ANALYSES ON THE CHARACTERISTICS OF URBANIZATION PROCESS IN THE M'ZAB VALLEY, ALGERIA

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The M'zab valley in Algeria, which is known for its historical value, has been faced with the urbanization process. The purpose of this paper is to analyze the characteristics of this urbanization process through the two works: a literature survey and GIS data analysis. First, from the literature survey, we show the features on the valley’s geography and history, and then we compose a causal diagram to explain the sprawl problem. Secondly, on the GIS data analysis, we digitize land use data from 1968 to 1997 from aerial photomaps, and analyze the building-up process of the valley during this period.

Keywords: The M'zab valley, urbanization process, Ksour, Oasis Farmland, independence period, GIS (Geographical Information System), land use change.

1. Introduction

The M'zab valley is a city with many oases that holds about one hundred twenty eight thousands people, is situated some 600 km south of Algiers and is known as the entrance to Sahara desert. There are five old towns called Ksour that were established in the 11th century, and have become well known since being designated as worldwide historical heritages by UNESCO in 1982.

For a half century, the M'zab valley has suffered from population growth, and several studies have reported problems including urban sprawl problem that faces a loss of farmland for date planting in the oases.

For the sake of understanding these problems, we need to reorganize the characteristics of the urbanization process of M'zab valley. In this context, the urbanization process should be examined not only from the physical and spatial aspects but also from the historical and socio-economic which make up the background of the development of the valley.

The purpose of this study is to address the characteristics of the urbanization process of the M'zab valley through two major works. As a first task, we over viewed the sprawl phenomenon of the M'zab valley based on two geographical descriptions and several fact-reports written in the French language. We will show the geographical and historical features of the M'zab valley, and compose a causal diagram for the emerging urban problems, especially focusing on the sprawl problem. As a second task, we analyze the change of land use of the M'zab valley after the 1960's through data analysis on GIS by using aerial photo maps and show the spatial characteristics of urbanization process in the M'zab valley.

2. Features of the urbanization process in the M'zab valley from a literature survey

In this section, we examine the references and explore the unique characteristics of the urbanization process in the M'zab valley. The references that we examined were composed of two geographical descriptions (E,F) published during the 1950's, and seven fact-reports (A,B,D,G,H,L) mainly published by domestic public sectors after the 1990's. The fact-reports includes official statistics (G,H). We show the following subsections as a summary we obtained through this work.

2.1. Geographical overview of the M'zab valley

We over viewed the geography of the M'zab valley based on references E,F. Physically, the Algerian Sahara consists of rocky plateaus (called Hammada), gravel-covered plains (reg), and sandy areas (erg). The M'zab valley is situated on the Hammada plateau, where the rocky surfaces stand higher than the sandy areas. The surface of most Hammada was created by wadis, a river that has become dry.

A wadi of the M'zab is called Oued M'zab in the local language, and

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it runs from the northwest to the southeast along the valley. It floods once or twice per year due to the desert climate. Along the wadi and on the rocky hilltops, the M'zab people settled their Ksour: El-Attetuf (1014 AD), Bounoura (1046 AD), Ghadaia (1053 AD), Melika (1124 AD) and Beni Isguen (1347 AD). The M'zab valley has an undulating landscape. For example, from the hilltop of Melika Ksar to the bottom of the wadis there is a 40 meters altitude difference (figure 1).

A Ksar is characterized by its compact appearance and only one mosque tower standing on the hilltop. There are hundreds of two-story individual residences adjacent to each other and maze-like narrow streets inside the town. Residences are made of local material such as sand, lime and wood (date trees) frame. These features make the Ksour famous as a historical heritage site.

The M'zab people developed date farms for each Ksar on the lower side of the plains (erg). Each Ksar is associated with a date palm farm. Date palms are a pecies of palm tree that grows on the plains (erg) over the water table. The roughened trunk reaches a height of 80 feet or more, topped with a crown of leaves up to 15 feet long. Profitable production begins within six years of planting and may continue for up to 100 years or more. Date palms have been cultivated for eighty centuries. Date farms provide the M'zab people a micro environment for the cultivation of vegetables and fruits for their daily life by supplying adequate humidity. It means oasis.A B C D E F

The traditional water supply system in the M'zab valley is also well known. The M'zab people built sluices on their wadi in order to hold the water during the flooding. They also built a network of channels to irrigate their date farms. The ground water (aquifer water) is at a depth of 20 meters and also connects to this network, so the traditional wells are available all over the valley.

