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Evaluating Relationship between Mixed-land Use and Land-use Compatibility in Algiers Bay

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ABSTRACT

MLU is considered as one of the main component leading to a successful urban planning and urban regeneration operations. This policy was advocated as principal characteristics of contemporary urban trends. Most of the literature focalized on the relationship between MLU and other factors such as transport, health and other social aspects. However, the study of relationship between MLU and LUC seems to be completely ignored even such studies are scarce when talking about Algerian cities. Hence, this paper is a part of a study where one of the main objectives is to explain the relationship between MLU and LUC and by using Algiers' bay as a case study. This paper is structured in three sections. The first section deals with the review of the development of mixture through the available literature. The second section is related to the assessment of the MLU and its compatibility, this assessment is done by using Algiers Bay as a case study. The last section consists of evaluating the relationship between those two factors by using Spearman's Rho correlation coefficient. This study leads us to confirm that there is a direct relationship between MLU and LUC. However, it is important to mention that MLU may have a negative impact on land use compatibility, so, the challenge for the planners is to find the balance between MLU and LUC. Moreover, it is imperative to integrate LUC as a variable in measuring MLU.

Keywords: mixed land-use, land-use compatibility, Algiers, MAVT

INTRODUCTION

Mixed-land use is considered as one of the most important indicators of successful urban planning and urban regeneration operations in many planning policies such as Smart Growth and compact city.

The literature highlight the positive impacts of the mixed land use in developing urban areas, in terms of rational consumption of land resources, safety and urban vitality (Shi & Yang, 2015; Song & Rodríguez, 2005). In addition, Mixed Land use reduces cars congestions (McNeill, 2011; Shi & Yang, 2015), and promotes urban diversity…

Through the analysis of some cases, we will illustrate, in one hand, the use of the mixed-land use as a support leading to the development of urban regeneration operations and urban planning. However, these actions require to look carefully at the compatibility between activities involved in that mixture. On the other hand, this literature leads us to take into consideration of the relationship between mixed land-uses and other factors such as: the effect of mixed land use on social capital realized by (Nabil & Eldayem, 2015) and the relationship between mixed land use and accessibility (Huang & Hsieh, 2014).

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This paper will focus on exploring and explaining the relationship between mixed-land use and land use compatibility. Hence, this paper will be based on the hypothesis that MLU and LUC are related to each other.

The main objective of this work is;

- Because there is no standard model for measuring mixed land use, our first objective was to build a model in order to measure urban MLU mainly based on technical approach.
- To understand the effect of land use mix on the performance of different activities in urban space.
- To understand the relationship between MLU and land use compatibility (LUC) in different levels.
- To highlight the impacts of the urban activities in the determination of the mixed land use (in terms of design brief, regulation, aesthetic, traffic and economy).

This work is structured into three parts:

1) Firstly, a literature review on the development of mixture;
2) Second, assessing mixed land-use and land-use compatibility using Algiers' bay as a case study;
3) The third and last part deals with the evaluation of the relationship between MLU and LUC in different scales. The evaluation relies on the method called: Spearman's Rho correlation coefficient.

In this research, MAVT methodology was adopted in measuring both MLU and LUC. Through this method, we evaluate and explain the relationship between MLU and LUC.

The results obtained showed that there is a strong and direct relationship between mixed land use and land use compatibility. Hence, in application of the mixed land use policy, and in order to avoid negative impacts between the different activities, land use compatibility should be seen as one of the major criteria.

it is important to study the relationship between mixed land use and land use compatibility because knowing the nature of that relation in details leads to conceive more sustainable environment by hindering negative externalities such as Noises, air pollution, congestion ..

To conclude, that investigation will open doors to identify the nature and activities needed for more sustainable urban space. The performance of the urban space will be measured trough the contribution of each activity and the effect of activities on each other.

LITERATURE REVIEW

The urban and sustainable developments are usually evaluated by using the mixed land as one of the main indicators. Through this indicator, it can be said that in terms of urban composition, the mixed land use is a tool leading to avoid the segregation whether physically, socially or functionally (Shi & Yang, 2015).

Nowadays, the mixed land use is the main subject of many research studies. It is also analyzed in terms of its impact on fluidity and transportation, ecology and sustainability, happiness and well-being.

The main objective from this research paper is to understand and explore the relation between mixed land use and land use compatibility in different scales.

Mixed Land-use

Many research papers were developed on studying the characteristics of the MLU and its influence on other factors. The recent works are concerned with the methods of the assessment and evaluation of the mixed land use: (Bakhtiarifar, Mesgari, Karimi, & Chehreghani, 2011; Gehrke & Clifton, 2016; Huang & Hsieh, 2014; Javadi, Taleai, & Karimi; Rupjyoti, Amit, Partha, & Mallikarjuna, 2013; Shi & Yang, 2015; Song, Merlin, & Rodriguez, 2013; Song & Rodríguez, 2005).

Most of research papers that analyzed MLU policy focus in measuring MLU without highlighting and specifying the impacts on the different land uses.

So our objective is to evaluate the impact of MLU on LUC.

Mixed land use is defined as the co-existence of many different functions in the same area or neighborhood (Bahadure & Kotharkar, 2015). According to Lagendijk (2001, p. 144), Mixed Land use consists *"to return to non-separatist approach to land use, as was common in preindustrial and early industrial cities"*.

Through history, many cities have used the mixed land use as a tool of urban composition. According to Nabil and Eldayem (2015), the emergence of the mixed land use started in Roman cities, and were developed

to get more importance during the Middle Ages. During that period, mixed land use was approached vertically in a way that compatible activities were developed in the same building: the first levels of the building (ground and first floor) were usually left for urban activities mainly commercial activities and the other levels were used as residential.

Nowadays, in contemporary urban planning are recommending the MLU as tool to achieve a good urban design, through it, we can insure a diversified activities and typologies of buildings as we can enhance opportunities for gathering and exchanging.

