

## RESEARCH ARTICLE

# CONSERVATION OF EKISTICS-BASED URBAN FORM: CONTROLLING AMALGAMATION OF TWIN CITY GROWTH PATTERN

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## ABSTRACT

This paper analyzes the amalgamation of two different urban forms in the context of twin cities and their conservation according to the contemporary approaches. Despite high interdependence and close connectedness of Islamabad and Rawalpindi as its twin city in Pakistan, their urban forms weave inverse physiognomies, which is vulnerable to amalgamate due to the conurbations process. Both city were conceptualized as "Dyna-metropolis" by Greek architect C.A Doxiadis based on ekistics determinant but deteriorated due to governance issues. The methodological approach for conservation outlines the criteria that protect the future controlled growth and quality to human life, which is not possible through a static form of the old city. Therefore, the adopted method examined Islamabad on two scales like micro (neighborhood-scale) and macro (city-scale) through analysing existing literatures, maps, photographs, case studies and questionnaires to identify the causes of diversion from original Ekistics variables such as modulus and dynapolis. This study argues that conservation is significant not only from the theoretical perspective but also because Islamabad is the first large-scale application of ekistics, designed as 'city of future'. This study identified several challenges hindering urban development such as rapid urbanization, demand and supply gap of housing, Unaffordable land value, imbalance of ekistics elements and less mix use. The solutions are proposed through the revision of the ekistics logarithm scale for modulus and a new dimension to dynapolis. Finally, if the conservation method is not proposed at the right time, it will not only produce adverse effects on the physical morphology but also affects sensitivity to the science of human settlement.

## KEYWORDS

Urban form; Amalgamation; Islamabad; Ekistics; Conservation.

## 1. INTRODUCTION

Human settlements always follow a physical pattern based on demand, technology, and constraint, which produced urban textures and congregate it into a single canvas known as an urban form (Costa and Lee, 2019). Since centuries urban form is used to interpret the ideas behind physical patterns of the past cultures, it reveals the 'determinant' behind the particular form, for example, ruins of Indus valley civilization reveal 'egalitarian society' centered around Indus basin irrigation system (Morris, 2013; Sarker et al., 2020). Similarly, some cities survived and agglomerate along with their determinants, for example, Buda and Pest in Hungary. In modern urban terminology, they can be called twin cities of a past, that existed in close proximity's but their urban form conflates holistically into one, transforming their identity (Williams, 2014). This situation develops a hypothesis over a very unique case of Islamabad and Rawalpindi, susceptible to lose their urban form because they improvise an exceptional case to the urban planning in terms of history, geography, culture, and economy (Khan, 2005). The reason can be found in the determinant of Islamabad site selection, it was positioned next to Rawalpindi as a twin city (Lovejoy, 1948).

In the urban development context, Rawalpindi urban form develops through basic determinants of 'trade', showing a bottom-up approach with organic urban form (Khan, 2011). On the other hand, Islamabad is a result of the top-down approaches that reflects in its gridiron urban form. The basic determinant for its urban form was ekistics and dynapolis. Doxiadis saw it an opportunity to apply his Ekistics theory at neighborhood formation and concept of dynapolis for its future controlled growth of twin cities (Wu, et al., 2018). Initially, the growth was somehow executed according to the original Master plan but recently it is observed that Doxiadis theory of Ekistics in the development of the new sector is reoriented (Farizkha et al., 2019). Specifically, at the amalgamation node of twin cities, the urban form of the old city is found to be more influential, as it provides the opportunity of mix-use compact development for people affecting the ekistics-based grid-iron urban form besides imbalance between ekistics elements (Shafi et al., 2020; Ahmed, 1992). The dilemma began due to poor understanding of the current need and non-collaborative action between administration authorities of twin cities (Maria and Imran, 2006). Although until a few decades ago there was a

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balance between urban development and population growth but recently, the growth of the services industry drastically increases the population of Islamabad industrial areas from sector I-9 to I-17 (Shafi et al., 2019). The most precarious factor was cheap private housing societies without the ekistics concept, at a very reasonable price which is somehow good but holistically, it is a probing situation from Doxiadis 'Human dimension' point of view.

Apart from damage at micro-scale (Modulus), one more reason behind fractured ekistical form is its deflection from the macro-scale (dynapolis) concept, apparent in the form of twin city growth pattern. This imbalance between functions of the Islamabad city core (city-scale) with the twin city (regional-scale) reference is a failure of Dyna-metropolis. It is evident in uncontrolled arbitrary sprawl of twin city networks, away from proposed dynamic centers. In conclusion, after conducting the detailed research survey a probing situation for Islamabad is found that it is growing as a dispersed city with a high dependency on the car; less population density; less mix-use and poor network of transportation (Williams, 2014). This research is questioning about the possible reason for fractured ekistics (Modulus, dynapolis & Dyna-metropolis) concept on three scales; neighborhood, city & regional-scale and proposing a solution to control dispersed expansion & amalgamation through the methodology of micro & macro-scale analysis that can conserve ekistics; specifically, the systematic human settlement (Farizkha et al., 2019).

## 2. RELATED LITERATURES

For centuries, the origin of urban form always influences the city growth than any other aspect of urban design. In different development periods, the urban form has been transformed swiftly according to the need of human settlements (Muminović et al., 2020). The transformation was caused by several forces, of which the most significant are geography, economy, society, politics and technology. These forces shaped planned (grid-iron) or unplanned (organic) urban patterns, depending on settlement's comprehension to planning but after large scale destruction of WWII, the most rapid phase of urbanization occurred, dominated by a new force of 'instant redevelopment' that highlighted the vulnerability of urban form amalgamation at regional-scale, further limit centers static to grow (Middleton, 2009; Cao et al., 2019). Hence, this new force demanded a systematic investigation in settling human (Dix, 1985).

