



Developing Sustainable Cities in Arid Regions

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There is increasing need for efficient management of resources within developed and emerging cities. However, without an adequate framework within which to address relevant issues, there may be no legacy for the next generation in most cities. This paper makes an attempt at highlighting a framework through which an urban center could be established and administered within the arid regions. The first part looks at the general background and concepts of sustainable development while the second part highlights the characteristics of the arid regions and the pertinent issues that warrant the adoption of sustainable development. The third part draws from the various concepts, to generate a general framework that can be applied in any part of the arid regions with little or minimal adjustment. The fourth part makes a passing survey of some regions and cities, which have made use of sustainable development approaches in trying to solve relevant problems of cultural interaction, energy and the economic challenges. Based on observations and analysis drawn from the proposed design framework, the paper concludes that there is need for more research and application of the concept of sustainable development in the arid regions. © 2002 Elsevier Science Ltd. All rights reserved.

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Introduction

Despite social and scientific advancements, setbacks are a common feature in the development of cities. Some of the reasons can be traced to misplaced priorities or short sightedness, with regard to global interaction of both natural and engineered systems. To overcome this, judicious exploitation of resources within the city and its neighborhoods are paramount, in creating a balance between natural systems and those crafted to assist the day-to-day undertakings of occupants. This trend of accounting for development is variously referred to as sustainable development. The Brundtland Report defines sustainable development as follows: “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (1987). This definition is carried further by Berke and Manta (1999) for the purpose of assessing sustainability in master plans, to embody the aspects of reproduction, balance, dynamic process and, linking of local to global concerns, which reads: “sustainable development

is a dynamic process in which communities anticipate and accommodate the needs of current and future generations in ways that reproduce and balance local social, economic, and ecological systems, and link local actions to global concerns”.

The rapid adoption and application of this concept within the context of a global industrial and information society derives from recognition of the harmful repercussion of wrongful exploitation of natural resources, and the growing crunch on energy in the face of higher taxation. In developing countries, this is more or less related to shortages of natural resources on which most societies have traditionally depended for energy. The absence of equity and efficiency has led to crises that range from compounded externalities within city centers to the much-rebuked global warming. While scientists and policy makers are at loggerheads as to the exact causes of the phenomenon, there seems to be a general consensus on the need to urgently address the resulting consequences, especially in developing countries. So far, the most acclaimed course has been a concerted choice of indicators, such that there is a marked degree of dynamism within co-evolutionary systems. Since sustainability implies a constant evolution

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within an organized and adaptive set of systems, it is paramount to select the indicators that best ensure such co-existence. The choice of indicators that will allow a set of systems to be put in place and adequately monitored for a desired outcome, is largely dependent on component systems, their required degree of interaction, the scope of the aspects or projects involved and the time frame within which a desired result is anticipated.

The Bellagio Principles suggest some valid guidelines for deriving and implementing a framework suitable for a wide range of development projects (Bossel, 1999). Among the ten principles listed in the guidelines, any chosen set is guaranteed to provide fairly substantial explicit goals for a given concern. The drawback is perhaps how to identify which is appropriate for what purpose, and how to judiciously implement a scheme such that it yields a positive outcome. Yet, these principles have been introduced as a result of the inadequacy of the previous indicators, or relevant parameters for measuring developments at both micro and macro levels of a society's development. Prior to their introduction and subsequent adoption, the major indicators of development were the Gross Domestic Product (GDP), the Gross National Income (GNI) and a host of others that were derived from these two.