According to Grant (2002), most of the contemporary actions taken in urban areas in terms of urban regeneration or urban revitalization are based on the development of mixed land-use as a major component. Lagendijk (2001) argues that, this idea has been realized first, in America and Europe. (The urban regeneration in London in 1970's is an illustrative case showing the impacts of the mixed land use in the metamorphose of the area).

Hence, mixed land use might be seen as one of the recommended approach to resolve dysfunctional problems of urban area. As it might be considered as the main component of Urban Smart Growth and urban planning (Huang & Hsieh, 2014); New Urbanism and Compact city.

Through time, Mixed-Land use becomes one of the most important indicators to preserve in urban planning operations and sustainable development.

Scholars explain that Mixed land use present many benefits. Among these benefits, one can cite the reduction of the mechanical traffic by minimizing the dependency on cars and encouraging people to use public transport (Coupland, 1997) and non-motorized modes (Rupjyoti et al., 2013). The reduction of the mechanical traffic leads also to the reduction of traffic congestion that will end up by having numerous ecological benefits. Besides, it helps to make urban spaces more secure, vital (Coupland, 1997) and diverse by encouraging citizen's interactions, and concentration.

According to Teller and Becue (2005), there are three types of mixture (Social, Residential and Functional mixture).

This study was based on Functional Mixture, because it constitutes the component element of a successful operation of revitalization (the opportune operation for the context of Algiers bay). Also, it has direct influence on social and residential mixture. In addition, the large scale of the study area needed working on horizontal mixture.

Despite of different advantages embedded by several scholars, mixed land use may cause negative effects such as environmental problems like pollution, car congestion and noise inside urban blocks (Nabil & Eldayem, 2015), (Vreeker, 2004), when cohabitate industrial, commercial and residential activities in the same urban space. In addition, it may cause overcrowded parking (Vreeker, 2004). So, citizens will get problems in finding places for their own cars.

They argue that there is also, social inconvenient as the increase of population density and high crowded (teeming) places (Vreeker, 2004) and lack of privacy for inhabitants in the same space. In addition, the presence of a high crime levels in such locations**.**

What's Land-use Compatibility?

Land-use compatibility is defined as "the degree to which two or more land use types co-exists without significant negative impact" (Taleai, Sharifi, Sliuzas, & Mesgari, 2007, p. 377).

The co-habitation of different activities of different scales may cause positive or negative effects on urban space. Those effects may vary from one space to another, depending on the existing activities in the urban area. For example cohabitation of residential and industrial activities in the same urban space may cause negative impact like congestion, air pollution which makes urban life more difficult.

According to Taleai et al. (2007), interaction between different activities could get a constrained land use usability. They explain that the existence of different activities in the same area may cause negative externalities, impeding by consequence, the functioning of land uses that exist in urban area.

Land use incompatibility could lead to less valuable land uses. However, compatibility may get more performed and more valuable urban spaces. Compatibility between adjacent lands uses leads to improve safety and welfare and protect environment health by reducing different kinds of pollution, increasing well-being and value of urban space. The most relevant recent findings on the evaluation of the impacts of the land use

compatibility are presented by (Abedini, Lotfian, & Moradi, 2015; Taleai et al., 2007; Taleshi & Ghobadi, 2012; Vaezi, Mesgari, & Kaviary, 2015). For instance Taleai et al. (2007) developed a model in order to evaluate land use compatibility in both horizontal and vertical directions. Abedini et al. (2015) proposed a model in order to verify how suitable different location for the construction an elementary school. Even, Vaezi et al. (2015) proposed a model for assessing and mapping land use compatibility.

There is difference between micro and macro scales when evaluating land use compatibility. According to Taleai et al. (2007) some activities are needed at macro scale. However, their existence in the micro scale may introduce negative externalities in the neighborhood, they explain that industrial activities have negative impacts on residential activities but they are needed in macro scale because it provides jobs and goods.

To conclude, Land-use compatibility is a component element of urban planning. So, planners do their best to avoid conflicts between functions, in order to get a best desirable urban space.

However, planners might be seen as one element of the whole system. The interactions with the other elements (socio-cultural, economic, environmental, technical…) that constitute the land use compatibility lead us to say highlight that the dynamism more than impossible, such as social, security and economic constraints.

Hence, the challenge that planners need to take is to conceive an urban space with compatible land uses, despite impediments that may hinder achieving that goal.

The researches on the diversified and compatible urban activities highlight that criminology is higher in commercial land uses mix (Sohn, 2016). Also, Nabil and Eldayem (2015) proved the existence of a direct link between mixed land use and social capital. Bahadure and Kotharkar (2015) found that travel behaviour is related to mixed land use. They surprisingly discover that moderate mixed land are more sustainable comparatively to the high and the low mixed land use. Hajna, Dasgupta, Joseph, and Ross (2014) found that mixed land use is associated to lower cardiometabolic risk. Ozbil, Peponis, and Stone (2011) discovered that distribution of flows of pedestrians depends partially on the urban structure and land use. Duncan et al. (2010) explain that mixed land use encourage walking and riding bicycles. Frank and Pivo (1994) found that transport behaviour is affected by mixed land use and density …

Through these non-exhaustive literature, it is highlighted the role and importance of the mixed land use and land use compatibility on the urban fabric and the structure of the city. However, is Land use compatibility considered as a positive or negative effect of mixed land use policy? Has it the same effect even when changing urban scale? The answer to this question will be through the study of the effect of mixed land use on land use compatibility and by taking Algiers' bay as a case study.

In order to realize that goal, measuring both of mixed land use and land use compatibility using measured variables that define each indicator was an important way to get interesting results.

METHODS AND MATERIALS

Multi-Attribute Value Theory

The MAVT is based on mathematical representation of human judgements. It is used in the objective to create a useful tool for better decision making. This kind of methods is widely opted by many scholars such as (da Cruz & Marques, 2017; Ferretti, Bottero, & Mondini, 2014). It is based on aggregating multitude of attributes that define the objective under study. Those attributes maybe different in type and measurement' scale. It is generally used to measure and rank the performance of a service or an activity.