In recent decades, the widespread recognition and appreciation of architectural heritage, combined with the increasingly nuanced ways of defining, maintaining, preserving and presenting it, has greatly increased the scope of historical urban landscape planning and management (Huda et al., 2019). It is obvious that a time of immense complexity imposes the need to consider multiple potential patterns of preparation that could be adapted to change continuously. Many cultural heritage communities face problems such as declining prices of real estate, economic downturns, and leaving the city (Muminović et al., 2020). It is necessary to continuously change the approach and practice in order to sustain life in historic urban landscapes, since the preservation of historic urban landscapes today goes beyond the conventional sectors identified in the economic, social and political systems.

Mismanagement also has significant consequences and not only risks the loss of a valuable architectural heritage, but also also undermines the local community's socio-economic growth. At present, cities, including their historic urban environments, are the subject of economic, social and cultural activities in which new projects and ideas are generated through a diversity of interactions (Kowalczyk et al., 2019). Historical urban landscapes need to be revamped in order to preserve their vitality through a planning approach focused on modernization, adaptation and regeneration, while preserving entire complexes, or at least individual buildings, that give the city its character, its identity and its competitiveness. For these reasons, new strategies must be established that can predict the complexity of change and establish an appropriate forum for growth and preparation to function in a new, dynamic environment (Costa and Lee, 2019).

These forces are also termed as determinants. The determinants are very useful in finding the root of urban form characteristics and their development period. Sometimes it is an amalgamation of more than one determinant based on settlement's need and available resources (Newman and Hogan, 1981). On a regional-scale, the available network of infrastructure and its future flexibility of conurbation is a key in deciding pattern between two cities (Constantinos A. Doxiadis, 1970). The flexibility of conurbation demands an understanding of the desired population density to avoid static growth. Here it is important to note that city growth is unavoidable; what matter is an efficient layout with precise mobility because it is the time of traveling which matters rather than distances (Constantinos A. Doxiadis, 1962).

In the evolution of new human settlements, arising from both planning and spontaneous circumstances, the social and spatial structures of any given region play important roles. In terms of features and management, these meanings are interrelated to the point that each system influences the other. Planning is consistently described as a political driver in the science of land-use change (Muminović et al., 2020). A large number of public and private actors have to deal with the establishment of a polycentric urban area as an actor, all having their own priorities and desires and also having differences in practices, culture and control, perceived and actual. The degree to which human activities impact the environment is primarily determined by the natural value of local habitats and the destruction of them.

In areas characterized by high natural value and severe destruction, the most serious conflicts can be expected (Huq et al., 2020). To reduce the likelihood of social conflict, road planning includes comprehensive awareness campaigns, which greatly hinders and delays decision-making and development (Costa and Lee, 2019). It is important to convey the relevant information not only to the owners of land directly affected by the highway or in the immediate vicinity of the proposed route, but also to all members of the local community. During development and service, local residents are mostly affected by the adverse effect of the road on the local landscape and climate. In order to provide all stakeholders with accurate information about the nature and environmental impacts of road transportation projects (Kowalczyk et al., 2019).

Considering efficient layout with precise mobility, Doxiadis proposed the concept of Dynapolis, that orient around a 'dynamic city center' and expand in uni-linear direction to avoid the vulnerability of congested static center (Coccosis, 2004). He assured that as a building consists of several blocks, hence the city also consists of a basic block called 'Modulus', similar to what people understood by the term 'neighborhood' or superblock. Moreover, this 'Modulus' was systematically organized through a hierarchic structure of human communities, each defined through the scale of their central functions from a community of class I to V. Holistically, Doxiadis weaves the integration of his three basic urban scales, Ecumenopolis, Dynapolis and the Modulus, by a basic conceptual framework of ekistics logarithm scale (Lynch, 1954).

He expanded the Geddes idea of 'Live, work & play' through five elements; nature (ecology), man (anthropology), society (sociology), networks (transportation), and shells (architecture). The relationship between these 5 elements was conceptualized through the ekistics logarithm scale (ELS). He established ELS through history; that traditional society kept the optimum size of 50,000 people considering human dimensions that physically, everyone is at a 10-minute distance from the centre of the neighbourhood. The classification of ekistics in terms of communities (from I to XII), is based on kinetic fields of Anthropos, allocating grid a-g for pedestrians and A to H for automobile (Muminović et al., 2020).

## 3. METHODOLOGY

### 3.1 Methodological design

In response to the research problem and subsequent literature reviews, a framework to avoid amalgamation is needed because amalgamation exacerbates the origins of urban forms due to uncontrolled growth (Naveh and Lieberman, 1990). Therefore, a mixed research methodology to

identify significant origin is derived to address research questions. It compares the methods adopted by other authors in the conservation of urban form and expounds the reasons for choosing the current method. Since conservation is a process of emphasizing human values and passing them on to future generations (Kareiva and Marvier, 2012). It demands a systematic approach to preserve these values (Margules and Pressey, 2000). To conserve the urban form of any city, different methods are required to analyze, implemented by previous authors. The first step is to understand the urban form of the city itself; through clear analysis of city structure, The results are normally apparent through the figure-ground method of dissection (Lynch, 1954). Conservation desire to bridge the gap between intentional figure-ground configuration with existing urban form (Hu, 2014).