Like all aspects that require subjective interpretations, these indicators are not an end result in themselves, but an attempt to portray how comprehensive is a system being assessed vis-à-vis the constituent parts. The more comprehensive the indicators, the more likely it is that the chance of a cumulative impact assessment will be fair and, to an extent, accurate. However, the concept of sustainable development serves to check the cumulative impact of a given development on an existing state of economy, society and environment. This leaves the reverse impact unaccounted for. To make up for this shortcoming, the concept of Strategic Environmental Assessment (SEA) is often brought into play to complement planning efforts. SEA was introduced into development planning sometime in the late 1980s, and gained recognition in the mid 1990s as a proactive tool for sustainable development, such that environmental issues could be established and adequately addressed at the policy level. This allows for the assessment of cumulative environmental impacts from secondary and downstream developments associated with large projects. Thus, according to Wiseman (1996), it can improve the efficiency and effectiveness of policies and plans whilst focusing attention on sustainable development. It is this last aspect that can render the concept of sustainable development quite suitable for checking the problems of cities within the arid regions of the world.

Characteristics of arid regions

Technically, the arid regions of the world include those located within the tundra belts, commonly

referred to as cold deserts, and those located within the equatorial belts of the world, otherwise referred to as hot deserts. It seems the need for differentiation is responsible for introducing the term *Arid Lands*, which applies to those developable and habitable belts, mostly in desert and semi desert areas. These include the Sahara, the Arabian, the Atacama and the Taklamakan among others (Fig. 1). According to Golany (1978), at least four major types can be identified, influenced by the latitude of the area, the distance from the sea, the absolute or relative elevation, and the topography and geomorphology. Somehow, the location of these deserts coincides with the location of most of the world's underprivileged populations, particularly with regard to arable lands, natural resources, population structure and socioeconomic potentials. In most desert settlements, the challenges stem from extreme temperatures that are characterized by high diurnal ranges, shifting sand dunes and occasional sand storms. These areas are known to be drought ridden, subject to sporadic storms and floods beyond the capabilities of most makeshift or transient dwellings. The general health per capita expenditure is estimated at an average of \$165 and energy consumption per capita is put at some 1500 kg of oil (Newsweek, 1995). The percentage of arable land is low, (at 1.0 – 9.0)% across the equatorial belt, and the availability of potable water is equally very low.

In both the Saharan and the Central Asian regions, increasing desertification is blamed on the chopping of trees for domestic fuel. Yet, the region abounds in one of nature's inexhaustible energy resources—solar energy—and in addition to this are both wind and geothermal energies, particularly on the coastal areas. The production of waste, ranging in tens of thousands of tons per day, also provides further dimension for energy potential. However, the absence of technological potential has deprived the majority of governments and communities of their exploitation. Those located within the third world, as of 1995, had a 49% rate of urbanization. In addition, they have some of the world's most rapidly growing population (8.3%) often of a relatively young age, all gravitating towards urban centers. According to Hall (2000), these regions approximately have a 5% urban growth rate, which is likely to double in the next 13 years. Their informal hyper growth is likely to hit double-digit millions by the year 2025, with aggravated poverty, an unsound economic base, and a population deprived of basic education. Most of the cities, particularly within the desert belts of the equator, experience drastic water shortage increasing desertification, deforestation and deplorable urban sanitation due to increasing immigrants that they can barely, and most often, ill afford to support. The result has been devastating living conditions and the prospect of increasing pollution and other such malaises, unless drastic steps are taken to address them, as articulated through a revisit of the Istanbul declaration in the urban21 manifestations.