In MAVT method, measuring the objectives' performance believes in two kinds of description of attributes, it may be qualitative description or quantitative description depending on characteristics of the objective under study. Hence, expert's judgment play a great role in replacing quantitative data especially when information is not available.

"The intention of MAVT is to construct a means of associating a real number with each alternative, in order to produce a preference order on the alternatives consistent with decision maker value judgments" (Ferretti et al., 2014, p. 3).

Using that method, all alternative values could be transformed in a simple one value by aggregating all attributes values. The alternatives with the best value are the most valuated.

This methodology is conceptualized following different steps:

1. **Conceptualization:** by fixing attributes which define the objective under study. This step was carried out through literature reviews in order to fix suitable attributes that define the objective under study. It is important to mention that selecting the appropriate attributes leads to better analysis of the objective under study and by consequence better intervention to solve problems.
2. **Operationalization:** this step is based on moving from abstract definition on the objective under study into its assessment by measuring attributes already fixed in the first step of this work. *"Those attributes may be natural (extracted directly from definition of objective), constructed (they specify a finite number of degrees to which objectives are met), proxy (they are indirectly related to the definition of objective)"* (Ferretti et al., 2014, p. 4). The objective under study can be measured using qualitative or quantitative attributes. This step is carried out by following different kind of measures:
   - Direct measuring when talking about quantitative attributes (this kind of measuring is essentially applied when measuring MLU attributes.
   - Qualitative attributes are measured using value function (it is used in this work in order to measure LUC).

Hence, Value function is a mathematical expression of human judgement; it has the role of transforming human judgement into measured values.

"They offer an analytical description of the value system of individuals involved in the decision and aim at capturing the parts of human judgments involved in the evaluation of alternatives" (Ferretti et al., 2014, p. 4). This method play the role of transforming the performance of alternative attributes into scores in order to reveal the level to which the objective under study is achieved (Ferretti et al., 2014).

Value function is a dimensionless value; hence, values are between 0 and 1, so zero means higher performance and zero means lower performance of the alternative attributes. Value function is based on human judgment (built basing an interviewing process which will be analyzed and transformed into multi attributes profiles).

It is important to mention that qualitative attributes are difficult to be transformed into scores, when quantitative attributes are easier to be transformed into scores. Hence researchers explain that there is many methods to measure qualitative attributes such as MACBETH Method, pairwise method (*i.e.* AHP method).

Aggregating scores

This step is carried out by fixing a weight value to each attribute. This value represents the importance of an attribute or variables comparing to others. Measuring weights appropriately is important when using MAVT method. There are many ways for transforming information to weight scores, the most used are (*i.e.* Swing weights, rating, pairwise comparison, trade-off, qualitative translation).

This method is called "the Analytic Hierarchy Process" based on pairwise comparison technique in order to extract numerical evaluation of qualitative description of service or activity performance. It recommends experts' and decision maker's opinion.

In AHP method, the sum of weights assigned to attributes is equal to 1.

According to AHP method, the best alternative is chosen following result extracted from *Equation 1* (Ferretti et al., 2014).

$$V = \sum w_i * v_i(a_i) \quad (1)$$

V is the global value

w_i is the weight assigned to reflect the importance of attribute i

$v_i(a_i)$ is the single attribute value function reflecting alternative a′s performance on attribute i

Statistical analysis

Correlation analysis: Is a bivariate analysis used to measure the linear relationship between two variables for several areas (Haining, 1991). Correlation analyses play a great role in revealing the strength and the direction of that relation. Correlation indices varies between (+1, -1).

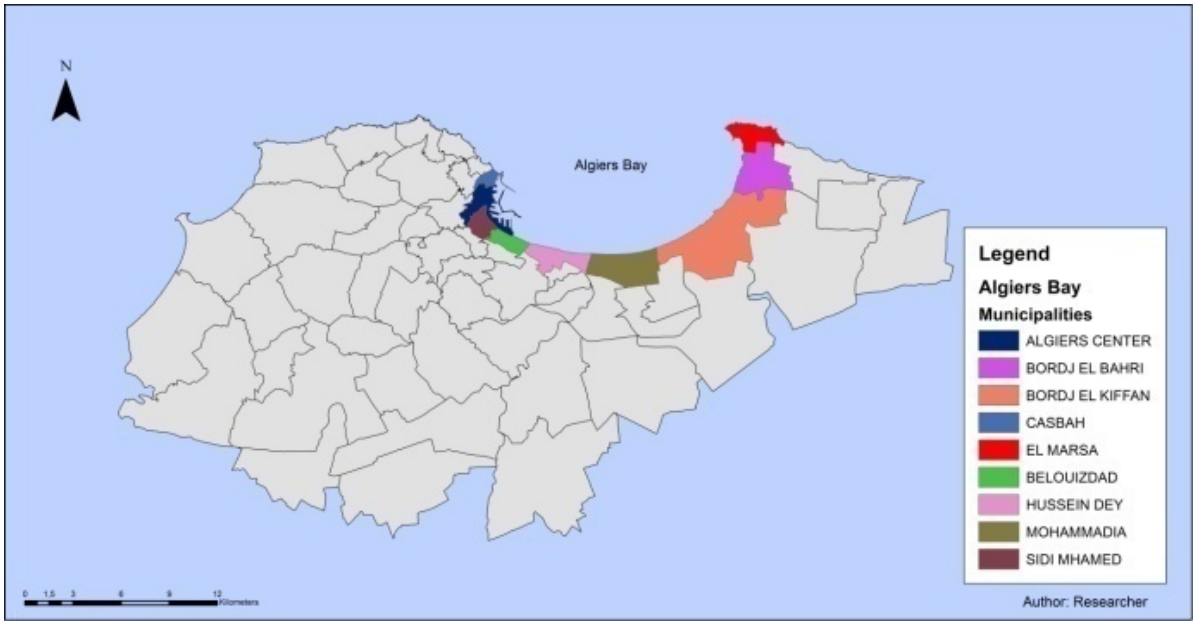


Figure 1. Situation of Algiers Bay

"A statistically significant test of association does not necessarily indicate a causal link between x and Y, but in the case of spatial data there is an additional problem in interpreting an apparently significant measure of association between two data sets" (Haining, 1991, p. 210).