As the urban form is a reflection of the historical development of the city, its conservation demands analysis of its historic-geographical structure or its origin (Whitehand and Gu, 2010). Some method for conservation of form is explained through the direct observation of settlements features, ranging from the smallest detail of dwelling unit to the morphology of an entire town. The comprehensive apprehension of this process layouts a framework for conservation priorities (Whitehand and Morton, 2004). However, small effort has been done for conservation at regional-form, due to the large domain of research (Larkham, 2006). Most often conservations are carried out at 'micromorphology'-scales such as small historic town or buildings (Whitehand, 2007). Following the above statement; as ekistics-based urban form relies on two-scales, ranging between modulus & dynapolis; its conservation method will also be based on two-scales; 'Micro' and 'Macro'-scale analysis and subsequently over regional-scale, because both cities were designed as Dyna-metropolis (Doxiadis, 1962). Subsequently, the scope of conservation in scholarly domain is mostly confined to historic towns or buildings; Larkham defines criteria of holistic conservation through the 1971 Act and the principal guiding circular which describes that an area, retaining unique architectural and historic significance; or whose character and morphology is desirable to preserve; or presumably any combination of these is justifiable to conserve (Larkham, 1996).

Since the ekistics is a revolutionary idea that provided a controlled growth and quality to human life and is strongly associated with the psychology of local people. Therefore, it is an unfortunate situation to allow deterioration of ekistics-based urban form due to amalgamation (Banerjee and Loukaitou-sideris, 2012). It will also support the old city considering its historic value and cultural significance, otherwise, urban forces may also deteriorate it with time. Conclusively, as the research is unique in a twin city context, therefore after reading previous methodologies; a new methodological flow is derived, in relation to the research problem; described through the following steps.

1. Finding out the origin of urban form.
2. The way it was conceived, altered or adjusted in the period of its growth
3. Setting out the Criteria.
4. From an urban designer prospect; which city determinant, satisfy the controlled growth prospect to avoid amalgamation and at the same time provide quality to human life?
5. Conservation of the principle and elements of that philosophy or idea, integrated with contemporary solutions; ensuring social, economic, and physical viability (Naveh and Lieberman, 1990).

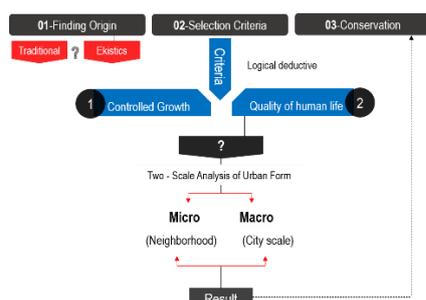


Figure 1: Methodological approach process

### 3.2 Origins of Twin Cities Urban Form in Pakistan

Based on the methodology, in case of twin city, one of the city have to be revitalized, that satisfy the futuristic growth and quality to human life criteria. The determinant of Rawalpindi was found to be based on trade initially, which derives its traditional or Islamic based urban morphology. Residential area (Mohallas) and bazaars (Mall roads) define neighborhood at inconstant flexible scales (Whitehand and Morton, 2004). These neighborhoods are dissected by bazaars which consist of communal space for trading (Chen, et al., 2020). The residential streets are short, narrow and walkable in the form of Cul-de-sec, enabling the dwellers a sense of protection, Whereas Islamabad determinant is based on the ekistical concept where Man (Anthropos) is a measuring tool for neighborhood dimensions and multiplication of its 2 Km X 2 Km neighborhood (Modulus) around its dynamic center is a measuring tool for its future growth (dynapolis) (Sawas et al., 2013; Khan, 2011). This results in two different determinants that exist nearby, with some similar spatial morphology such as cul-de-sac.



Figure 2: The Visible Cul-de-sec in Rawalpindi and Islamabad urban form

### 3.3 Controlled growth and quality to human life

Spatially, in the 1960 Master plan of twin city, it was conceived to grow in a similar way as Islamabad dynamic center with the same Modulus concept but Rawalpindi urban form with its static center does not allow it to grow like Islamabad's urban form. After analyzing the origin of two cities, it is found that Islamabad's ekistics urban form is supportive of future controlled growth and quality of life but due to diversion from dynapolis as well as Dyna-metropolis concepts both cities came to the point where they desire independent growth of urban forms (Banerjee and Loukaitou-sideris, 2012). This is because of the gap that exists between theory and practice of urban design. The original plan of the Islamabad-Rawalpindi metropolitan area was overambitious since Doxiadis misread territorial governance by perceiving a holistic approach to twin cities (Figure 3).

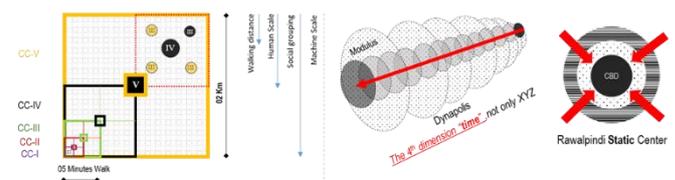


Figure 3: Dynapolis: A city with infinite 'uni-directional center'.

## 4. FINDINGS

From the birth of twin cities, the spatial structure of ekistics concepts has been significantly altered due to rapid arbitrary growth, especially at the amalgamation patch of the twin city. It is a vulnerable situation for the Anthropos because ekistics measure success of settlements according to the efficient human dimension, and recently the pressure of population influx and urban forces from Rawalpindi have compelled Islamabad to follow its inefficient static organic urban form in the modulus (Figure 4). The fractured form is due to Doxiadis dependency on 'automobile' at city-scale and low-density development at Modulus-scale. Both factors contributed to dispersed growth. Therefore, the main research results are as follows:

1. Failure of dyna-metropolis concept & subsequently dynapolis concept
2. The low density of Islamabad set according to the ekistical Logarithm scale.

