The Spatial Organization of Ancient Greece Cities, Case study: Priene City from Hellenistic period (Third Century BC)

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Abstract. The city of Priene is one of the most important historical cities and represents a basic reference of the gridiron plans which has applied in many contemporary cities in the world. Priene city was built on the slope of a steep topography with a rigid grid system, this contradiction made the city unique. However, urban studies did not give much attention to the spatial organization of historical cities by quantitative methods. This paper investigates the main planning characteristics and the spatial organization of ancient Greece cities in term of axiality and convexity by generating axial lines of the city. The spiritual and mundane zones such as Agora, Acropolis and other civic buildings were located on the integrated spaces which are directly connected to the city gates. The spatial articulation between the religious and secular spaces was clear to enrich the spatial values of the city. Space syntax analysis has shown a lower degree of axial integration of convex spaces, a high degree of axiality, little deformation of the system, more synchrony, and moderate intelligibility.

1. Introduction
Why Priene City? Priene is a small city in Ancient Greece (located in present-day Turkey). It is considered to be one of the first examples of city planning on the orthogonal plan. Priene had followed the grid system on steep contours but in fact, responded well to the natural features of the site [1], this contradiction between the geometry of the city and the natural landscape made the city unique. Priene city was a basic reference of passive solar orientation which provides model solar planning. The city was surrounded by a mountain that protected the city from the north wind, residential units were faced south to capture winter sun. The compact urban form represents the character of Priene city to be adapted with climate and to achieve integrated social life. Small urban blocks were used to support the ability of access and more opportunities to turn corners within the city [2], and in term of placemaking, "alternative ways through the environment allows people a choice of access, from place to place, it is therefore central to making responsive places" [3]. The spatial organization was sophisticated gave a clear integration between the city components (space and mass) and the natural environment. Pedestrian paths were designed to support urban public life in the city.

2. The city of Priene
The city of Priene, in Ionia, designed on the miletian pattern, escaped the ravages of war and the substantial reconstruction in Roman, Byzantine and Turkish eras which affected many greater cities. It may well be the best-preserved Hellenistic city. Priene village organized are uncertain, but from the fifth century BC, it was
an Athenian colony, a trading centre on the Aegean Sea. It was rebuilt around 350 BC. Alexander the great supported its construction as a model city, following Hippodamus’ principles [4].

Priene flourished as a port and religio-political focus for the 12 cities of Ionia, with a population believed to be around 4000 people. Priene city is built on four broad terraces on the side of a hill, with river wharfs at the bottom, and the Acropolis at the summit of the rocky outcrop above. The orthogonal grid of streets was laid down across the terraces, with steps between levels. The grid creates adaptable development blocks circa 60×60m. The site is now pleasantly green, but beneath the trees you can see something of the quality of the place.

At the heart of the city, within easy walking distance of the whole, is the agora- a substantial square providing for markets and events, surrounded by colonnaded buildings serving as offices, shops and meeting rooms, creating the social hub of the city. Nearby, there is the splendid, well-preserved theatre, with seating for 6500 people curved into the hillside-large enough for all or most of the inhabitant, there are the upper and lower gymnasia, offering physical activities and baths for all, and schooling for children on either side of the city. There is the stadium, with seating tiered up on one side, nearly 200m long next to the lower gymnasia. Towering over all, on the top terrace, is the temple to Athena, the largest of several temples in the city.

3. The Architectural and Planning Characteristics of Ancient Greece Cities:
Classical Greek cities were either the result of continuous growth, extending from prehistoric times through the dark age and archaic periods, or created at a single moment, usually as the result of colonial settlement [5]. The former cities had streets which followed lines of communication, curving and bending where necessary to avoid obstacles or to ease gradients; the latter generally had grid plans, with straight streets crossing at right angles, ignoring obstacles and becoming stairways where the gradients were too step. Despite these differences, certain features and principles of arrangement are common to both [6]. Most Greek cities were laid out to a common pattern of long, slim blocks separated by narrow feeder streets. The feeder streets led into a few wider main streets at right angles. This is a repetitive pattern, applied heedless of topography. The city is enclosed by an irregular wall which responds to the defensibility of the terrain, having no apparent relation to the street pattern within. Defense, order, rapid and equitable allocation of houses site and access seem to be the principal motives [7].