2.2. Historical features of urbanization process of the M'zab valley:

There are few references to describe the whole structure of the urbanization process in the M'zab valley, whereas each of the fact reports mentions the different aspects of this process. On this point, we can not find any contradiction among these descriptions in the references, so assuming that all of the descriptions are given, we tried to compose the whole structure. As a summary of this work, we can show the history of the M'zab valley is divided into three periods: the traditional period (1014-1850), the colonizaton period (1850-1962) and the independence period (since 1962).

(1) The traditional period (1014-1850)

The M'zab people who practiced the "Ibadisme" settled in this valley in the 11th century in order to escape from other Islamic groups in the Middle East and northern Africa. Selection of this valley was primarily based on defense.

The five Ksour in the M'zab valley were built according to local laws called "Ourif" made by a committee called Jemaa, which was composed by the old and wise men among the M'zab. The Ourif functioned on social norms that concerned environmental matters such as land use and water management, as well as religious, social, and economical matters.

The M'zab people built simple cottages for their secondary residences by the date farms in order to avoid the heat of the summer from May to October. This seasonal movement between the Ksour and the secondary residences became a part of their custom. We can interpret this traditional lifestyle supports this valley's sustainability. Thus, we summarize this period as "self-sustaining.".

(2) The colonization period (1850-1962)
The French colonial authority brought economic developments to the valley. Using artesian drilled wells, the water supply from the aquifer increased in 1937. A new water resource was also developed in 1949 via modern dwellings. The *Albian* water table became accessible at the average depth of 500 meters, which means that new technologies broke the constraints of the water supply for this city.

Furthermore, reference mentioned two reasons that accelerated the migration flows during this period. The first reason concerned the construction of road infrastructure that linked the valley from the north to the south of Algeria in 1953. The second reason was the discovery of oil in Sahara in 1956.\(^6,7\)

The colonial authority encouraged these flows by the settlement policy of nomad people. The authority gave them land that was forbidden to any construction by the *Ourf*. Some of the references pointed out that the breaking of the *Ourf* triggered anarchic urbanization.\(^5,6,8\) In figure 2 we show the urban land use in the valley into 1960. Thus, we summarize this period as one of "modernization."

**3) The independence period (since 1962)**

Many people have been attracted by the opportunities of work and investment, so they flowed into the valley. Especially, since the 80's, when a new industrial zone was developed, the *M'zab* valley has opened much more to the regional economy. The needs to housing and public facilities for new comers also increased during this period.\(^9\)

In figure 3, we show the available data concerning population statistics from 1954 to 1998. This period shows that the *M'zab* valley faced a rapid growth of population that caused the problems of urban sprawl. This figure shows an increase from 25,541 to 128,087 people. The population grew at a noticeable pace during two periods; between 1966-1977 by an annual growth of 4.5% and between 1987-1998 by 3.0%. The statistics show that the *Ghardaia* municipality, which includes *Ghardaia Ksar* (the largest *Ksar* in the valley) and *Meilka Ksar*, has always had the largest population in the valley in comparison with the other municipalities (*Bounoura* and *El-Atteuf*). For instance, in 1954 it represented 66.0% of the total population and 68.4% in 1998. This can be explained by the policy of focusing on promoting *Ghardaia* as a regional center by the French, and then followed by the Algerian national policy. Thus, we summarize this period as "urbanization."

**2.3. Composition of a causal diagram for explaining urban sprawl problems in the *M'zab* valley**

From the viewpoint of a causal explanation for the emerging problems of sprawl, we composed a diagram shown in figure 4 which displays the historical conditions and causal relationships mentioned in section 2.2 and in which all elements are grounded on the reference sources. The contents of this diagram are explained as follows, the items related to the colonization period (1850-1962) are marked by the numbers from 1 to 7; Those items related to the independence period (since 1962) are marked by the numbers from 8 to 12. Finally, the urbanization problems are marked by the number 13 and 14.