4.1 Challenges at City-Scale

Today the urban form of Rawalpindi with a population of 1.7 million inhabitants, presents an agglomeration of three towns, i.e., a traditional form in the middle, a colonial form in the southeast, and modern suburbs form in the north-east (Figure 2). Due to dissimilar determinant and urban patterns; the population influx from Rawalpindi is forwarding a serious threat to the new sectors of Islamabad especially the I and H sectors. The difference in urban pattern is due to Anthropos of different socio-economic and socio-cultural background (Chen et al., 2020). Moreover, the dynapolis concept of Islamabad could be successful and would never need Modulus conservation if; Islamabad-Rawalpindi are still treated as Dynametropolis. From the time when Dynametropolis concept collapse, government have recently established a bus rapid transport system (BRT) to connect two centers for commuting of people which have transformed the twin city holistically as one city.

The twin Cities are constant in size but dynamic in population, so this diverse interdependence requires more housing and infrastructure needs, based on the influx of people from Rawalpindi. Moreover, this pressure comes not only from population inflow but also from the theoretical framework of Ekistics; Because Doxiadis has set its limited housing infrastructure at modulus according to the Ekistics logarithmic scale (ELS) (Middleton, 2009), due to which Islamabad began to expand in arbitrary direction instead of following dynapolis concept (Figure 4) (Chen et al., 2019).

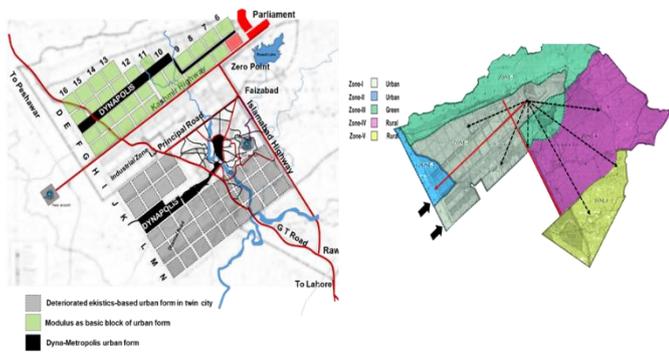


Figure 4: Dynametropolis Concept & Dispersed Growth (Doxiadis, 1970)

After the search of affordable housing, people started to disperse far away from dynapolis and considering this dispersed growth the authorities integrated rapid transport system in the urban form to connect two ends of the region. But later it raises another problem that this transport system was not accessible by most needed residential neighborhoods, which is why most of the dwellers do not prefer the BRT, instead they prefer private taxi system (Pyla, 1994). The response from the citizens indicated inefficient integration of the existing private bus system with BRT. Hence recently, it is not working as a replacement of dynapolis. Also, the I-series of Islamabad that acts as a buffer between twin city is mostly occupied by lower to middle-income residents and most of the new population desire to find a house in this series, if the BRT is linked with the amalgamation patch, its maintenance cost and efficiency concerning the growth of the city will be more successful (Kamruzzaman et al., 2019).

Thus, strategically, the Asian development bank BRT proposal seems better suited to dealing with uncontrolled growth in the south-west (Pollalis et al., 2014). For example, while analyzing the G-6 sector (modulus) and BRT connectivity with it, the analysis results show that BRT is located near the commercial belt where the high-grade government employees and commuters exist. Most of the lower-income people are living in G6-1/1 sub-sector about 2 km far away from BRT. Moreover, the existing private bus system is not in-link with BRT. People need to walk a minimum of 10-15 minutes to approach BRT, that's why people still depend on the automobile and their daily individual commuting from home to work puts pressure on the city center (Yang, et al., 2020). Hence, the dynapolis theory by Doxiadis which was a response to the static growth of past theories will now soon become the static model again, considering this situation.

4.2 Problem at Neighborhood-scale

This rapid urbanization has changed the spatial structure of Modulus, especially at the node of twin city, Anthropos of Islamabad have been seriously affected, as they had more rational infrastructure in the past for ekistics elements (Table 1) (Sajjad, 2015).

Table 1: Inter-relationship of Ekistics principle and elements in Islamabad		
Principle of Ekistics	Elements	Description
Men's Protective space	Shell	Walkable community from CC- I to III
Maximum Men's potential	Society	Systematic Hierarchy of community I, II, III, IV and V
Minimum Men's effort	Network	Square grid for efficiency (Machine-scale)
Men's relation with Nature	Nature	Integration and preservation of blue-green corridors

This is due to rawalpindi's relatively high population density which has put pressure on Islamabad's infrastructure, such as the foundation of Bus Rapid Transit (BRT) system linking the two centres (Lovejoy, 1948). The pressure is not limited to city-scale but it has intervened into the neighborhood and modulus of the city and fractured the ekistics grid at modulus scale due to imbalance of ekistics elements (Figure 5). Therefore, it needs to be protected, optimized and integrated according to the theoretical requirements.

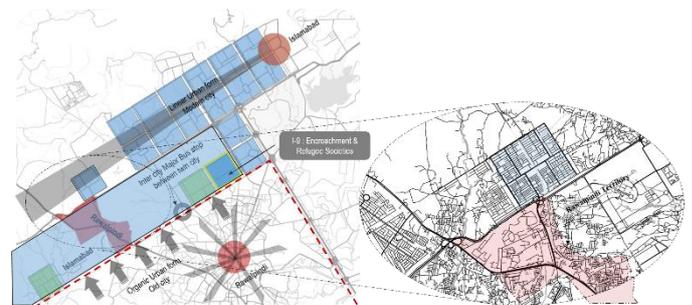


Figure 5: Amalgamation patch of Twin city

During spatial phasing of ekistics-based urban form, Doxiadis emphasizes dynapolis as the heart of the city and principally focused on the macro-scale expansion of the city that was oriented around multiplication of modulus around dynapolis center (Figure 6). At the modulus-scale, the ekistical Logarithm scale by Doxiadis specify population density of 50,000 people, with horizontal mixed land use rather than vertical mixed land use. Due to the development away from the central city, the horizontal expansion deformed the modulus morphology (Kreutzmann, 2013).



