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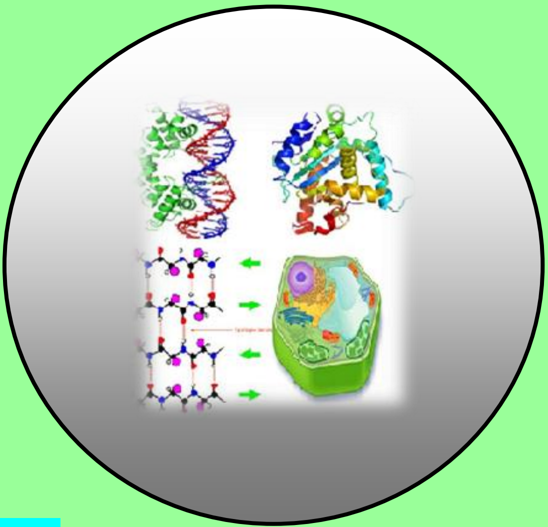

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System Analysis in Geographic Studies: A Biological Perspective on Rural-Urban Interaction

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ABSTRACT

This paper examined the concept of a system as made up of objects with components, attributes or parts that interact like the biological system in terms of material exchange. This interaction is responsible for the kind of relationship that exists. The paper asserts that a system (subsystem) may be part of another system (super system) and a break in any part of a system will surely affect the entire super system. The paper equally reiterated that a system is ordered and could be closed or open depending on the material supply and the direction of complementary relationship that exists. The paper argued that geographers are very much interested in the inter relationships between and among objects or phenomena in space. That Man is a major component of the earth or environmental system as an agent of change through his interactions. The paper reveals that man's activities as well as his relationship with the environment is largely responsible for the observed pattern of human endeavours and impacts such as erosion, flooding, urbanisation, climate change, deforestation, movement and transportation. Examining Mabogunje's empirical analysis of rural-urban interaction in Africa, we emphasized that rural area is as important as the urban area because they both complement each other like a functional biological system.
Keyword: Geography, Interactions, Rural, System, Urban.

INTRODUCTION

The spatial organisation of the environment of an individual and the society objectively exists since the dawn of mankind (Pklapka, Frantál, Halás and Kunc, 2010). There also exist some sorts of perceived chaos or complexities in this organisation. Pidwirny (2006) stated that one common conclusion of scientific inquiry is that the world of nature is often very complex and argued that to understand this complexity; scientists usually try to envisage the phenomena of nature as simplified versions of reality known as a system. He further defined a 'system' as a collection of interrelated parts that work together by way of some driving processes. In theory, therefore, Geography deals with complex interactions of biotic (living) and abiotic (non-living) components in an ecosystem. Literature reveals that before World War II, no technique had been developed to enable geographers analyze complex systems (Mondal, 2015). According to Onokerhoraye (1994), the idea of systems came originally from the biological sciences and from electronic processes that stimulate the interaction of biological organ, and the early development of system thought is associated with biologist (von Bertalanffy, 1950). According to Mondal (2015), a system where one or more of the functionally important variables are spatial may be described as a geographical system. Geographers are primarily interested in studying systems whose most important functional variables are spatial circumstances, such as location, distance, extent, sprawl, density per areal unit, etc.

As reiterated by Von Bertalanffy (1950), Systems theory is an interdisciplinary theory about the nature of complex systems in society and science, and is a framework by which one can investigate and/or describe any group of objects that work together to produce some result. Thus, Von Bertalanffy's General Systems is the theory that is most relevant to geographic analysis (Onokerhoraye, 1994). Furthermore, the general System analysis provides a framework for describing the whole complex and structure of activity and therefore, peculiarly suited to geographic analysis since geography deals with complex multivariate situations (Mondal, 2015). It was because of this advantage that Berry (1964) and Chorley (1962) both suggested systems analysis and general system theory as the basic tools for geographic understanding.

The aim of this paper, therefore, is to examine the nature of systems analysis in geographic studies using the concept of biological system in analysing rural-urban interaction. The specific objectives are to (i) examine the concept of systems analysis, (ii) identify the characteristics, types and functions of system analysis, (iii) examine the merits and demerits of system analysis, and (iv) present a typical application of systems analysis to rural-urban interactions.

Materials and Method

The data used for this study were collected mainly from documented literatures from research repository: libraries, e-libraries, as well as lecture materials. The collected materials were descriptively analysed and findings presented.