Significance of correlation scores are verified by P value,

P-value is a test for statistical significance (Verhagen, Ostelo, & Rademaker, 2004), it is used to prove that results got are not got by chance. Hence, the null hypothesis is proposed in order to confirm or affirm the significance of correlation results. So, if the null hypothesis is true, outcomes differ only by chance (Verhagen et al., 2004, p. 261).

Verhagen et al. (2004, p. 261) argue that there is always a risk when basing on statistical analysis, even when the null hypothesis is correct there is a chance that the alternative hypothesis is true. This risk is represented by P value. Researches explain that the null hypothesis will be rejected when P value is less than 0.05 (5%), so, results will be automatically significant.

"The fact that P value is almost always set at 5% is one of the points of criticism. Situations can occur in which a 10% risk of an incorrect decision (null hypothesis incorrectly rejected) is also appropriate, or when this must be kept as low as possible and should be set at 1%" (Verhagen et al., 2004, p. 261).

CASE STUDY

This research paper is about the relationship between the MLU and LUC; and choosing Algiers' bay as a case study. The research has been carried out by using GIS tool. This tool helped us to determine and measure each attribute.

According to Huang and Hsieh (2014), GIS provides information that can be used in assessing levels of mixed-land use and land-use compatibility. Hence, it might be seen as a tool leading to manage the urban areas.

Study Area

Algiers' Bay (**Figure 1**) is considered as one of the most important bay in Algeria, because of several variables such as strategic situation, history, patrimony, social and culture, economy and harbor activity (1st commercial harbor in Algeria).

Table 1. Mixed land use Model

	Attributes	Measurement	Scale of measure District level
Mixed-Land use	**Entropy Index**	$H = (-\sum_{k=1}^{n} P_k \ln(P_k))/\ln N$ P: $propotion of land$ area occupied by activity N: $Number of activities\ types$	n=1
	Dissimilarity Index	$D = 0.5\sum_{i=1}^{n}\lvert r_i - s_i\rvert$	n=1
	Herfindahl-Hirschman Index	$HHI = \sum_{j=1}^{k}(100 * p^i)^2$ $p^i = percentage\ of\ each\ land\ use$	n=1
	Atkinson index	$ATK(Y) = 1 - \left[\frac{1}{n^{\varepsilon}\sum_{j=1}^{n}(s_i)^{1-\varepsilon}}\right]^{(1/1-\varepsilon)}$	n=1
	Exposure index	$EXP(x) = \sum_{i=1}^{n} r_i q_i$	n=1
	Residential Land use	Counting (Percentage)	n=1
	Non-Residential Land use	Counting (Percentage)	n=1
	Land use Categories	Counting (Percentage)	n=1

$r_i = propotion\ of\ residential\ area\ in\ i\ area$
$s_i = propotion\ of\ non - residential\ area\ in\ i\ area$
$q_i = propotion\ of\ residential\ area\ in\ i\ area$

Source : Researcher

The study area composed by eight municipalities[1] with 50.55 km², covering 6.25% of Algiers area with approximately 562101 inhabitants, and representing 17.82% of the population of Algiers capital. These municipalities are different in term of surfaces, population number and density, blocks density and land-use categories and proportion of activities in urban areas, social and economic importance.

The proportion of residential activities in the case of Algiers bay varies from municipality to another. It varies between 26% and 96%.

It is important to mention that, the study case' municipalities are divided into 682 districts. Those districts are designed by Algerian authorities. They are different in size, form, and surfaces.

Mixed-land Use Model

The process used for measuring mixed land use was based on two steps:

1. Fixing variables which define mixed land use. This step was carried out through literature reviews in order to fix suitable attributes that define mixed land use. Choosing those attributes is mainly based on the definition of the concept of MLU.

Hence, **Table 1** demonstrate attributes defining MLU, even the way of their measurement.

We needed to mention that we used those attributes to measure MLU.

2. This step was realized by moving from abstract concepts into measured attributes.

In our case, measuring attributes was based on using Algiers' bay database. This operation was done following two steps:

- First, Building a Geo-database based on GIS tools. The Attributes data are constituted through collecting different information about every district in our case of study.
- Second, in the classification of the activities, we went through parcel looking mainly at its function and size (Housing, education, culture, leisure …).

To measure the attributes, we applied the methods explained in **Table 1**.

It is important to mention that measuring MLU was carried out following two steps.

First, dividing every municipality into multiple districts (in our case we chose districts designed by Algerian authorities).

Second, we chose to measure MLU following attributes suggested in **Table 1**. So each district is simulated using those formulas.

[1] Municipalities concerned by this study are: Casbah, Algiers center, Sidi M'hamed, Belouizdad, Hussein dey, Mohammadia, Bordj El Bahri, Bordj El Kiffan.