Figure 6: G-6 Sector (Modulus): The First Sector Designed According To ELS

Furthermore, in the recent development of G-6 (Modulus), human settlements are in imbalance state according to ekistics principles. The 'Network' of both dynapolis and modulus has been altered without considering the ekistics principle. Even well-paid government employees live in small rooms just to get in and out of the city centre (Zölch et al., 2017). There is a dire need to add vertical dimension in Modulus development so that hierarchical order can be maintained and in the same way the urban form (Figure 7). Moreover, housing prices in amalgamation areas are likely to rise further due to housing shortages, making it

unaffordable for low-income groups (Alam et al., 2019). Already authorities have officially declared the shortage of 60,000 housing units, as a result, some proposal of affordable housing in sector-I was presented by CDA (Wazir and Goujon, 2019).



Figure 7: Diversion from Center planning of Modulus in new development

4.2.1 Case of I-9 Sector (Modulus)

The entire I series of Islamabad is likely to merge in the future, so in order to analyze the ekistics principles and limitations of ELS, sector I-9 was

selected as the case. The average plot size of government housing in Islamabad are categorized through letters A to I, that respectively grow low to high according to the grade of government officials. Specifically, In sector I-9, the Category C, D and E are allotted to low middle income according to their salary status (Sawas et al., 2013). For example, Category-E apartments are for grade-18 & above, it has 6 blocks and each block contains 8 DU, with a minimum of 2 cars (Figure 8).

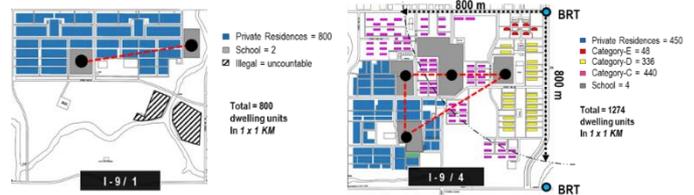


Figure 8: Category of Housing in I-9 / 4 Neighborhood

The Land values in the area have increased significantly in recent years due to the integration of the Bus Rapid Transit system (BRT). But given the inconsistencies in its form, the benefits of BRT peripheral development need to be taken advantage (Table 2).

Table 2: Characteristics of Ekistics in I-9 sub sectors

Ekistics Principle	Existing synthesis of Ekistics elements and principle in I-9
Optimization of Man's Protective Space	Doxiadis designed community-III as a walkable community for the privacy & protection of humans. Whereas; This principle is deteriorating because of inadequate public transport and reliance on cars. People prefer private taxi services, which provide home pickup and increase the vehicular traffic flow within the local streets. This regular flow of traffic reduces community social interaction and awareness of child protection. Hence the hierarchy of good & safer public transport is required.
Maximization of Man's Potential	According to this principle, man has to increase his potential interaction with Nature, Shell, Society, and Network whereas while analyzing the two sub-sectors it was found that both sectors were planned without the concept of compactness & mixed-use. The 'I-9/1' is dedicated to single unit private residences and just beside its periphery, another human settlement in the form of encroachment is found. Holistically, the interaction of man with other ekistics elements is not constant, reflecting the characteristic of amalgamation.
Minimization of the Man's Effort	Population density has dramatically increased (Maria & Imran, 2006). With this growth; The number of motor vehicles and parking problems also arises. Subsequently, as per capita income and liquidity needs increase; An additional parking space will be required, which will affect the housing site. Therefore, in order to minimize human efforts, coordination between man and machine is needed.
Optimization of the Man's Relationship with His Environment	As per the hierarchy of communities, Doxiadis proposed parks, dedicated to each community class-II to increase the interaction of man with his nature. Most of the theme parks in the I-9 sector lacks the qualities of the park and Well-designed green elements. The families living in the surrounding area are rarely seen in these green spaces, intended for the interaction of man and his environment. The existing predefined parks of the I-9 sector intensively need to be well designed.

The result declares that it's not the fault of Ekistics' overall theory. The Ekistics principle is still applicable for the success of any settlement, only the limitation set through the linear axis of dynapolis and ELS of modulus is creating a problem. If these two variables of ekistics theory are revitalized, the idea of human settlements can be conserved (Theodosis, 2015).

5. DISCUSSIONS

5.1 Considering Concept of Dynapolis and Modulus Urban Form

Earlier to 1930, the urban form of old Riyadh was similar to Rawalpindi. The morphology was identical to any Islamic cities (Budiarto et al., 2016). However, similar to the rejection of Rawalpindi urban pattern while planning Islamabad, based on its inflexibility to handle future controlled growth. The Riyadh old city form was also rejected considering future controlled growth. Therefore two-scale flexibility in urban form was carried out by Doxiadis Associates from 1968 to 1972 (Frantzeskakis,

2009). Subsequently, the Master plan of Riyadh had been revised 2 times until the 1990's by SCET and ADA whereas Master plan of Islamabad which was designed 8 years before Riyadh, is never been revised since the 1960's (Aina et al., 2013). Although ADA unintentionally conserved the outer form of Modulus for benefit of efficiency and replaced dynapolis idea to connect city far away from centers, but it was not intending to conserve ekistics-based urban form. Hence the following conclusion can be drawn from the Riyadh case:

1. Dynapolis was a great response to controlled growth of the city but its linear rigidity restricts expansion of cities, hence TOD can provide flexibility & connectivity to the city's future controlled growth at city-scale.
2. TOD appears as a justified response to dynapolis but to integrate TOD with Ekistics, the thorough comprehension of TOD in relation to Islamabad existing BRT is necessary therefore the first model of TOD in Curitiba, Brazil is chosen to support feasible TOD development and estimation of the population at modulus-scale.