The design ideas which they used came from long experience and observation. Its principles are credited to a lawyer named "Hippodamus”, who lived in the fifth century B.C. He proposed regular street layouts along gridiron patterns. Some of his inspiration probably derived from ancient Babylonia [8]. The Greeks thought of cities as the area of finite size, they built them as a series of rectangular blocks or cells, all adding up to a whole town, designed from the inside out and ending against a steep hillside or along a shore. The town sites were quite often built on irregular topography. The harbours of such towns were enclosed by walled quays with the Agora located alongside the harbour. Building materials also give a special architectural identity for Greek cities, stone blocks cut in set shapes (dressed masonry), rubble and mud brick were used for wall construction [9]. Marble was the medium by which Greek architecture attained standards of perfection seldom reached in later history. The accurate finishing of Greece architecture reflects the high skills in a treat with different materials, especially with marble works.

4. Case study: Priene city from Hellenistic period (Third Century BC)

4.1. Spatial Description
Priene was a small provincial town of about 4000 inhabitants founded in its present location in about 350 BC [10]. The city is built on four broad terraces which descend some 97.5m from the Acropolis to the stadium and gymnasium on its southern edge (figure 1). The temple of Athena Polias, the theatre, a second gymnasia, and the Agora are located on the two intermediate terraces. The basis of the plan is formed by
seven east-west streets following the contours, and a total of fifteen north-south stepped paths, giving access between them, up and down the hillside. The main streets are 7m wide, streets and paths are oriented north/south and east/west: housing blocks so formed are of a regular 47m by 35.3m size and contains four dwellings on average by 24m x 18m for domestic buildings [10]. It has been estimated that there were about 400 houses in Priene, thus giving a total population not exceeding 4000 persons [11]. At the centre of the plan was the Agora, occupying two blocks of the grid, about one-fifteenth of the built-up area of the city. Some terracing was necessary on the south side to provide a sufficient extensive flat area. The Agora was completely bordered by stoas. Behind the north stoa at Priene is an (Assembly Building), substantially constructed with limestone walls, and with stone seats arranged in straight lines around three sides, to hold perhaps 640 people [12]. It is restricted for the popular assembly of a small town rather than a council chamber, but the form is similar to the classical council houses at Athens and at Miletus [6]. The spatial articulation between Acropolis as spiritual part in the highest place and Agora as mundane part in the lowest place (Acropolis is some 75m above the level of the Agora) are drawn together in the tightest of creative tension [13], a tension made explicit by the face-to-face encounter between the Parthenon and Hephaisteion. The psychological appeal of spatial articulation derives from the dialectic between the expression of 'this place' and the implication of 'that place' [14]. This kind of tension is possible because of the mind's innate curiosity which, in itself, is a complex drive. Sensory dimension enriches the spatial value of the place and here the importance of placing the senses in the urban context in term of seeing, hearing, smelling, and touching [15]. Figure 2 explains the attenuated articulation and spatial interaction between Acropolis & Agora.

**KEY:**

A-The Acropolis, rising to more than 375m above sea level (some 300m above the level of the agora).
B- Theatre (Amphitheatre).
C- Agora.
D- Gymnasium.
E- Stadium.
F- Temple of Athena.

**Figure 1.** Priene, general plan (north at the top). The contour lines, both sold and dotted, are at 25-meter intervals; the 50-meter contour passes through the main western gate into the city [10]
The city of Priene demonstrates the "Hippodamian plan" as it developed toward the end of the Hellenic period (figure 3). The Agora occupies the approximate geographical centre of the town. There are the temple shrines, public buildings, and shops about it. The dwelling blocks are planned to provide the appropriate orientation of houses in a manner similar to that shown at Olynthus. Recreation and Entertainment facilities are provided in the gymnasium, stadium, and theatre [16]. The contours of the site indicate that some of the streets were very steep, steps being frequently required, but the main streets connecting the gates and the agora were generally placed so that beasts of burden and carts could traverse them readily.
4.2. Space Syntax Analysis

4.2.1. Axial Lines Generating. In term of space syntax, axial lines represent a straight line ("sight line"), possible to follow on foot [17]. The Priene city consists of 63 axial lines as main spaces in the city (figure 5).