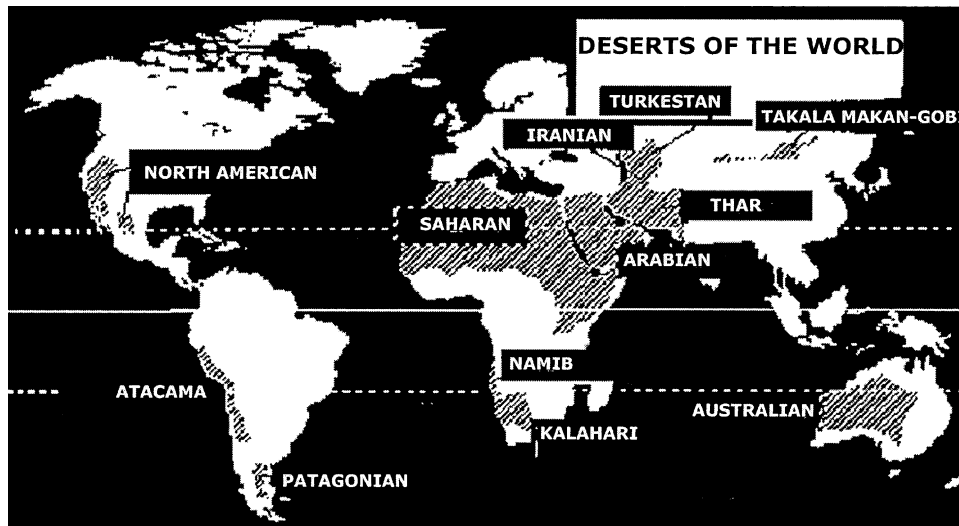


Figure 1 Major deserts of the world

Examples of sustainable cities in the arid lands

Globalization tends to spread uniform urban cultures, though the time and conditions of their operations mark a great difference in resulting consequences. Development within the Sahara region and across the Arabian deserts points to the fact that there is some measure of awareness related to current sustainability issues. The case of Morocco is worth noting with regard to its water management policy in the Souss-Massa region. According to Rhodes (1999), "economic growth and educational opportunities are stunted, especially for rural women who spend an average of 90 minutes per day hauling water in rural areas. Water scarcity is also a catalyst to Morocco's rapid urbanization, as farmers unable to pay for new wells are forced to join the rural exodus". The region is characterized by an average of 250 mm annual rainfall, a land extent of some 27,000 km² and a population of approximately 2,500,000 people. It is additionally responsible for about 60% of the country's agricultural products, mainly citrus and tomatoes, which depend extensively on irrigation drawn from an aquifer, which is experiencing an annual fall of approximately 1.5 m per year in some areas. Prompted by the need to conserve the ecological system and ensure a measure of management with regard to the consumption of natural resources, the government has put in place a number of pilot projects in conjunction with partners such as the USAID and the German agency KfW. One of these ventures is a partially self-sufficient wastewater system that will see the generation of methane for sale and for the powering of the plant's generator. Sales of treated water to neighboring green houses could further boost cash flow. Similarly, reed stems grown for denitrification, were also expected to be sold for structural uses. Earlier schemes have already taken off within the areas of the Tadla irrigated perimeter near Beni Mellal, pro-

viding an annual water supply to a city of 500,000 people, in addition to the provision of water to some 120,000 people within the mushrooming peri-urban areas between 1994 and 1998 alone.

Another project of similar magnitude is the *EcoPeace* project, in the Gulf of Aqaba, a consortium of non-governmental organizations from four countries headed by Palestine. The principal goal of the consortium is to foster sustainable development in the Middle East, through funding from the German Heinrich Boll Foundation. The project, which debuted in 1997, has succeeded in establishing a comprehensive framework that sees to the implementation of the general principles of sustainability, particularly with regards to a sustainable environment. The main emphases of the scheme are the reduction of "the potential negative impact of mass tourism, which involves the unplanned building of hotels and tourist infrastructure, inadequate arrangements for waste disposal, overuse of energy and water resources, and poorly supervised tourist activities of various kinds—so that the unique environment biodiversity of the Gulf, the very basis for its touristic appeal will be preserved" (Twite, 1998). In addition, the consortium advocates active participation of the local community as a primary component of the scheme's success.