**5.2 Considering Concept of Ekistics Logarithm Scale for Modulus**

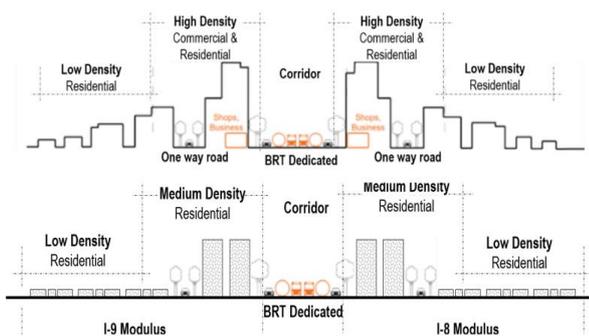
To apply TOD for restructuring Islamabad dynapolis, a feasible study of TOD through BRT is required. This can justify the number of people living in Modulus and support the revision of ELS according to this modern concept (Dix, 1985). However, TOD through BRT requires certain criteria for analyses that will justify this integration as feasible. For this study case, the key factor is to extract; how many people will live around standard catchment area set by ITDP, that recommend certain minimum guidelines to achieve maximum points of TOD (Newman and Hogan, 1981). Here it is important to notice that TOD development all around the world is achieved through fast trains system (Zhou et al., 2020). Moreover, it was found that is I-8 and I-9 sector are the only modulus where BRT is connected to amalgamation patch. From the self-analysis and several other in-depth studies, it is revealed that there are around 2000 DU in 2 km<sup>2</sup> area of I-9/1 & I-9/2 sector, that means 10 DU per hectare (Table 3).

Table 3: Islamabad and Curitiba BRT minimum Comparison		
Specifications	Curitiba , Brazil	Islamabad, Pakistan
Passengers / hour / direction	10,000	10,000
City population	1.9 Million	1.015 million
City average density / sq. km	4405 person / sq. km	3872 person / sq. km
House hold size	03	06
Catchment area	93 DU/Ha i.e. 279 people/ha	10 DU/Ha i.e. 60 people/ha

Here, the key factor while proposing TOD in the future development of Islamabad is the average household size of Pakistan because in Islamabad context 279 people/hectare can easily be achieved by allocating only 46.5 Du/Ha since the household size in Pakistan is '6' as compared to Brazil where household size is '3'. The number of existing people around BRT catchment area in both cases are calculated through the Table 4.

Table 4: Existing Population Pattern in 2 X 2 Km of Curitiba & Islamabad		
Calculation Factors	Curitiba BRT Catchment area	Islamabad BRT Catchment area
Number of DU	93 DU/Ha	10 DU/Ha
100 Ha= 1 Sq.Km	9300 DU/Sq.Km	1000 DU/Sq.Km
Catchment area	9300x(3) =27900 People / Sq.km	1000x (6) =6000 People / Sq.km
In Modulus	27900x4=111600 People / 4 Sq.km	6000x4=24000 People / 4 Sq.km

In Curitiba case, TOD development demands high-density mix-use development for maximum utilization of land adjacent to BRT station (Figure 9), whereas in Islamabad BRT. Modulus restricts even medium-density mix use development. Indeed all of the modulus are mainly occupied by residential land use.



**Figure 9:** Sectional Profile of Curitiba & Islamabad BRT development

According to the Ekistics logarithm scale (ELS), modulus was planned with a scale of 50,000 people. Even If modulus is calculated with its full capacity of dwelling units, as intended by DA. The results show that it will be still lesser than Curitiba (Table 5).

Table 5: Existing Average and Planned Modulus Population for Number of DU		
Calculation Factors	Existing BRT Catchment area	Planned Modulus by DA
Modulus	6000x4=24000 People/ 4 Sq.km	12500 x 4 =50000 People/ 4 Sq.km
100 Ha= 1 Sq.Km	1000 DU/Sq.Km	2083 DU/Sq.Km
Number Of DU/Ha	10 DU/Ha	20.83 (21) DU/Ha

Therefore considering the above table following conclusion can be drawn for ELS of modulus:

1. There is a need to add mix use development along with residential land use.
2. There is a need to increase the number of dwelling unit according to existing condition of amalgamation patch as well as utilization of BRT according to international standards.

**6. RECOMMENDATIONS**

Doxiades himself explained in his book that 'for increasing population density we need sufficient infrastructure to survive' (Doxiadis, 1965). Recommendations are established on findings of Islamabad case; which clarified that framework of ekistics-based urban form is affected at two-scales, hence the integration of TOD with land use reconfiguration is recommended. It allows CDA to control organic development of modulus and provide entirely efficient mixed-use housing infrastructure (Table 6).

Table 6: Problems Found in Ekistics-Based Urban Form at City and Neighborhood-scale			
Scale	Determinant of Ekistics-based urban form	Findings	Causes
City	Dynapolis	Growth away from dynamic center	Rapid urbanization
			Demand and supply gap of housing due to increase in population density
			Unaffordable land value
Neighborhood	Modulus	Fractured Ekistics grid	Low density of Islamabad, set according to ekistical logarithm scale.
			Imbalance of ekistics elements.
			Less mix use

Therefore, amalgamation area needs medium density compact development with revision of ELS to conserve dynapolis and modulus urban form. It also integrates the existing BRT system in a thoughtful manner to reduce housing shortage and connectivity of modulus to reduce pressure over the city center.

**6.1 Conserving Islamabad's Urban Form**

Doxiadis rely mostly on the individual automobile for transportation which becomes obsolete because the concept of Mass transit is prevailing in the developed world in terms of efficiency in current urban design. The modulus idea of ekistics with 2 Km x 2 Km is a highly efficient form for a

basic block of the city but the concept of dynapolis is unable to control the growth pattern (Table 7). Therefore, the ekistics philosophy of Doxiadis is recommended as follows.