4.2.2. Convex Spaces Generating. The formal mathematical definition of convexity is that no tangent drawn on the perimeter passes through the space at any point [17]. A concave space has to be divided into the least possible number of convex spaces [17]. Priene city consists of 96 convex spaces.

4.3. Alpha-analysis

Alfa-analysis is aimed at providing rigorous and objective descriptions that permit the comparison of urban forms with one another, the object of analysis is not merely to offer another description, but to show how it can be that these differences are generated by, and embody in their very form and structure, different social purpose. These basic concepts are enough to allow us to build a general interpretative framework for urban space structure [17]. So, Alfa-analysis is a good method to find the relationship between two types of spaces; axial spaces and convex spaces, and the nature of this relation determines the spatial pattern of the settlement.

\[ \text{Axial articulation} = \frac{\text{number of axial lines}}{\text{number of buildings}} \quad (1) \]

\[ \text{Convex articulation} = \frac{\text{number of convex spaces}}{\text{number of buildings}} \quad (2) \]

\[ \text{Grid convexity} = \frac{(\sqrt{I+1})^2}{C} \quad (3) \]

(I is the number of islands and (C) is the number of convex spaces).

\[ \text{Axial integration of convex spaces} = \frac{\text{number of axial lines}}{\text{number of convex spaces}} \quad (4) \]

\[ \text{Grid axiality} = \frac{(\sqrt{I+2})^2 + 2}{L} \quad (5) \]

(I= number of islands, L= number of axial lines).

5. Space Syntax Data (Zone’s Description)

The spatial analysis has executed by generating the axial lines of the city using "DepthMap 10". The number of axial lines and convex spaces give a clear understating of the spatial pattern (Table 1).

| No. | Index            | Value |
|-----|------------------|-------|
| 1   | No. of Axial lines (L) | 63    |
| 2   | No. of Convex Space(C) | 96    |
| 3   | No. of islands (I)    | 80    |
| 4   | No. of Buildings      | 410   |

5.1. Space Syntax Analysis

The relationship between axial and convex spaces determines the spatial pattern of the city. (Table 2) is alfa analysis of Priene city.

| No. | Index                      | value |
|-----|---------------------------|-------|
| 1   | Convex Articulation       | 0.23  |
| 2   | Convex Deformation        | 1.0   |
| 3   | Axial Articulation        | 0.15  |
| 4   | Axial Integration of Convex Spaces | 0.65 |
| 5   | Grid Axiality             | 0.31  |
5.2. Representation of Spatial parameters
Space syntax analysis categorized three types of spaces, main spaces (red colour), side spaces (yellow colour), and back spaces (blue colour). The main spaces represent the most integrated spaces in the system, while back spaces represent the most segregated spaces in the system (figures 4-9).

Figure 4. Connectivity values
Figure 5. Axial lines of the system
Figure 6. Local integration [HH] R3
Figure 7. Global integration [HH] R7
Figure 8. Axial Lines Intensity
Figure 9. Mean Depth Values
6. Results
The study has classified axial lines into three categories for the purpose of analysis; low, average and high value and calculated the percentage for each value to give a clear indication for the spatial pattern (table 3 and 4), from the other hands, the correlation between local and global parameters also give clear understanding for the whole system (figure 10-12).