Table 2. Explanation of each attribute introduced to measure MLU

	Attributes	Definition
Mixed-Land use	**Entropy Index**	Is conceived in order to measure MLU. It takes in consideration the percentage of each activity that exists in the area, so higher ratios of entropy index means greater mixture in that area (Song et al., 2013). This latter explain that this measure is symmetric. He adds that if we suppose that an area contains three land use types which the percentage of each land use is 50%/35%/15%; and another area which had three land use types with the following percentages 15%/50%/35%, entropy Index of the two areas will be the same. Perfect balanced land uses is realized in a solely case, when all land use types have the equal portion. That means that real urban interaction hasn't been taken in consideration.
	Dissimilarity Index	It evaluates if the distribution of different land uses within districts is similar to the distribution of land uses in the whole area (Song et al., 2013). He adds that This attribute could be measure evenness in distribution of different activities in an area. The specificity of that attribute that is takes in consideration the whole area when measuring each district. Hence, each district will be measured regarding to the whole area.
	Herfindahl - Hirschman Index	Conceived for measuring level of land use mixture. It takes in consideration the proportion of each land uses that exist in an area. Higher value of Herfindahl Hirschman Index means less of mixture in that area (Song et al., 2013). Like entropy index HHI will be perfect if all land use types are equally presented.
	Atkinson index	It measures the level of evenness between districts. ε is kept between 0 and 1. When ε approaches to 1, it means that imbalances that reflect extreme scarcity in term of activities were weighted heavily (Song et al., 2013).
	Exposure index	It explores opportunities for interactions between land uses types. It is classified between 0 and 1. So higher value indicates higher mixture (Song et al., 2013). They explain that this attribute depends on the size of two groups willing to be compared, however evenness measures do not. They add that *«Exposure measures are therefore more useful when we have an absolute standard for interaction rather than a relative one in mind. That is, if land uses are evenly represented in all districts, but the percentage of the minority land use is small overall, evenness measures will produce a low one"* (Song et al., 2013, p. 6). Hence, This attribute may produce different results as dissimilarity index. *"Exposure index is most useful when districts are of significantly different sizes. Exposure index would help to account for variation in size across Tracts. When districts are of equal size by design, the exposure index trends to be highly correlated with land use percentage"* (Song et al., 2013, p. 6).
	Residential Land use	The proportion of residential land uses within districts.
	Non-Residential Land use	The proportion of Non-residential land uses within districts.
	Land use Categories	The number of types of land uses within districts.

It is important to mention that formulas presented in **Table 1** are conceived to measure district units.

There is no standard rule to measure mixed land use. Even, most relevant formulas such as entropy index and dissimilarity index were criticized. (Bordoloi, Mote, Sarkar, & Mallikarjuna, 2013) in their work, they find out that entropy index and dissimilarity index have limitations in capturing the characteristics of land use mix observed in the smaller Indian cities

Hence, in this work, those variables were fixed in a way to capture all characteristics of mixed land use basing on recommendation mentioned in the work of (Song et al., 2013).

In order to understand those variables, we found important to explain them in **Table 2**.

Land-use Compatibility Measurement

The steps required for measuring land-use compatibility are:

1. Classifying land use types according to their activity. This operation is based on constituting GIS database of every parcel of our case of study.

Building Land-use Compatibility Matrix. Developing that matrix depends highly on type and characteristics of each activity and its compatibility with surrounding activities (Taleai et al., 2007). Land use compatibility matrix depends also in scales of each activity. There are some activities that are compatible in local level, but incompatible in district or regional level.

The Classification of the degrees of land-use compatibility per order was done following five levels (High Compatible, Medium Compatible, Neutral, Medium Incompatible, and High Incompatible).

Table 3. Land use Compatibility Matrix

		Residential	Industrial	Commercial		Cultural		Religious	Wasteland	Administration	Health			Educational		Hospitality		Leisure		Transport facilities	Security	Military Zone	Port
				District Scale	City Scale	District Scale	City Scale				District Scale	City Scale	School	University	District Scale	City Scale	Stadium City scale	Parks					
Residential		1																					
Industrial		5	1																				
Commercial	**District scale**	1	5	1																			
	City scale	4	5	1	1																		
Cultural	**District scale**	2	5	3	3	1																	
	City scale	4	5	3	3	1	1																
Religious		2	5	1	4	1	4	1															
Wasteland		5	3	5	5	3	5	5	1														
Administration		4	2	3	4	2	2	3	5	1													
Health	**district scale**	1	5	1	3	2	3	3	5	3	1												
	City scale	5	5	2	4	3	3	3	5	4	1	1											
Educational	**school**	2	5	2	4	1	5	3	5	3	2	5	1										
	University	5	5	1	5	1	1	3	5	3	3	3	1	1									
Hospitality	**District scale**	1	5	2	2	2	2	3	5	3	4	4	4	4	1								
	City scale	4	5	2	2	2	2	3	2	2	3	5	5	4	1	1							
Leisure	**Parks**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1						
	Stadium city scale	5	5	2	2	4	4	3	5	5	5	5	5	5	5	5	1	1					
Transport facilities		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				
Security		4	3	4	3	3	3	3	5	3	3	3	3	3	2	2	3	3	1	1			
Military Zone		5	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2	1		
Port		5	4	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	1	1	2	1	

1 High Compatible | 2 Medium Compatible | 3 Neutral | 4 Medium Incompatible | 5 High Incompatible

Source: Researcher basing on experts' opinion

Table 4. Compatibility Levels using AHP Method

Compatibility Levels	Standardized Values
High compatible	0.43
Medium Compatible	0.28
Neutral	0.18
Medium Incompatible	0.08
High Incompatible	0.04

Hence, **Table 3** represents results realized from collecting and analyzing information got from experts (35 experts) concerning compatibility between different activities in different levels. It was realized by forecasting and evaluating the cohabitation of two different activities in the same space.

In order to quantify LUC matrix, Analytic Hierarchy Process (AHP) was used (**Table 4**). This operation is conceived by (Thomas Lorie Saaty) and used by several scholars such as (Forman & Peniwati, 1998; Thomas L. Saaty, 1990; Thomas L Saaty, 2008; Vargas, 1990; Zahedi, 1986). This method helps decision makers to define priorities and opt for the best decision (Masoomi, 2014; Vaezi et al., 2015).

The development of a matrix showing the degree of compatibility was done by relying on the theoretical background and the consultancy of some local well-known experts.

2. Quantifying the degree of compatibility of each parcel depends on neighboring land uses.

In order to evaluate the degree of compatibility level in each parcel of Algiers' bay, Equation 1 was used.