Table 7: Alteration of Ekistics Variable on City-Scale		
Earlier Ekistics	Modulus + Dynapolis	only uni-directional linear center ( Figure 3)
Future Ekistics	Modulus + TOD	More dynamic center then before (Figure 10)

6.1.1 Conserve at City-Scale

As the city is subjected to decentralization and new sub-center, the dynapolis concept needs replacement through TOD (Figure 11). But it is important to note that replacement needs integration of two concepts. The concept of TOD is based on 8 principles; that construct compact urban form. It connects the major urban centers of the city and shapes the future growth per the connectivity, whereas dynapolis was restricted to linear directional growth. Hence the connectivity of those centers, sprawling in arbitrary direction can be achieved by multiplication of the modulus around TOD instead of only linear dynapolis. In this way, the concept of dynapolis will be retrieved & conserved by adding a 5<sup>th</sup> dimension to it.

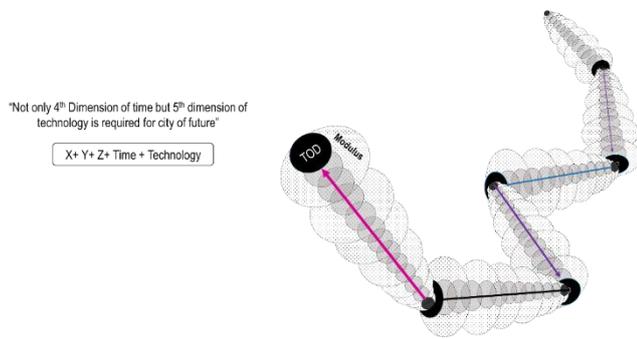


Figure 10: Conservation proposal at city-scale

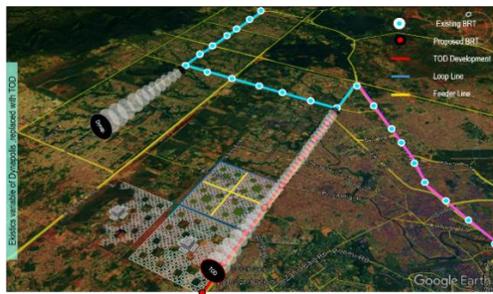


Figure 11: Proposed BRT System at Amalgamation Node with TOD

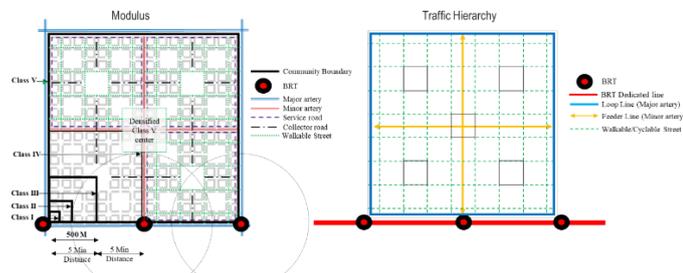


Figure 12: Conservation proposal at Modulus-Scale

6.1.2 Conserve at Modulus-Scale

The reason behind the fractured ekistical grid at the modulus-scale is due to the inverse relationship of population and housing. Doxiadis explained in his book that 'balance among the elements of a settlement is dynamic, a population increase means more complicated functions, and greater investment in the Shells'. Concerning the future need of the city, the ELS envisages the population of modulus as a low-density sector, which needs a revision from the smallest unit of CC-I. Densification of this revision can

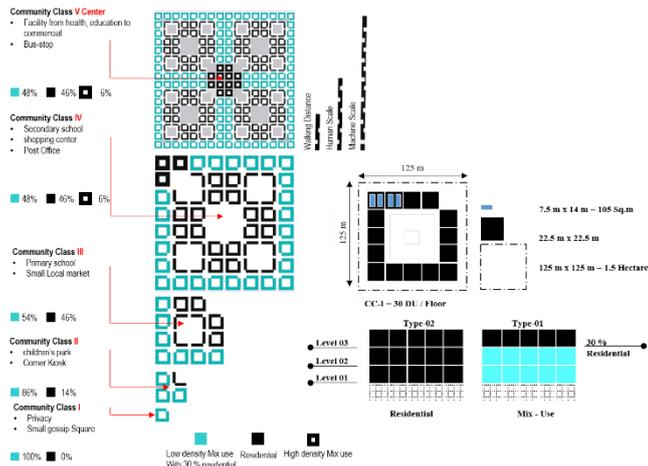
be achieved by creating an optimum synthesis between ekistics elements and principle according to the existing situation of Islamabad.

1. Considering population density extracted from the Case study of Curitiba, Brazil. Therefore, concerning household size in Islamabad and ITDP standards, it is recommended that 60 DU/NHa will be a feasible number. Otherwise, the population will become very high and may require a fast train system for TOD feasibility.
2. Also bearing in mind the plot size of these dwelling units, the important thing to study is a type of people who are going to be accommodated in amalgamation area and as already discussed that mostly lower-income people are expected to arrive in future because the amalgamation is the result of lower-income immigrants from twin cities. Therefore, it is important to consider what size of plot area suggested for this class of people in the modulus by authorities. It may provides a starting point in calculating the number of a dwelling unit and amount of people that would live around the catchment area of TOD.
3. Assuming that 105 Sq. m as an optimum dwelling size between class A and B income people according to the suggestion of DA, the following conceptual configuration is drawn to calculate the number of a dwelling unit in community class-I and similarly for the whole modulus of 2 Km x 2 Km; keeping in mind the revision of E.L.S.

