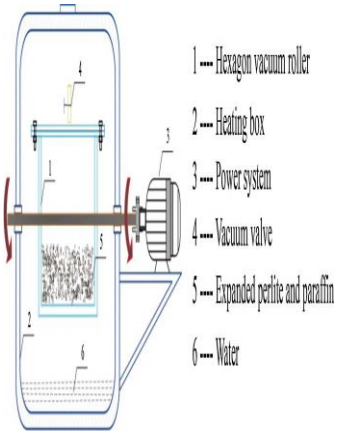
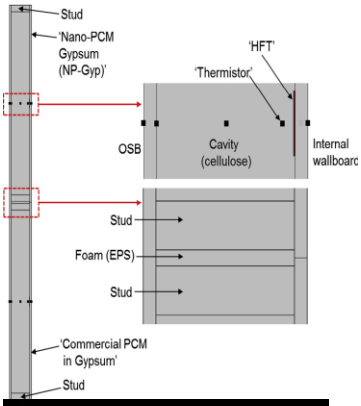
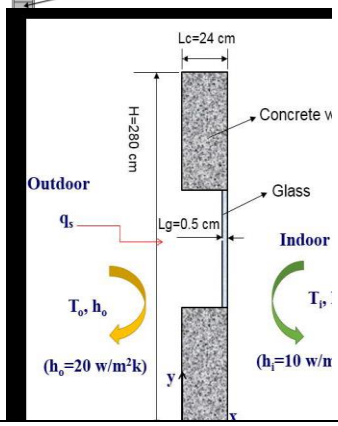
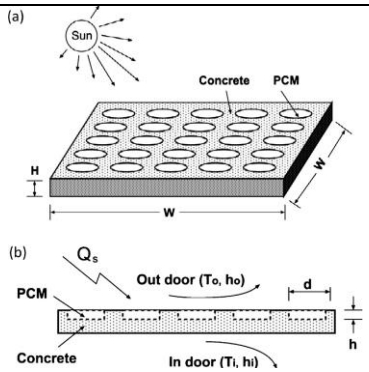
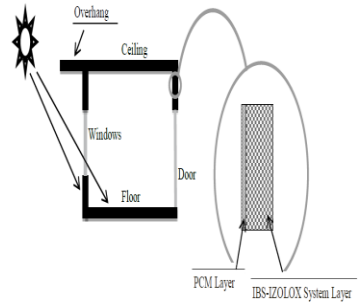
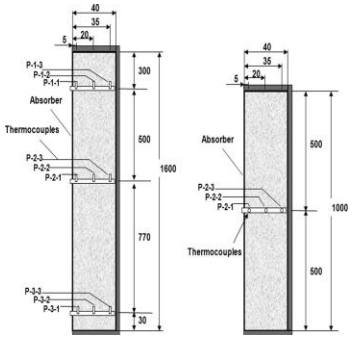


Figure 6 Phase change of PCM throughout warm climates

Table 5 Previous Study on PCM cooling applications for buildings.

Investigation method & Author	Image	Used PCM	PCM-LHTES method	Outcomes
Experimental **(Vika TA et al. 2018)**		Bio-PCM Q23 M51	Conceded roof and roof plates	Huge cooling impact for roof PCM presented to tenants.
Mathematical (**Ning M et al.2017)**			Outside room envelope outfitted with PCM	Variety of outside hot condition impact is limited viably by the PCM. As Tm is expanded, variety of return air temperature is decreased when the proportionate envelope temperature is high.
Experimental **(Wang SM et al.2018)**		Paraffin based micro-capsulated PCM	mPCM fused into 8-mm center cell Al honeycomb plate	Thermal safety stages of 4 hours, 4.7 hours, and 4.7 hours for cases 1–3, respectively. Heat liberating times: 2.8 hours, 3.3 hours, and 3.8 hours for cases 1–3, respectively.
Experimental **(Lee KO et al.2017)**		Paraffin-based PCM	Paraffin PCM blended in with cellulose protection in walls holes	Normal pinnacle heat flux were time deferred by about 1.5 h - 26.6% hourly pinnacle heat flux decrease and a normal cost investment funds of 3 pennies/m2 for all walls.