Table 5. Summary statistics for mixed land use and land use Compatibility measures (682 simulations)

	Min	Mean	Max	Standard deviation
Herfindahl-Hirschman Index	0.0000	0.8471	1.0000	0.2455651
Exposure Index(x^2)	0.000000	0.004073	0.350000	0.0209722
Exposure Index (y^3)	0.00000	0.00432	0.98000	0.04061752
Atkinson Index (Y) ε=0.9	0.0010	0.5821	1.0000	0.470551
Atkinson Index (Y) ε=0.1	0.5100	0.9858	1.0000	0.04441478
Dissimilarity Index	0.000000	0.009558	1.000000	0.04320731
Entropy Index	0.0000	0.2285	1.0000	0.3283585
%Residential (x)	0.0000	0.8460	1.0000	0.2741497
% Non-residential (y)	0.0000	0.1592	1.0000	0.8106884
Land use Categories	0.00000	0.09531	1.00000	0.1539415
Land use Compatibility	0.0700	0.3993	0.4300	0.05958414

Source : Researcher

Land use compatibility degree in each district was done using mean value of compatibility degree of parcels present in each district.

Statistical Analysis

Mixed land use and land use compatibility of each zone were mapped and assessed by using GIS tools. Then, measures were compared and evaluated.

Bivariate analysis was conducted using Spearman's Rho correlation coefficient. Correlation test was realized in every zone in order to evaluate Correlation between mixed land use and land use compatibility. Besides, In order to verify significance of results, P value Test was used (P <10%).

RESULTS

After collecting information using urban surveys (dated in 2017) and mapping the distribution of Algiers' bay land uses and finally calculating their percentage in each zone of the study area as it is shown in (**Table 6**) that demonstrates the distribution of land uses of Algiers' bay municipalities. This table shows that the most part of land uses is occupied by residential activities. So, the most important part was located in Bordj El Kiffan (96.02%) and Bordj El Bahri (96.33%) and the smallest part of residential activities were located in Belouizdad (26.49%). The percentage of land uses in Algiers bay differs from municipality to another. For example, security function is higher in Algiers center (20.5%) and smaller in the other municipalities such as Bordj El Kiffan with (0.24%) In addition the big part of industrial activities was concentrated mainly in Belouizdad (18.5%) and Hussein Dey (19.36%). However, it was absent in other municipalities such as Algiers Center, Bordj El Bahri.

Measuring variables was accomplished following steps explained above.

Hence, **Table 5** demonstrates summary statistics for MLU and LUC measures (682 simulations). It contains the minimum value, mean, maximum and standard deviation of results got from simulation of 682 districts using eleven measures. Standard deviation in multiple measures showed small variation, for example, Exposure index for residential land use showed the smallest standard deviation value which is equal to 0.02.

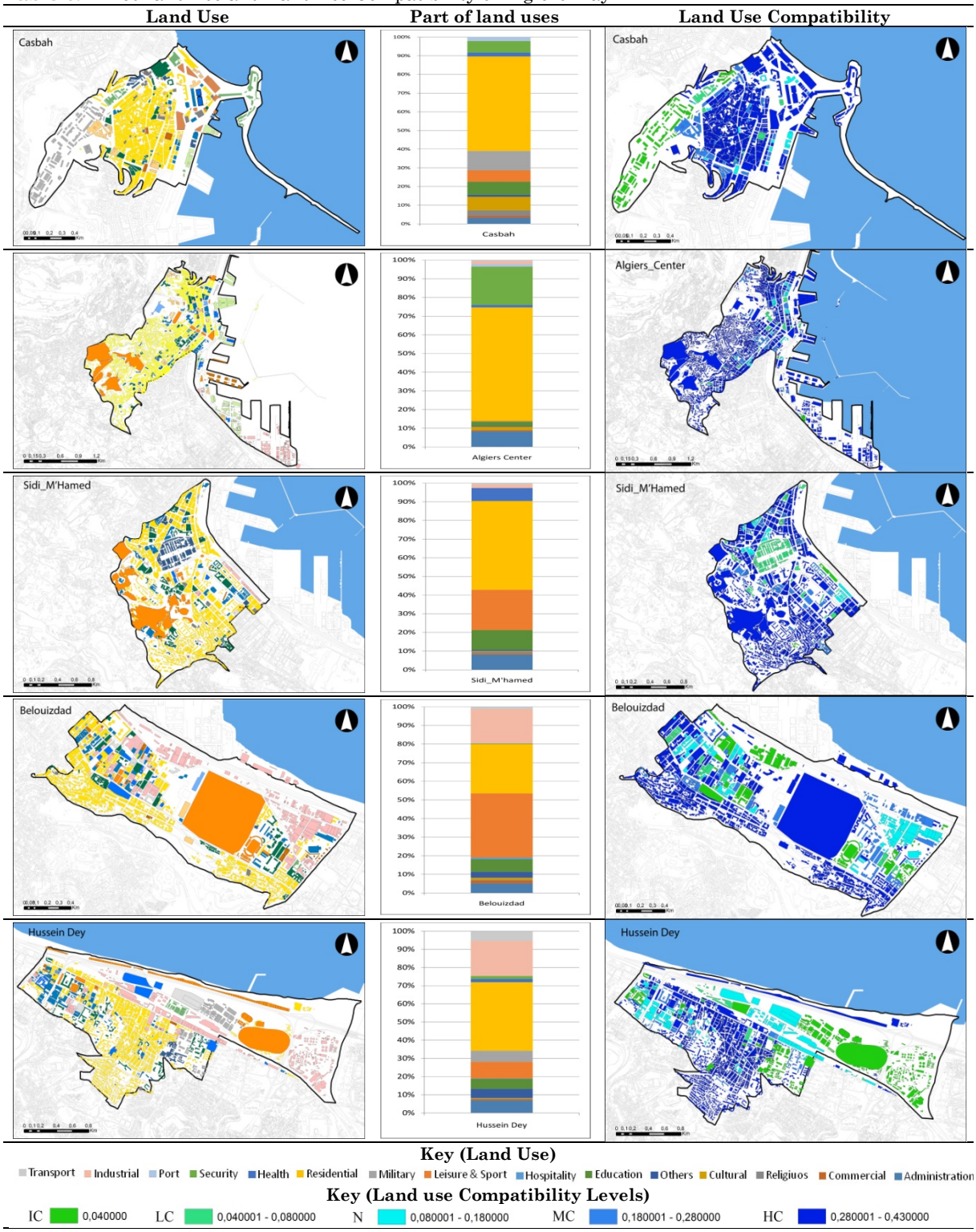
Results got from measuring land use compatibility showed small variation too with (0.05).