Results and Discussions

System Analysis

The Concept of a 'System' has been defined by different authors. According to Onokerhoraye (1994), a system could be defined "as a complex whole, a set of connected things or parts, a department of knowledge or belief considered as an organised whole". He further asserted that, although the above definition is useful, it is necessary to attempt a more precise definition as provided by Hall and Fagen (1956) in the context of geographic analysis. In this regard, 'a system is a set of objects together with relationships between the objects and between their attributes (Hall and Fagen, 1956 in: Onokerhoraye, 1994: 172).

Mondal (2015) stated that a system may be defined as a whole (a person, a state, a culture, a business) which functions as a whole because of the interdependence (interactions) of its parts. If we accept this definition, then it can fairly be said that geographers have been using forms of system concepts since the dawn of the subject. With respect to its importance, Systems are often visualized or modelled as component blocks that have connections drawn between them (Pidwirny, 2006). These blocks are like the biological unit of life which exist only when there is interdependency of component parts on one another. Thus, whatever affects one component invariably affects the others. When there is stoppage in material flow from one source, there is the penchant for the other component to die and possibly go into extinction. Thus, to keep the system alive, there should be continued interactions and flow of material between and among component parts.

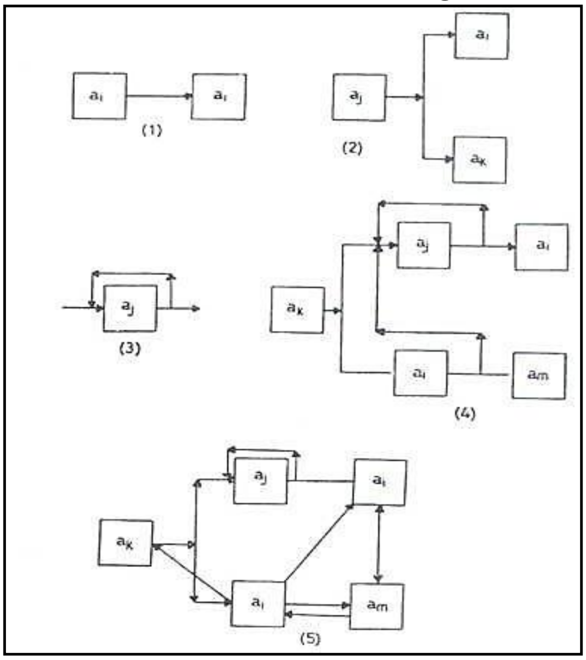
According to Onokerhoraye (1994), three words are of crucial importance in the definition of a 'system'. These are:

a) **Objects** – parts of components of a system which are unlimited in variety; the kinds of parts (things or substances) that make up a system. These parts may be atoms or molecules, or larger bodies of matter like sand grains, rain drops, plants, animals, etc.,

b) **Attributes** – properties of objects; the characteristics of elements that may be perceived and measured. For example: quantity, size, color, volume, temperature, and mass, and

c) **Relationships** – the associations/interactions that occur between elements and attributes. These associations are based on cause and effect (Mondal, 2015) characterised by material flows. Although a system has wholeness, complex parts systems can be identified, but it is these connections or interactions between these parts which makes it a system.

According to Rana (2015), a system is a functioning whole with various sub-systems interlinked with each other as illustrated in Figure 1.



(i) Series relation.

(ii) Parallel relation.

(iii) Feedback relation.

(iv) Simple compound relation.

(v) Complex compound relation.

Figure 1. Links or relationships between elements in systems

The 'system', contrary to chaos, has an order. In other words, it is 'the way, sequence in which the various components or phenomena are organized into a whole, into a totality. Many reasons abound as to why system analysis is very important in geographic research. All around us, we find every phenomenon, every event and every feature assigned to a system, e.g. Academic system, economic system, geologic system (Chorley, 1962), , City systems (Berry, 1964), rural-urban system (Mabogunje, 1970), political system, earth and solar system (Pidwirny, 2006), Environmental Systems (Pidwirny, 2006), transport system (Davies and Beven, 2015), ecological system, climatic system, hydrological system (Davies, 2014; Davies and Beven, 2015), and even an individual human being is also a (biological) system in himself (Onokerhoraye, 1994). Each part of the system or each individual over the earth is significant, not only in terms of the functions it performs independently, but also in terms of its relationships with others; and unless and until these individuals are studied together they cannot form a system (Mondal, 2015). Hence, it is within the framework system analysis that we are studying each and every component of the Earth for which human interactions and movements are considered germane. For example, using the academic system, the department of Geography and Regional Planning is a sub-system within the faculty of social science system in Ambrose Alli University. The faculty system is also a sub-system within the entire Ambrose Alli University System. To understand, the entire University system, one must look into the various faculties, and by extension, look into the various departments as non can be isolated when discussing the Ambrose Alli University System because its component parts work together to achieve the aim of training students, contributing to research and development. Hence we have sub-systems within a super-system. The system's approach, can therefore, be suggested as a way or a method of comprehending the world as a whole as well as the interaction of man and his environment. Mondal (2015) further argued that the modern emphasis on system as an explicit item for analysis may be seen as a part of a general change from the study of very simple situations in which the interactions are few, to situations in which there are interactions between very large numbers of variables. The interest in these complex systems has grown very rapidly in the 20th century. Given the multivariate nature of most geographic problems, it is hardly surprising that systems analysis provides an appealing framework for discussing these problems. In geography, Mondal stated that the awareness towards the use of system's approach has developed because of the realization that:

i. the earth's surface (world) is made up of different types of areas, regions, or places; and these, besides having an individual significance, also are part of a 'whole' as conceived by Ritter (in his Erdkunde) and Humboldt (in his Cosmos); and
ii. these parts or sub-parts are not only inter-related with each other, they also form independent sub-systems of their own.

Literatures on the application of system theory and systems analysis in geography include those of Von Bertalanffy (1950) on the theory of open systems, Hall and Fagen (1956) on the broad definition of system, Chorley (1962) on Geomorphology and general systems theory, Berry (1964) on Cities as systems within systems of cities, Harvey (1969) on explanation in Geography, Mabogunje (1971) on systems approach to a theory of rural – urban migration in Africa, Odum (1983) on systems ecology, Laszlo and Krippner (1998) on systems theories:

their origins, foundations, and development, Christopherson (2005) on Geosystems as an introduction to physical geography, Pidwirny (2006) on humans and their models, Davies (2014) on glacier hydrology studies, Rana (2015) on models, theory and systems analysis in geography, Davies and Beven (2015) on the study of Hysteresis and scale in catchment storage, flow and transport.

Onokerhoraye (1994) stated that considering the complexity and interaction with which most geographers deal with their geographic data, it is obvious that the adoption of systems analysis is inevitable if geographers are to make adequate explanation of the complex variables they deal with. Consequently, system thinking in geography is very much associated with 'the functional approach', with optimistic analogy, with the concept of regions as complex interrelated wholes and with the ecological approach in geography (Harvey, 1969) as the works of geographers such as Ritter, Vidal de la Blache, Brunches and Sauer indicate elements of system thinking (Onokerhoraye, 1994). Stoddart (1967) for example emphasised the role of the concept of an ecosystem as an organising concept in geography with his argument that the environment bring together man, plants and animals within a single framework, within which the interaction between them exists. In this regard, the work of Curry (1967) in analyzing settlement-location in system framework is well established. The inference drawn from all the above scholars is that geographers are interested in the spatial distribution, differences, interaction and factors responsible for the observed spatial variations. These variations can better be understood from the 'system analysis' point of view. And as reiterated by Hornby and Jones (1980), the system and the environment act and react upon each other continuously as whatever affect one part (components) invariably affects the other.

Characteristics, types and functions of a system

This session of this paper examines the attributes, types and functions of a typical system. This is carried out under separate headings as presented below.

Characteristics of a system

According to Pidwirny (2006) and Rana (2015), most systems share the same common characteristics which includes the following:

a) A system has an order of or sequence of functions;
b) Although each part of a system plays an individual role in the system's operation, no part is entirely independent of others.
c) A change in the operation of one part will have significant repercussions throughout the system.
d) Systems are generally open-ended, meaning it interacts.
e) Accordingly a system has some inputs and some outputs.
f) The system is not a juxtaposition of various elements; it is rather a functioning whole.
g) There is always some stimulus (or driving force) behind the functioning of a system.
h) Systems are generally at balance or at equilibrium.
i) Malfunctioning of one part disturbs the balance of whole system.
j) Within macro systems there are micro systems (the sub systems).