Table 1. Connectivity Analysis

| Integration [HH]R7 | Repeat | %  | Level |
|-------------------|--------|----|-------|
| 0.9-1.53          | 11     | 17.5 | low   |
| 1.54-1.94         | 35     | 55.5 | AVR.  |
| 1.95-3.45         | 17     | 27   | high  |

Table 2. Global Integration [HH]R7 Analysis

| Connectivity | Repeat | %  | Level |
|--------------|--------|----|-------|
| 1-3          | 30     | 47.6 | low   |
| 4-6          | 22     | 34.9 | AVR.  |
| 7-21         | 11     | 17.5 | high  |

Table 3. Local Integration [HH] R3 Analysis

| Integration [HH]R3 | Repeat | %  | Level |
|-------------------|--------|----|-------|
| 0.88-1.54         | 7      | 11 | low   |
| 1.55-2.04         | 16     | 25 | AVR.  |
| 2.05-3.70         | 40     | 64 | high  |

Table 4. Mean Depth Analysis

| Mean Depth | Repeat | %  | Level |
|------------|--------|----|-------|
| 2.01-2.56  | 12     | 19 | low   |
| 2.57-3.03  | 23     | 36.5 | AVR.  |
| 2.04-4.51  | 28     | 28 | high  |

Figure 10. Correlation between Local and global integration

Figure 11. Correlation between connectivity and global integration
Results Discussion

*In table (2)*

a. The value of (convex articulation=0.23) indicates less breakup and more synchrony.
b. The value of (convex deformation=1) indicates little deformation of the grid.
c. The axial articulation of the system (0.15) refers to the high degree of axiality.
d. The axial integration of convex spaces (0.65) indicates lower degree of axial integration of convex spaces.
e. The value of (Grid Axiality=0.31) refers to the (Griddy System).

*In table (3)*, connectivity values indicate that only (17.5%) of the spaces have high connectivity, and (47.6%) with low connectivity.

*In table (4)*, global integration [HH] R7 values indicate that (17.5%) of the spaces have high segregation, and (27%) high integration (globally).

In table (5), local integration [HH] R3 values indicate that (11%) of the spaces have high segregation (locally), and (64%) high integration (globally).

*In table (6)*, mean depth values refer indicate that (44.5%) of spaces are depth spaces and (19%) are shallow spaces.

*In figure 10*. shows the correlation between local integration [HH] R3, and global integration [HH] which reflects the degree of synergy between them, the correlation coefficient is \( R^2 = 0.94 \) which indicates a strong correlation and high degree of synergy.

*In figure 11*. shows the correlation between connectivity and global integration which reflects the degree of intelligibility of Priene city, the correlation coefficient is \( R^2 = 0.665 \) which indicates a non-strong correlation and moderate intelligibility.

*In figure 12*. "mean depth is calculated by counting the number of times each segment falls on the shortest path between all pairs of segments within a selected distance measured and expresses the flow of a space" [18]. There is an exponential rise in pedestrian flow with increased integration [19].

The numerical results have shown that (10%) most integrated spaces (integration core) lie on the center, and (10%) most segregated spaces lie on the outside of the centre (residential zones).
The values of integration have shown that only (27%) are integrated spaces which have high accessibility and poor privacy. The values of segregation (17.5%) give calm spaces for the residents with high privacy.

Finally, the spatial analysis reflects the efficiency of the spatial organization of Priene city, where the main activities in the centre are located on the integrated spaces with a high degree of accessibility. Residential zones were segregated and located on deep spaces to give the requirements of privacy and calm for city’s dweller (figure 13).

7. Conclusions
The city of Priene followed the Hippodamian layout, was divided into four districts: the religious, the political, the cultural and the commercial zone. The main religious area was in the centre and was occupied by the temple of Athena Polias. The cultural zone was associated with the function of the theatre. Priene's theatre is one of the best and most well-preserved Hellenistic theatres. The main streets were the ones oriented from west to east, connecting the gates of the city. The grid seems denser on the east side of the city, and wider on the west. In the centre, where also the site becomes flatter, two blocks had been removed and space was provided for the Agora. The streets around the Agora were pedestrianized and a big flat terrace was created to connect them. Meanwhile, close to the Agora, there was a big opening for the oldest building in the city, the temple of Athena, which was described previously. The east – west streets, and especially the main one crossing the open space of agora, were all paved and could be traversed by wheeled carriages.

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