In order to analyze correlation between mixed-land use and land-use compatibility, bivariate correlation indices was carried out using Spearman's Rho correlation and Algiers' bay database. Ratios were calculated and embedded in **Table 6**.

[2] (x) residential land use

[3] (y) Non-residential land use

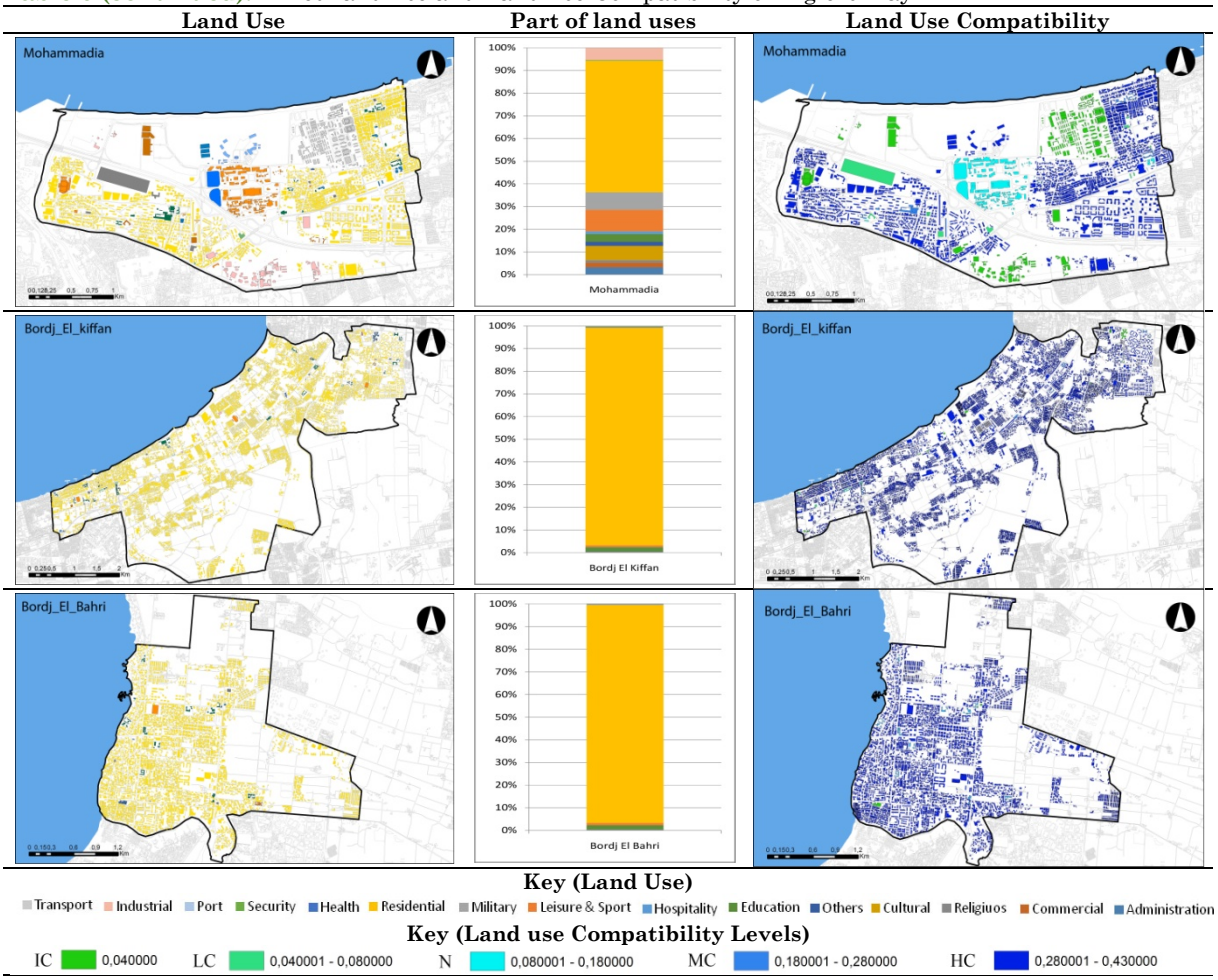
Table 6. Mixed land use and Land use Compatibility of Algiers' Bay[4]



Source: urban surveys (2017)

[4] Maps were realized using ARCGIS Software.

Table 6 (continued). Mixed land use and Land use Compatibility of Algiers' Bay



Source: urban surveys (2017)

Measuring relationship between mixed land use and land use compatibility in District level showed us the following results:

– Bivariate analysis between mixed land use and land use compatibility revealed that there is Strong direct positive relationship between Land-use compatibility and a set a variables such as (Herfindahl-Hirschman Index (+0,635), Atkinson index (+0.631) when ε =0.9, Atkinson index (+0.590) when ε =0.1, residential land use percentage (+0.677)). Moreover, Test of significance (P value) was Significant (p-value < $2.2e^{-16}$) in the case of all variables cited above.

– Bivariate correlation analysis between Land use compatibility and mixed land use revealed that there is strong reverse relationship between land use compatibility and a set of variables such as (Exposure Index for residential land (-0,534), Exposure Index for Non-residential land use (-0,587) , entropy index (-0.612), non-residential land use (-0,612), number of land use categories (-0.618), dissimilarity index (-0.084). Moreover, P value was Significant (p-value < $2.2e^{-16}$) in the case of all variables cited above. However P-value in the case of dissimilarity index, P value= 0.02767 which was not significant (P value superior to 1%).