Types of Systems

Scientists have examined and classified many types of systems. Some of the classified types according to Pidwirny (2006) include:

i) **Isolated System** - a system that has no interactions beyond its boundary layer. Many controlled laboratory experiments are in this category of system.
ii) **Closed System** - is a system that transfers energy, but not matter, across its boundary to the surrounding environment. Our planet is often viewed as a closed system.
iii) **Open System** - is a system that transfers both matter and energy cross its boundary to the surrounding environment. Most ecosystems are example of open systems.
iv) **Morphological System** - this is a system where we understand the relationships between elements and their attributes in a vague sense based only on measured features or correlations. In other words, we understand the form or morphology of a system is based on the connections between its elements. We do not understand exactly how the processes work to transfer energy and/or matter through the connections between the elements. This type is typical in glacier and geomorphological studies.
v) **Cascading System** - this is a system where we are primarily interested in the flow of energy and/or matter from one element to another and understand the processes that cause this movement. In a cascading system, we do not fully understand quantitative relationships that exist between elements related to the transfer of energy and/or matter.
vi) **Process-Response System** - this is a system that integrates the characteristics of both morphological and cascading systems. In a process-response system, we can model the processes involved in the movement, storage, and transformation of energy and/or matter between system elements and we fully understand how the form of the system in terms of measured features and correlations. e.g the cycle of erosion credited to Davies..
vii) **Control System** - a system that can be intelligently manipulated by the action of humans.
viii) **Ecosystem** - is a system that models relationships and interactions between the various biotic and abiotic components making up a community or organisms and their surrounding physical environment. This type is typical in environmental science and biogeography.

Merits of system theory and system analysis in Geography

According to Laszlo and Krippner (1998), the merits of systems theory includes:

i. Its potential to provide a trans-disciplinary framework for a simultaneously critical and normative exploration of the relationship between our perceptions and conceptions and the worlds they purport to represent.
ii. Its ability to render the complex dynamics of human bio-psycho-socio-cultural change comprehensible.
iii. Observed phenomena in the natural and man-made universe do not come in neat disciplinary packages labelled scientific, humanistic, and transcendental: they invariably involve complex combinations of fields, and the multifaceted situations to which they give rise require a holistic approach for their solution.
iv. Systems theory provides such an approach and can consequently be considered a field of inquiry rather than a collection of specific disciplines.

According to Mondal (2015), the application of system analysis is important for the following reasons:

a) Any geographical region (landscape) has a number of phenomena. System analysis attempts to reduce this complexity to a simpler form, in which it may be more easily comprehended and which models can be constructed.
b) It allows, for example, the development of abstract theory systems which is not tied down to any one particular system or set of systems.
c) This theory provides us with good deal of information about the possible structures, behaviours, states, and so on, that might conceivably occur.
d) It provides us with the necessary technical apparatus for dealing with interactions within complex structures.
e) System theory is associated with an abstract mathematical language, which, rather like geometry and probability theory, can be used to discuss empirical problems.

Demerits of system theory and system analysis in Geography

Onokerhoraye (1994) argued that the system analysis is very vital in explaining man-environment relationship. However, other scholars have argued that despite this relevance, the system analysis also has some draw backs. Some of these demerits include:

i) That 'the application of systems analysis has not achieved powerful operational status in geography' (Harvey, 1969: 469). That systems analysis tends to assume that a system exists and that the phenomenon in question is a component of that system.
ii) That systems analysts tend to attribute goals and characteristics to the system on the basis of little or no empirical evidence that the system exhibits.
iii) That the complexities of systems analysis itself which if it is to be fully employed, involves mathematical techniques beyond the reach of most geographers (Onokerhoraye, 1994).

Resulting from the merits and demerits of systems analysis in geography, it can be argued that a good understanding of systems analysis will help the geographers to better place his priorities on the objects or components to look for in his research as relationships are established and pattern observed.

A Typical Geographic System: The Universe as a System

According to Laszlo and Krippner (1998), the method proposed by systems theory is to model complex entities created by the multiple interaction of components by abstracting from certain details of structure and component, and concentrating on the dynamics that define the characteristic functions, properties, and relationships that are internal or external to the system. The history of systems theories includes contributions from such influential thinkers as Alfred North Whitehead, Ludwig von Bertalanffy, Anatol Rapoport, Kenneth Boulding, Paul A. Weiss, Ralph Gerard, Kurt Lewin, Roy R. Grinker, William Gray, Nicolas Rizzo, Karl Menninger, Silvano Arieti, and, in more recent years, the dynamical systems theorists, the family systems theorists, and those who deal with dissipative structures and holistic paradigms.

An empirical analogy of an example of a 'system' is illustrated with the work of Pidwirny (2006). He argued that Systems exist at every scale of size and are often arranged in some kind of hierarchical fashion.

Large systems are often composed of one or more smaller sub-systems working within its various elements. Processes within these smaller systems can often be connected directly or indirectly to processes found in the larger system. A good example of a system within systems is the hierarchy of systems found in our Universe as examined below. Figure 2 shows solar interception or attenuation by earth system.