Modernization (1) brought economical development to the valley. The development of new water resources, the discovery of oil near *Ghardaia* and the road traffic infrastructure, and development by colonization policy (2) generated economical development (3). Consequently, a migration flow (4) occurred among the nomad people by the settlement policy due to the colonization authority in 1968 (5). As a result, there was a housing development pressure (6). This pressure was the cause of the sprawl occurring during the modernization period. As an answer to this pressure, there was a breakdown of social rule "*Ourf*" (7). The land, which was forbidden to any construction, has been developed.

The economical development of the valley has enlarged to a regional scale, especially after the development of a new industrial zone (8) in the 1980's. The new opportunities of job and investment (9) encouraged the old *Ghardaia* habitants to return to the valley (10), increasing the migration flow (4) that was started by the nomad people during the colonization period (2). As a consequence, the housing pressures (6) became high. Some of the secondary residences (11) that are located in the oasis farmlands and used to be occupied during the hot season only, became permanent residences because of the housing pressure (5); especially those situated near the roads.\(^8\)
It appears that the decrease of the annual local migration during the hot season from the Ksour to the oasis farmlands, decreased consequently the custom of "secondary residence" and encouraged the development of new neighborhood in the oasis.

The land reserve policy (12) was applied in the valley in 1982 to provide the land for developing housing and public facilities. This policy was adopted in all of Algeria by the national government from 1974 to 1996 and consists of giving each municipality the exclusive right to use and manage the land inside the build-up area or near the boundary. However, most of the land provided by this policy in the M'zab valley was located inside the oasis farmlands near the urban areas as in the case of Ghardaia municipality. So, this paper argues that this policy facilitated the expansion of the urban land use (13) and the decrease of the date farmlands (14).

As a summary, this diagram implies that this sprawl problem in the M'zab valley has been mainly caused by the econo-demographic factor: housing development pressure by migration flow through modernization. At the same time, the analysis shows that the sprawl problem of the M'zab valley is influenced by other unique factors, such as geographical features, historical circumstances of the colonization, social and cultural changes due to modernization, and moreover after independence with factors such as a land reserve policy.

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3. Analysis of the building-up process of M'ozab valley during the independence period

In section 2, we extracted the historical, socio-economic and spatial and physical factors of the urbanization process of the M'ozab valley over a long time period from existing literature. Section 3 focuses on the spatial aspects of the sprawl phenomenon during the independence period, especially from 1968 to 1997, because of the availability of GIS data.

We mapped the sprawl process and measured the land use change of the M'ozab valley using GIS at four time points: 1968, 1982, 1991 and 1997. This section consists of two parts, the first one describes the features of the land use classification analysis and the second one measures the land use transition from 1968 to 1997.

3.1. Features of land use classification analysis

Our analysis consisted of the following steps. First, we made a map of the land use classification of the valley in 1997. Second, we made the maps for the years of 1968, 1982 and 1991. Third, we measured the amount of land use change over the four time points. Fourth, we analyzed and compared the results.

At the beginning of the mapping process, we drew the boundaries of the valley in conjunction with the available aerial photomaps of 1/25,000 scale in 1968, 1/60,000 in 1982 and 1/10,000 in 1991. In the next step, we classified the land use into four categories using the GIS database, which was re-produced from the aerial photomaps of 1/40,000 scale of 1997, the census of 1998, and the land use scale of 1/25,000. Our classification was mainly made by two criteria: the Plant Cover Ratio (PCR) and the Building Ratio (BR). We also used other criteria, such as the construction age, the building type, and the current land use criteria in order to further characterize features into the following categories: Old Town (OT), Built-Up area (BU), Mixed area (MX) and Oasis Farmland (OF). The characteristics of each category are shown in Table 1. The Old Town (OT) is defined by the five criteria established centuries ago and characterized by the high BR, the Oasis Farmland (OF) is characterized by high PCR and the agricultural activity besides the