Experimental and Numerical **(Stritih U et al. 2018)**		nPCM blended with Fatty Acid	Composite wall of concrete and cement with mPCM installed with 0.12 m total thickness.	Inside surface of the test lodge is colder by 5 degree celcius than the reference board.
Experimental and Numerical **(Yao c et al. 2017)**		Paraffin/ extended perlite SSPCM	Wallboard (PCMW) joined to the inner surface of the dividers and ceiling of tried model.	PCMW improves warm solace, smoothens indoor temperature vacillation, and increment the structure vitality effectiveness. Numerical model is approved with a certainty level >95%. Numerically, for 4000 m2 office, cooling load decrease of 22.16%, 5.84 years restitution period, and a life expectancy >20 years is accomplished. Optimum PCMW: have a stage change temperature scope of 25–26 degree Celsius and thickness 10 mm.
Experimental and Numerical **(Biswas K eat al.2014)**		Paraffin, n-heptadecane (C17H36)	Consolidation of shape settled nano-PCM in gypsum	Wallboard - For a cooling set purpose of 22 degree Celsius, the most noteworthy yearly divider heat gain decrease was accomplished. No decrease in heat gains for the instances of 22 and 23.3 degree Celsius set focuses. Potential of electrical utilization decrease is shown by the Nano-PCM wallboard
Numerical **(Wang Q et al. 2018)**		6RUBITHERM RT-line PCM	PCM layer joined into solid wall,	Heat transfer rate and normal inward surface temperature are decreased by utilizing PCM. The ideal PCM type, thickness, and position are RT42 with 20 mm thickness, put outside. Heat transfer decrease of 34.9% was accomplished

Experimental and Numerical **(Alqallaf HJ et al.2013)**		Paraffin-based PCMs A-28, A-32 & A-38	PCM packed in cylindrical cavity of a solid cement ceiling	Momentous decrease in heat gain with larger PCM holes diameter.
Numerical **(Kharbouch Y et al. 2017)**			Bio-based combined wall with PCM	PCM - Best execution as far as diminishing separation impacts was on account of substantial weight divider with PCM contrasted with lightweight
Experimental **(Li Y et al.2014)**		RT42 paraffin wax	PCM improved frame (with balances) adjusted to a solar.	Chimney - For three diverse sun oriented warmth motions (700, 600, and 500 W/m2), the best warm proficiency was for 500 W/m2 while the base outlet temperature was for 700 W/m2. - Air stream rates were 0.04 kg/s, 0.039 kg/s and 0.037 kg/s for 700 W/m2, 600 W/m2, and 500 W/m2, separately

6. Conclusion

The present effort represented a review on latest research work in the scientific community concerning the usage of phase change materials as latent heat thermal energy storage policies uses to buildings: commercial as well as residential. Two most application characteristics were presented: heating applications in buildings, cooling applications in buildings. The current reviewed articles were presented and their thermal performance analyses were included. Phase change materials are coming up as the best alternatives for utilization of solar thermal energy. Especially these are helpful during winter season or buildings in cold climatic zone for maintaining the thermal comfort inside the buildings. Thermal comfort in buildings integrated with PCMs depends on the various factors like quality, quantity, melting point and location of PCM. The PCM not only keeps the inside temperature of the building higher than ambient during winters but also able to do the just opposite during summer. The one reason that is responsible for maintaining the thermal comfort in all the seasons is the higher thermal inertia.

The PCM layer where ever applied in building, increases the thermal inertia due to which the heat transfer from outside to inside the building reduces. Secondly, the PCM layer inside the structure absorbs the heat by changing its phase from solid to liquid during day time and release it during night time by again coming back to its original phase. The effect of PCM had been tested by placing them in windows, walls, roof and floor. When PCM is put in two different places inside the room, then it saves 4% of energy consumption. When the PCM is attached to the roof, the temperature of the room is increased by 4 to 5% compared to another applied position of PCM. Nano-PCM based glazed window shows better performance in winter season, Temperature of the inner side glass surface is depending upon concentration and nano-particle size. It reduces the energy consumption by 1.5% in summer, 2.0% in autumn & 4.0% in winter season.

PCM do help as thermal buffers that permits residential thermal comfort in winter cold climates through peak instable and temperature fluctuate reduction.

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