- At the highest level in this hierarchy we have the system that we call the cosmos or Universe. The elements of this system consist of galaxies, quasars, black holes, stars, planets and other heavenly bodies. The current structure of this system is thought to have come about because of a massive explosion known as the Big Bang and is controlled by gravity, weak and strong atomic forces, and electromagnetic forces.

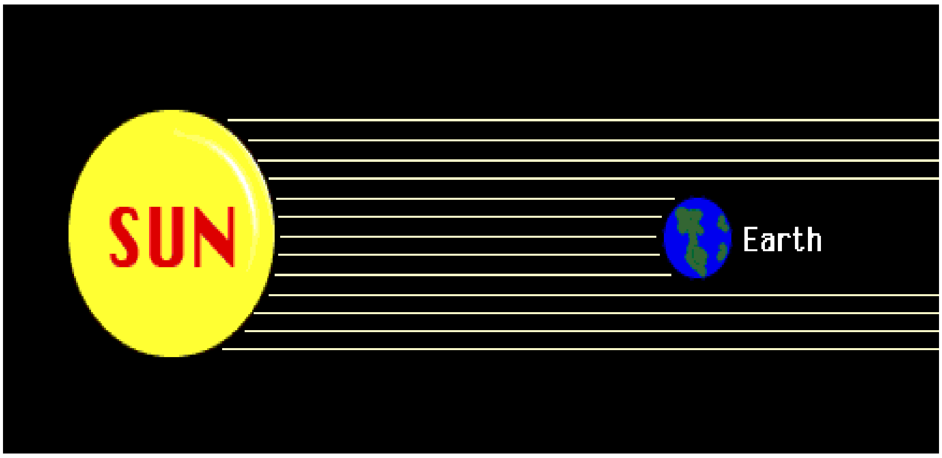


Figure 2. Simple visual model of solar radiation being emitted from the Sun and intercepted by the Earth
(Source: Pidwirny, 2006)

- Around some stars in the universe we have an obvious arrangement of planets, asteroids, comets and other material. We call these systems solar systems. The elements of this system behave according to some set of laws of nature and are often found orbiting around a central star because of gravitational attraction. In most planets conditions, there exist for the development of dynamic interactions between the hydrosphere, lithosphere, atmosphere, or biosphere.
- We can define a planetary system as a celestial body in space that orbits a star and that maintains some level of dynamics between its lithosphere, atmosphere and hydrosphere. Some planetary systems, like the Earth, can also have a biosphere. If a planetary system contains a biosphere, dynamic interactions will develop between this system and the lithosphere, atmosphere and hydrosphere. These interactions can be called an environmental system. Environmental systems can also exist at smaller scales of size (e.g., a single flower growing in a field could be an example of a small-scale environmental system).
- The Earth's biosphere is made up of small interacting entities called ecosystems. In an ecosystem, populations of species group together into communities and interact with each other and the abiotic environment.

- The smallest lining entity in an ecosystem is a single organism. An organism is alive and functioning because it is a biological system. The elements of a biological system consist of cells and larger structures known as organs that work together to produce life. The functioning of cells in any biological system is dependent on numerous chemical reactions. Together, these chemical reactions make up a chemical system. The types of chemical interactions found in chemical systems are dependent on the atomic structure of the reacting matter. The components of atomic structure can be described as an atomic system.

Empirical Application of system analysis in Rural-Urban Migration and Spatial Interactions

Mabogunje (1970) used the system analysis in explaining rural-urban migration in Africa. And, according to Onokerhoraye (1994), rural-urban migration has been a major area of geographical research for a long time especially in the context of developing countries such as those in Africa. He further assert that, often, rural-urban migration has been explained in terms of push-pull theory which views rural-urban migration essentially as a one way process, that starts and finish between origin and a destination (Figure 3).