Table 1 Characteristics of land use categories

<table>
<thead>
<tr>
<th>Building type</th>
<th>Construction age</th>
<th>Building Ratio (BR)</th>
<th>Plant Cover Ratio (PCR)</th>
<th>Current land use</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLD TOWN (OT)</td>
<td>Traditional, individual residence</td>
<td>Till the 19th century</td>
<td>(0.85) BR &gt; 0.7</td>
<td>Residence, mosque, basic commerce (daily life goods)</td>
</tr>
<tr>
<td>BUILT-UP area (BU)</td>
<td>Individual and collective residence</td>
<td>From the 20th century</td>
<td>(0.72) BR &gt; 0.4</td>
<td>Residence, public facilities, integrated industries, different commerce (all of kinds)</td>
</tr>
<tr>
<td>MIXED area (MX)</td>
<td>Individual residence</td>
<td>From the 20th century</td>
<td>(0.4) BR &gt; 0.2</td>
<td>Date farmlands, residence, public facilities, commerce.</td>
</tr>
<tr>
<td>OASIS FARMLAND (OF)</td>
<td>Traditional, individual secondary residence</td>
<td>Till the 19th century</td>
<td>(0.2) BR &gt; 0</td>
<td>Date farmlands, agriculture, second residences</td>
</tr>
</tbody>
</table>

3.2. Land Use Transition from 1968 to 1997

Figure 6 shows the area amounts through the four time points of 1968, 1982, 1991, and 1997. The total amount of area in the valley has been increasing gradually due to the expansion of the boundaries. Only OT has not increased. The BU is the only category that consistently increased in the four years.

In 1968, BU occupied 13.8% of the total amount of the valley. This area increased to 25.3% in 1982 to 29.2% in 1991, and reached 29.7% in 1997. On the contrary, the OF decreased steadily from 72.1% in 1968 to 40.2% in 1997. This means that the green coverage areas have consistently decreased. The MX fluctuated in the four time points; it increased from 10.3% in 1968 to 27.4% in 1982, but then decreased to 25.6% in 1991. In 1997, the MX
increased again and occupied 26.7% of the total amount of area.

The results of the area’s calculation leads the authors of this paper to conclude that MX as well as OF were changed by urbanization, and both might be transformed into the BU in the long term. If the urban sprawl phenomenon continue at this pace, the BU might become larger than the OF in the future. This will regress the image of the M’zab valley as an oasis city. Here figure 7 is shown in order to examine the transition of the geographical features of the M’zab valley.

During the period 1968-1982, the available land was built-up around the OT, such as the Ksar of Ghardata, which expanded the urban centers. It can be seen that some of the date farmlands, especially those situated near the OT actually regressed. The sprawl directions in this period were as follows: from the west of Ghardata Ksar toward its own OF, south of Beni Isguen Ksar toward its OF, northeast of Melika Ksar, east, south, and north of Bounoura Ksar, east and south of El Attal Ksar toward its OF. The land development reached the both sides of Oued M’zab, so its width became smaller.

These results can be interpreted at least partially by the application of the land reserve policy to the M’zab valley from 1982. References C, D, I reported that this policy was applied to satisfy the high demands of residences and public facilities due to the increase of the population from 46,530 people in 1966 to 89,977 people in 1987.2

According to statistics presented by the municipality of Ghardata, 1244 lots of land representing an area of 47.98 hectares were designated as a land reserve in 1982. So, we tried to map the land reserve policy in this period from the references.

Thus, due to data availability, we could partially identify the applied areas of this policy in Ghardata municipality (figure.8). Reference C only mentioned the name of the places, so this figure shows these areas by GIS. By overlapping this figure to the land use change during 1968 to 1982, the build-up of the east part of Ghardata OF such as the neighborhood of Benghanem, Chabet Nichen, Baba Saad, Ben Smara etc. This fact has also been verified by the results of an interview with a municipal officer.
Although this policy was applied from 1982 to 1991 and provided lands for development of MX, this latest increased only in 1982. The reason is that BU increased very much by building up MX after 1982.