Elsewhere in Arid Central Asia, emphasis is equally placed on the development of sustainable management of water schemes. The area contains the countries of the former Soviet Union, that include the newly independent republics of Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan, and Turkmenistan. The region consists mainly of low lying desert surrounded to the South and Southeast by very high mountain ranges, which have great impacts on the climate of the region as a whole. As a result, the limited supply of the region's water reserve is being challenged by rapid population increases in the urban areas that are exceeding traditional demand. With a population of

over 56 million in 1998, and an estimated 131 cubic kilometers per year of water supply, the average person gets under 2.5 m³ (2500 l) of water per year, or more specifically, 6.94 liters per day. According to Smith (1999), the bulk of the water supply, some 80% is used for irrigation, with the remainder is divided between industrial and domestic consumption. Again, most ground water that is used in the region is pumped up from fresh water lenses that form as water filters through the sandy banks of the many unlined canal systems of the region. Therefore there is danger of contaminants being easily transmitted to the large urban population. Current planning efforts include the development of reverse osmosis systems and drip irrigation agriculture. The emphasis is towards conservation rather than the development of new sources of water. There is also the activation of community cooperation, to better manage the shared resources.

Recent sustainability efforts have been launched at the Toshka area in Southern Egypt. The project, which is a mega effort to make the desert bloom, is estimated at some US\$ 90 billion by the time it is completed in 2017 (Anonymous, 2001a,b,c). It comprises a giant pumping station that could be the world's largest, with some 24 pumps that will raise water from Lake Nasser, to a height of 50 m, under driving forces of between 200 – 375 MW. The unit is expected to pump out about 5.5 billion liters of water per year (the equivalent amount of Egypt's allowable out-take from the Nile) into Sheikh Zayed canal and along its tributaries. The project, which is part of the South Egypt Development Project, could see the government reclaiming some 2268 sq km, for resettling the growing population of the country. As anticipated, the project is expected to open up new opportunities in the way of industries, mining, oil and gas production as well as tourism. However, the project is seriously criticized for lacking focus as well as sucking much needed cash liquidity from an already ailing economy. Nonetheless, it has been backed by a number of foreign investors such as Saudi Kadcó, the US fruit giants SunWorld Inc. and others.

The scale of a comprehensive city program similar to that of the development in Dubai, UAE is unparalleled for any of the cases that have been reported to date. The focused program of reclamations, modernization and decentralization is so elaborate that most high-tech firms have started relocating to the newly established cyber city of Jebel Ali. The projects range from new airports, seaports, elaborate road networks and offices through to housing developments. Apart from sewage transformation plants and seawater desalination plants, other industries have been created to cater for secondary developments such as environment and related issues.

The overall population of the UAE is expected to roundup to 2 million by 2005, with a work force growth rate of approximately 9.5% (Anonymous, 2001a,b,c). However, the pivot of development efforts is the capital city of Dubai. Its strategic development

plan stretches to the year 2015, which will see the development of approximately 42100 ha of land over three phases of five years each. Infrastructure development is expected to account for some \$1.36 billion, in the first phase alone. Due to the harsh climatic conditions, that are characterized by temperature fluctuations and high humidity, special techniques have been developed for the implementation of various development plans that should prove useful to other cities in the region.

The range of applications is reflected in the state-of-the-art intelligent parking systems at the recently inaugurated airport complex. An internationally acclaimed group of companies successfully implemented automated systems to handle parking for over 1100 vehicles over a usable area of 55,000 square meters. Housing projects include the skywalk towers, made of twin 17-storey executive apartment complexes, the 60 million square meter marina project, whose first phase alone accounts for six major towers, comprising some over 1200 apartments capable of accommodating 80,000 persons. In addition to these, a \$20.8 million children's city covering some 9000 square meters will complement the housing schemes with information and recreation facilities. The developments in the city have attracted a large following internationally, to the extent that a \$26 million contract has been initiated by a desalination plant at Jebel Ali, to provide 40,000 cubic meters of fresh water per day to the Russian Black Sea resort of Gelenjdik. Other developments include elaborate street lighting, irrigation systems for landscaping and storm-water drainage systems. The initiation, which has already witnessed international exposure, is set to revolutionize development in the gulf region and beyond. However, the cultural dimension has somehow been down played.