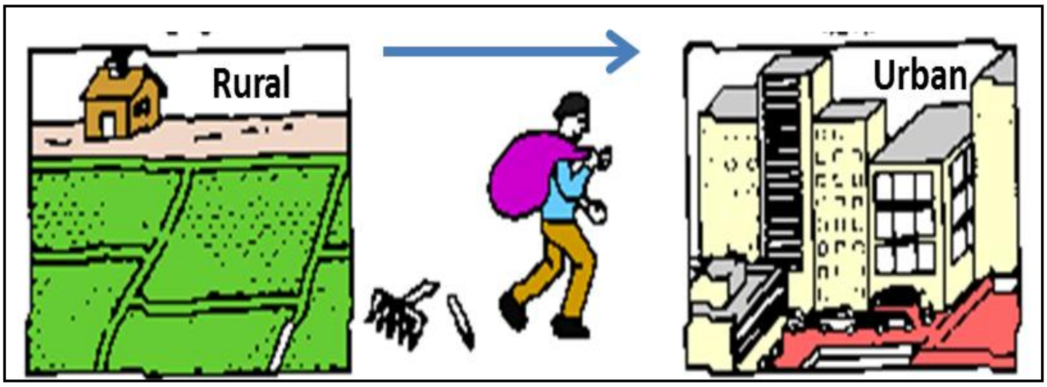


Figure 3. Model of a migrant from rural area (origin) to urban area (destination).

In his study, Mabogunje (1970) took a comprehensive view of rural-urban migration in terms of a system which is undergoing continued modification as events in one part cause repercussions elsewhere. He conceived of the African rural-urban migration system as operating within an economic, social, political and technological environment. He described such environment as one of a change; of increasing degrees of commercialization and industrialization of rising health and educational standard, changing government policies and of better transportation links and increased mechanization. He further argued that having been stimulated to move by the environment, the potential migrants then comes under the influence of what he called the rural control subsystem which in the African context, is the family and the rural community whose attitudes will determine the volume of rural-urban migration. These attitudes will in turn be influenced by the ability of families and communities to adjust to migration loss.

Thus, when migration takes place, the rural dweller passes from the rural control sub-system to an urban sub-system with its own control subsystem such as housing and job opportunities, and adjustment mechanism such as an expanding labour market, which may transform the rural dweller into an urbanite.

If the migrant maintains contact with his home area as the adjustment to urban life takes place, he sends back information which modifies the system. This information may be of difficulties, setbacks and frustrations (negative feedback) which will not encourage further migration. Although Mabogunje's system approach to rural-urban migration clearly demonstrates the value of system analysis in geography, its applications in other field of endeavours is noteworthy.

A practical analogy in Nigeria finds expression in the influx of people from all works of life into urban areas like Lagos and Abuja from the rural areas. While the rural areas experiences deficit in manpower supply for agrarian purposes, the urban centre is thus filled with unskilled labour. Without full employment, most of the unskilled (and even skilled) labour at the end of the day cannot cope with the financial cost of housing, feeding, transportation and general welfare in urban centres. On the other hand, the rural area is rendered desolate and incapacitated in meeting up her usual agrarian importance. This incapacitation invariably affects the urban centres that depend on food stuffs supply from rural farms thereby weakening the entire system and making food prices to rise both in the rural areas and in urban centres. This is similar in all respect to the biological body that requires continuous flow of materials and functioning of its component parts to keep the body stable. As a consequence, unsteady supply of food stuffs to the urban centres often leads to increase in price. In addition, it creates slum in cities as low income earners are forced to settle for make-shift or low cost housing which are often unplanned, untidy, and filled with people of questionable character ranging from prostitutes, pocket pickers, arm robbers and other social vices. Thus what affect the rural area is felt in the urban area because the rural area provides the urban centre with agrarian food stuffs ranging from local fish, yams, garri, plantain, red or palm oil, bush meat, vegetables and semi/unskilled labour. On the other hand, the remittance from urban settlers goes to the rural dwellers. Similar to a typical biological body system, if there is a break in this rural-urban system, a healthy relationship is eroded as both may no longer be able to satisfactorily complement one another as a functional system.

From the forgoing, one can conclude that system analysis is very important in geography as well as in many other disciplines, and even in our offices, homes, universities, churches, mosques, traditional system, to mention but a few.

SUMMARY AND CONCLUSION

In this paper, we emphasized that a system is made up of objects with components parts that interacts. This interaction is responsible for the kind of relationship that exists. We also assert that a subsystem may be part of another super system. That a break in any part of a system will surely affect the other components parts. We equally stated that a system is ordered and could be closed or open depending on the material supply and the direction of complementary relationship that exists. We argued that geographers are very much interested in the inter relationships of objects or phenomena in space. That Man is a major component of the earth or environmental system as an agent of change and his relationship with the environment is largely responsible for the observed pattern of human endeavours and impact such as migration, erosion, flooding, urbanisation, climate change, deforestation, to mention but a few.

Therefore, system analysis helps geographers in their study to understand as well as to explain geographic phenomena in space which was exemplified in this paper using rural-urban migration and spatial interactions.

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