During the period 1982-1991, MX was remarkably built-up in the northeast of Ghardaia Ksar, southeast of Melika Ksar and north of El Atteuf Ksar. However the fringes of BU were enlarged especially between Ghardaia Ksar and its OF from the north and south sides and the west side of El Atteuf Ksar. Consequently, the BU increased from 205.0 ha to 247.7 ha and the MX decreased in this period.

We can interpret this to mean that the amounts of OF sustained from this period because of the program launched by UNESCO in 1982. This program included the limitation of new constructions inside the date palms as well as the restoration of the historic architecture of the Ksours.

Between 1991 and 1997, the MX increased by developing the land outside the boundary of the valley of 1991, which reached 234.5 ha; for example, the one situated on the southwest of the Ghardaia OF. While the BU continued to increase to 260.8 ha, the amount of OF kept its original area since 1982. One of the reasons that the OF amount did not change was due to the application of "The Oasis Rehabilitation" program, launched by the Ministry of Environment in 1994. This program focused on the amelioration of the condition of the existing oasis. Another reason was due to the municipalities' improvement of enforcement in building-permission.

The boundaries and area amounts of the fourth zones (OT, OF, MX, BU) changed from 1968 to 1997. The largest part, which composed the valley, was OF (72.1% in 1968 than 40.2% in 1997), the second part was BU (13.8% in 1968 than 29.7% in 1997), and the third part was MX (10.3% in 1968 and 26.7% in 1997). The smallest part was OT, which did not change at all (3.8%). Clearly, the sum of BU and MX areas in 1997 was 56.4%. The increased growth of MX in the future will result further imbalance in the valley's composition.

A summary of the findings can be made through the GIS analysis as the characteristics of the land use change in the independence period as follows;
(1) the city boundary expanded 8.5% from 810 ha in 1968 to 879 ha in 1997;
(2) the urbanized area grew rapidly during 1968-1982, so the oasis farmland decreased by 40%; (3) the mixed area fluctuated, on the other hand, the building-up area has been increasing steadily, so we verified the tendency of the loss of the green coverage through the urbanization process; (4) since 1982, many countermeasures taken by UNESCO, the Ministry of Environment and the valley municipalities stopped the decrease of the oasis farmland area; (5) we cannot deny the influence of the land reserve policy, because we could find it spatially in Ghardaia municipality.

4. Conclusion

This paper has analyzed the characteristics of the urbanization process of the M'zab valley from the two works: the literature survey and the GIS data analysis. In the literature survey, we composed a diagram explaining the process of urban sprawl problems of the M'zab valley. In the GIS data analysis, by focusing on the independence period, we measured land use changes in the M'zab valley from 1968 to 1997.

Although population migration after the modernization period can be seen as a global phenomena, the uniqueness of the M'zab valley's urbanization process can be characterized by not only its geological features such as the existence of valley and oasis in a desert, but also by the traditional society that was formed on these geographical conditions, and moreover the historical circumstances of the colonization experience. The references have also warned that policy factors should not be ignored in order to analyze the spatial aspect of the urbanization process especially after the independence period.

The GIS data analysis has enabled us to analyze the numerical change of land use in this period, so we verified several facts such as the expansion of the urbanized area and the loss of the green coverage all over the M'zab valley. We also attempted to analyze the influence of the land reserve policy based on the current available data; nevertheless we conclude that the influence of this policy cannot be denied, because we found several places in the east part of the Ghardaia Oasis Farmlands. Further investigation of policy effects is required in order to assess the other areas.

The M'zab valley is an oasis city, so both its water resources and oasis farmland have functioned as the critical lifelines for sustainability. From this point, the city should become an interesting case to study for sustainability as an example for many other cities during this century. Further analysis is needed on the detailed process of building-up the M'zab valley because topographical factors such as elevated shapes or micro-locations of water supply would be closely connected to such patterns of development.
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Notes

1. Oued M'zab is the name of a dry river in the M'zab valley and means river of M'zab people.

2. Oued M'zab floods 1.92 day per year. The average number of rainy days is between 10 to 15 days per year, however, the annual precipitation average is 66-68 mm/year.