Table 7. Spearman Rank Correlation between mixed land use and land use compatibility in district level

Correlation between mixed land use and land use compatibility variables in DISTRICT Level		
Herfindahl-Hirschman Index	0.6352848	p-value < 2.2e-16
Exposure Index (x)	-0.5344174	p-value < 2.2e-16
Exposure Index (y)	-0.5875667	p-value < 2.2e-16
Atkinson index (ε =0.9)	0.631641	p-value < 2.2e-16
Atkinson index (ε =0.1)	0.5906147	p-value < 2.2e-16
Dissimilarity index	-0.08431856	p-value = 0.02767
Entropy Index	-0.612727	p-value < 2.2e-16
P residential (x)	0.6773314	p-value < 2.2e-16
P Non-residential (y)	-0.6894568	p-value < 2.2e-16
Land use categories	-0.6189997	p-value < 2.2e-16

Source: Researcher

DISCUSSION

Fortunately, our findings support the hypothesis of this paper; we proved by exploiting Algiers' bay database which was highly useful to study the objective under study, that there is correlation between MLU and LUC.

According to some researches, MLU is related to many factors such as social capital (Nabil & Eldayem, 2015), travelling behavior and sustainability (Bahadure & Kotharkar, 2015; Frank & Pivo, 1994), health (Hajna et al., 2014) and accessibility (Ozbil et al., 2011) and mobility choices (Duncan et al., 2010). Hence, it is our role to prove that MLU could be related to LUC. So, in order to prove that hypothesis, we, first exploited findings of (Song et al., 2013) who try through their work to compare different measures of MLU, by analyzing each measure separately and explain the characteristics of each attribute and finally they get the ability to recommend the appropriate attributes of MLU measurement. Hence, we tried to take in consideration those recommendations in order to build a technical model that includes recommended attributes to measure MLU in a better way. This operation includes comparing results of each attribute in order to extract the nature of relationship between those attributes and LUC using Algiers' bay data base.

Hence, our work showed us two kinds of results. First, because there is no standard model to measure MLU, we suggested a new model based on technical measures done by (Song et al., 2013). This model includes all characteristics of MLU. This model is based fundamentally on numerical scores got from applying numerous formulas in order to assess MLU in urban area. Second, this work showed more details about characteristics of MLU that affects the most the LUC; it contributes widely in the understanding of that relationship and by consequence trying to minimize external alternatives. Also, it may be a new base for further researches for more sustainable urban planning, especially when talking about the case of cities located in underdeveloped countries.

Measuring the relationship between MLU attributes and LUC proved that those results were in perfect coherence with the work of (Song et al., 2013). This consideration was proved by correlation scores and confirmed with P value which was highly significant. However the nature of this relation differs from attribute to another.

Hence, this work pushed us to discover that land use compatibility is sensitive to:

First, the degree of distribution of each land use type presented in the urban area, this conclusion was realized by analyzing the nature of the relationship between LUC and Entropy index and HHI index.

Also, the relationship between LUC and exposure Index explained that land use compatibility may Increase opportunity for land use interaction.

Moreover, Analyzing that relation using Atkinson Index, explained that LUC may be sensitive to the level of evenness in land use distribution within districts, so increasing level of evenness may decrease land use compatibility in urban area. Finally, we need to mention that in the case of Algiers bay database, opting for more residential land use lead to get a high land use compatibility degree in urban area.

The importance of those results resides in the analysis of an important number of samplings (682 samples in Algiers bay municipalities) and confirmed by significance test (P value) which was highly significant. Hence, it lets us to confirm that is possible to get the same results in the case of other urban spaces especially when talking about the case of Algerian cities. However it maybe not the same results when talking about other

countries, because in this work we took in consideration the opinion of Algerian experts who took in account the context of Algerian social and cultural aspects of Algerian society when evaluating compatibility between different land uses in urban space, maybe this vision will be different when talking about another city in another country.

It is important to mention that MLU model couldn't include Clustering index (CLST) which seems to be interesting in analyzing another characteristic of MLU regarding LUC. It was difficult to do this because of the lack of some information in our database.

This work tried to present a new model; it is known that there is no standard method to measure mixed land use. So, many researchers tried to measure it with their own point of view. In this article we were based on creating a model that measures mixed land use using technical formulas that we judge complementary because it fulfils different characteristics of mixed land use. Hence, this model could be applied easily in the case of other cities.

This work proved that there is correlation between mixed land use and land use compatibility, however, it couldn't prove which degree of mixture that is the best for better land use compatibility.

Hence, this work presented a new research that treats factors that affect mixed land use. It is proved that mixed land use could be affected by land use compatibility and vice versa. Hence, our findings will play a great role in promoting land use literature review in the way to build more sustainable environment.

CONCLUSION

Mixed land use is still one of the most recommended indicators for successful urban planning, and urban regeneration.

Mixed land use may play a great role in solving urban problems such as pollution, over consumption of lands…etc. however, it could also, play a negative role on land uses performance.

This study believed that mixed-land use is sensitive to land-use compatibility and vice versa. Hence urban analysis of land use compatibility needs to be included in urban planning considerations in order to minimize external externalities. This operation maybe more operational when taking in consideration all attributes of MLU that could affect LUC.

Our findings contributes in one hand, in creating a technical model for measuring mixed land use by taking in consideration different measures that threat different characteristics of mixed land use. This model is conceptualized based on recommendations of (Song et al., 2013), and in the other hand, creating more valuable and more performed urban space by hindering negative externalities. It could play a great role in creating more sustainable urban areas. Practically, it contributes in creating a balance between characteristics of MLU and characteristics of LUC such diversity, level of evenness, and distribution of different land uses even opportunity for interaction between two land use types) in order to minimize negative externalities and create more performed and more sustainable urban areas.

Hence, we recommend that decision makers take land use compatibility in consideration when applying mixed land use Policy.

In our knowledge, there are few works that study the relationship between mixed land use and land use compatibility. This study helps to open doors to more consistent studies about the correlation between mixed land use and land use compatibility. It is by the way important to seek the best mixture for a best compatibility of land uses and the part of each activity implicated in that mixture.

Disclosure statement

No potential conflict of interest was reported by the authors.

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