The periphery of existing modulus was based on residential land use; especially at community-IV level, which is connected with minor arterial road (Ghosh et al., 2020). Hence considering Modulus traffic hierarchy according to DA, all the mix-use development is planned at the periphery of community-IV with 30 % residential; to get the maximum benefit of road frontage. The internal area of community-IV which is a grouping of 'community-III will be intact same as intended by DA keeping in mind the privacy of community (see Table 1). Full residential land use are proposed along with the similar hierarchy of 'centers'; suggested through ekistics human-scale perspective. To get rid of the low-density problem in Modulus; Increasing number of the dwelling unit is a key to revise ELS, that's why according to Figure , 60 dwelling unit are calculated in one hectare area. Here it is very important to mention that this 60 DU is not constant throughout the modulus. As discussed in the last paragraph, the internal area of CC-IV will be fully residential and its periphery will be mixed land use connected with BRT station.

The mix-use periphery which is community class-I of modulus; will contain 27 DU per hectare. The idea is justified because to keep optimum synthesis; ekistics suggest a balance between its elements, if too many DU will be accommodated against the size of modulus, it will again result in the form of imbalance between Man, shall, his network, nature, and society. Therefore the recommendation by ITDP of 140 DU/ Ha and Curitiba case 93 DU/Ha is suitable only when the household size of a country is low. The Ekistics Logarithm scale to conserve modulus form is revised as follows.

Table 8: Revision of Ekistical Logarithm Scale			
Items	Unit	Old module	TOD module (Mix & Residential)
Communities	Area in Sq. Km	Population scale	Population scale
CC-I	0.125 x 0.125 (1.5 Hectare)	40 People	162 People
CC-II	0.25 x 0.25 (6.25 Hectare)	250 People	756 People
CC-III	0.5 x 0.5 (25 Hectare)	1500 People	7020 People
CC-IV	01 x 01 (100 Hectare)	7000 People	28080 People
CC-V	02 x 02 (400 Hectare)	50000 People	112320 People (in the 'Modulus)



**Figure 13:** Revision of Ekistics Logarithm scale (ELS) at Modulus scale

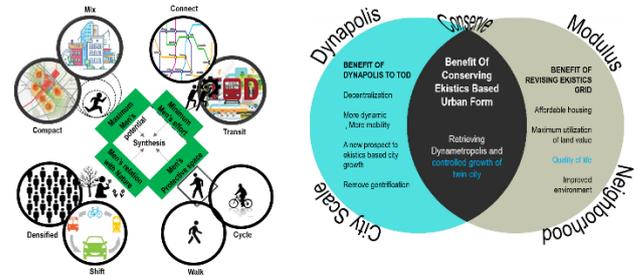
Through this proposal, ELS for Modulus can be revised according to desire standards and in 4 Sq.Km , 112320 people can be easily accommodated which is almost similar to the case of Curitiba and hence conservation of modulus form can be made possible (see table 4).

## 6.2 Conserving Ekistics-Based Urban Form Globally

The urban form is a reflection of theoretical principles therefore the recommendation is specific to cities, designed on the theory of ekistics because ekistics was a revolutionary idea of the mid-19th century, applied in a different part of the world for city's controlled growth (Sarker et al., 2018). The significance of this theory is with respect to human scale that many contemporary approaches lack in a machine world. To retrieve ekistics in a different part of the world, its principles need to be reevaluated according to 20<sup>th</sup> century approaches to city growth. For example TOD, its focus is machine-based settlement and ekistics focus is human-based settlements (Xiang, 2019). Therefore, the integration of the two theories principles can bridge the loopholes in ekistics idea and its urban form; susceptible to decay due to man-made innovations (Sarker et al., 2018). Although it may not be beneficial for TOD theory but ekistics theory can learn contemporary urban trends from it for its conservation. Though, Most of the principle of two theories are overlapping but their optimum synthesis will lead to a sustainable balance between 5 elements of ekistics.

## 6.3 Optimum synthesis of Ekistics and TOD Principles

1. Principle 01: The science of ekistics revolves around the Anthropos scale. In response to the current prevailing issue of dispersed urban form, the compact & mix-use principle of TOD can benefit in the maximization of man's potential.
2. Principle 02: Out of 5 elements of Ekistics, the network is a key for increasing the efficiency of urban form. The connect and transit principle of TOD can minimise man efforts by shortening of the entire infrastructure network and transportation system.
3. Principle 03: Ekistics encourage the privacy of Anthropos that is why Doxiadis adopted the concept of Cul-de-sac or dead-ends to avoid through traffic at modulus-scale to avoid any kind of sensory or psychological discomfort to Anthropos. The walk and cycle principle of TOD will benefit in terms of reduced traffic that will enhance the sense of privacy, protection, and social connectedness for dwellers with improved public health.
4. Principle 04: The quality of the spatial *relationship between Anthropos and its environment* is a key to ekistics-base urban form. Since TOD encourage compact development with densification contrary to dispersed urban form. It develops *ecologically efficient infrastructure*, less land consumption and decreased pollution by shifting transportation mode from cars to walkability & biked sharing (Figure 14).



**Figure 14:** Synthesis of Ekistics and TOD

## 7. CONCLUSION

In this paper, the conservation of urban form in the context of twin city case through the Ekistics & TOD method was presented. The main objective was to identify the amalgamation of two different urban forms and conserve any one of them based on determinant of its urban form, identifying the reason and problem behind conflate and its solution with modern urban trends. The test was based on the case of Islamabad which was the first city designed with the determinant of Ekistics and dynamopolis theory. Finally, The results, for research declares that the ekistics concept is conservable until the ekistical logarithm scale is revised with increasing population density and the dynamopolis concept is replaced with the modern concept of TOD. The conservation of ekistics-based urban form will not only benefit at regional, city and neighborhood-scale but it will control the amalgamation of twin city growth pattern by retrieving the original Dynamopolis concept, and beneficial for basic elements of ekistics.

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