3. Very hot and dry in summer and cold in winter, the temperature average is 36.3°C in July and 11.4°C in December.

4. M'zab are tribe of Berber, Arabic, and Persian people. The founder of this tribe was Mouad Ben Badine.

5. There are three jurisdictions presently in the M'zab valley: Ghadaria, Bououra and El Attouf municipalities.

6. The Ihadisme is the name of an Islamic doctrine.

7. The first technically advanced well, used in the M'zab valley, was in Ghadaria municipality with a pumping power of 80 m³/h in 1937, the second one was situated in El-Attouf in 1951.

8. The Albian water table of 600,000 km² is accessible at 500 m in the M'zab valley and other municipalities and under 120 to 150 m in other areas outside the valley. The predicted potentiality in the M'zab valley until 2040 is 7507 L/s in reference to the total potentiality of the water table (17557 L/s).


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和文要約

1. 研究の背景と目的

ムザッブ峡谷は、アルジェリアの首都アルジェから南に600 km、サハラ砂漠東端に位置する人口12 万人のオアシス都市である。丘を覆うコンパクトな都市型態と頂上にある一帯の谷が特徴的な旧市街地クスール(Ksour)で知られるこの都市は、1982年以降UNESCOの世界遺産に指定されている。ムザッブ峡谷では、この半世紀間に人口流入による急速な都市化が進み、オアシスを構成する貴重な農業環境であるダッツ農地が減少するというスプロール問題などが生じている。これらの問題を理解するうえで、この都市が迎ってきた都市化過程の特徴を理解しておくことが不可欠である。その際、都市化過程を、物理、空間的な側面のみならず、その背後にある社会的・経済的な側面から捉えることが必要である。

本研究では、これらの問題を通じて、ムザッブ峡谷における都市化過程の特徴を明らかにする。第一の作業では、現状調査の際に収集した主としてフランス語による研究文献ならびに事例調査書から、ムザッブ峡谷における地理的・歴史的概要を整理するとともに、都市化問題を含む図書の収集を試みる。第二の作業では、航空写真とディスタイズのGISを用いて、1960年代以降における都市成長を分析するとともに、都市化過程における空間の特徴を整理する。

2. 文献調査に基づくムザッブ峡谷の都市化過程の特徴

2.1 ムザッブ峡谷の地理的特徴

ムザッブ峡谷は、岩質台地にオード・ムザッブと呼ばれる谷川（ワジ）が刻み込まれた地域である。この地域は典型的な砂漠気候であるが、数年に一度ワジが洪水を起こすことも知られる。11世紀以来、このワジ沿いの岩質の丘に、ムザッブ族が5つのクスールを築いた。さらに、各クスールに対して各一ヶ所、ふもとの膏水脈上の砂地に拓かれたのがダッツ農地である。ダッツとは多雨の高地で、その実が食用になるばかりでなく、樹下の微气候が野菜や果物、また、木質資源供給の伝統のシステムとして、ムザッブ族はワジを堰け、洪水時には部分的に地下20 mに位置する膏水脈に蓄えた。

2.2 ムザッブ峡谷の都市化過程の歴史的特徴

ムザッブ峡谷の歴史は、3つの期間に区分することができる。

伝統社会期(1014〜1580)：ムザッブ族がクスールを建立した理由は防衛であり、ムザッブ峡谷における開発・維持管理は、長年組織が定めているカルファ随に従った。宗教、社会、経済面の観点から、土地利用や水資源管理といった環境問題を考え上げる上でのオアシスは社会規制として機能していた。また、この時期、ムザッブ族にはダッツ農地内に夏季住居を設けて避暑を行い、生活習慣があった。これらの水資源調節・社会規制・生活習慣、伝統社会におけるこの都市のサステイナビリティを支えていたと考えられる。この時期を特徴づけるのは自給自足性であると言える。

植民地期(1850〜1962)：仏蘭西植民地はこの地に交通網整備と工業開発をもたらした。これを支える水源域は、近代技術により拡大した。植民地による遊牧民の定住化政策をきっかけとして、ムザッブ峡谷の人口増加が始まる。これはサハラ沙漠の漬漬見をきっかけとする化学工業の労働需要増大によって加速化された。さらにこの時期、植民地政府は遊牧民によるダッツ農地の間接被害を推し進めた。これらの問題は社会規制としてのオアシスの破壊化をもたらした。この時期を特徴づけるのは近代化であると言える。

国家独立期(1962)：もともと周辺地域からの流入により、人口は半世紀後の3倍に増加した。アルジェリア政府もまたガダルマや地方政府を組織化した結果、増加人口はともにガダルマや自治体に集中した。これに伴って、スプロール問題を含め、様々な問題が顕在化している。この時期を特徴づけるのは、都市化であると言える。

2.3 むザッブ峡谷のスプロール問題をめぐる因果構造の整理

2節のまとめとして、スプロール問題の原因構造を図式図法として構成した。得られた因果図式は、この問題の主因が、近代化を通じた人口流入による市街化圧力といった人口経済的な要因であるが、同時に、近代化による社会変動や文化変容、オアシス都市の地域条件や植民地化の歴史的遺団、さらに独立以降は後述する政策的要因が主因に影響していることも示している。

3. 国家独立以降における都市化過程の分析

国家独立以降については、ムザッブ峡谷の航空写真が現存する。3節では、これに一次資料をデジタル化として1968年、1982年、1997年の土地利用データを作成し、GIS上で表示するとともに、その面積測定を通じて都市化過程の分析を行なった。主として構造変化とその成立年代により特徴づけられる4段階の土地利用カテゴリーは、旧市街地（OT）、新市街地（BU）、進行市街地（MX）、オアシス農地（OF）である。OTは伝統の低住居、建ぺい率70〜85%、総面積率5%、BUは近代の建造物、建ぺい率40〜70%、総面積率20〜50%、MXはダッツ農地と近代化の建造物、建ぺい率20〜40%、総面積率20〜80%、OFは夏季住居を含む農地、建ぺい率20%以上、総面積率80%以上である。また、記録資料にもとづき、土地保持地政策適用地域の一部をGIS上に表示し分析を試みた。

4. 結論

まず、文献調査から都市変化過程の知見を要約する。1. 伝統社会の変化による人口流入を、個を問わず都市化が現れるが、オアシス都市や峡谷の存在といった地理的特性や、その面積測定を通じて都市化過程の分析を行なった。主として構造変化とその成立年代により特徴づけられる4段階の土地利用カテゴリーは、旧市街地（OT）、新市街地（BU）、進行市街地（MX）、オアシス農地（OF）である。OTは伝統の低住居、建ぺい率70〜85%、総面積率5%、BUは近代の建造物、建ぺい率40〜70%、総面積率20〜50%、MXはダッツ農地と近代化の建造物、建ぺい率20〜40%、総面積率20〜80%、OFは夏季住居を含む農地、建ぺい率20%以上、総面積率80%以上である。また、記録資料にもとづき、土地保持地政策適用地域の一部をGIS上に表示し分析を試みた。

つぎに、データ分析からの都市変化過程の知見を要約する。1. 伝統社会の変化による人口流入を、個を問わず都市化が現れるが、オアシス都市や峡谷の存在といった地理的特性や、その面積測定を通じて都市化過程の分析を行なった。主として構造変化とその成立年代により特徴づけられる4段階の土地利用カテゴリーは、旧市街地（OT）、新市街地（BU）、進行市街地（MX）、オアシス農地（OF）である。OTは伝統的低住居、建ぺい率70〜85%、総面積率5%、BUは近代の建造物、建ぺい率40〜70%、総面積率20〜50%、MXはダッツ農地と近代化の建造物、建ぺい率20〜40%、総面積率20〜80%、OFは夏季住居を含む農地、建ぺい率20%以上、総面積率80%以上である。また、記録資料にもとづき、土地保持地政策適用地域の一部をGIS上に表示し分析を試みた。