Planning cities in arid regions

An increasing hyper growth phenomenon has seen the population of most cities soaring to tens of millions, without adequate resources to neither sustain them nor guarantee the future of subsequent generations. Since most of the countries in extreme need lie within arid regions, the challenge is even greater in attempting to generate a common framework for the development of cities, within their precarious socio-economic and environmental setups. According to Ortolano (2000) the challenges lie in the creation of methods to operationalize ideas and measure development needs. Various models have been proposed that range from wide abstractions, to some down-to-earth approaches. Of interest to us, however, are the flexibility, ease and viability of such models. Academic literatures have been growing with theories of sustainable cities over the last two decades. One of the torchbearers is Friedmann (2000), who reflects in *The Good City: In defense of Utopian Thinking*, on a wide range of arguments as to how and why "social action

and political projects are essential in the betterment of a society that clearly needs change and hope". Friedman's Good City is supported by four main pivots, which are: theoretical considerations, human flourishing as a fundamental human right, multipli/city as a primary good and, good governance. These bear distinct marks of the progress made in the past century with regards to both planning theories and physical planning. For instance, the issues of housing, affordable health care, employment and welfare are central items of his multipli/city. On the other hand Mega (2000), demonstrates four highly motivating approaches, through which innovative actions towards sustainable development in European cities can be achieved. The four points of synopsis are: the horizon of innovation towards the environmentally sustainable city, innovations reinforcing the socio-economic sustainability of cities, visions and actions for planning the sustainable city and, towards the city of humanness, solidarity and citizenship. The overall strength of this argument cannot be greatly distinguished from that put forward by Friedmann, which may imply some measure of convergence. However, Friedman's argues that "cities opened to the future cannot be conceived without regeneration of suburban areas...this entails recreating economic diversification, social heterogeneity, and cultural diversity in the periphery" and it must be argued that this backs up fine theories that need both commitment and local refinements to see any sort of implementation.

In addition to these theories, the UN Habitat Indicators Database provides a broad range of 70 indicators that are supposed to provide sustainable guidelines for any comprehensive development. The extensive discrepancy of local agendas and lack of data at various national levels does not seem to support the intentions or objectives of these indicators. This implies subjectivity may well lead to widely varied interpretations, again compounding the issues of simplicity and theory. What appears to be the locomotive for operationalizing sustainable development may as well have been left out in the drive for quick results. The absence of capital for development, and established habits of the people that make up these areas, cannot be discounted in the face of introducing western-focused industrialization that fosters accelerated biological and cultural destruction (Hempel, 2000). Additional concerns are how to implement the much desired restructuring without hurting the often-precarious political landscape or overcoming the difficulties of establishing an infrastructural network, in difficult and harsh terrains, as well as a highly mobile community. Again, proponents of sustainability take different tacks when it comes to implementation. On the one hand, there are those who favor community-oriented implementation, and on the other, those who favor development-oriented implementation. Even in the development trend, there are four subcategories that include, natural capital, urban design, ecological

systems and metropolitan governance. While it is not clear which option is best for any particular development, it is obvious that a successful implementation has to proceed from incubation, through assimilation, to dissipation of a chosen concept. The challenges abound and the responses could be as diverse as the will of the community, or as the microclimatic conditions dictate. Herein lies the need for an implementation mechanism that brings to focus the peculiarity of difficult terrains, cultural dynamism, and socio-economic diversities.

Developing a sustainable design framework

The establishment of the design framework for a sustainable development has to be within a balanced structure of "Top-Down" and "Down-Top" dialoguing, the reflection of the various components of a society as well as the composition of the natural environments at both micro and macro levels. The key emphases should be on clearly articulated set of goals, which should include:

1. The formulation of policy planning to ensure continuity of the schemes by subsequent generations of planners, administrators and citizens through periodic review of the scheme to ensure its legacy.
2. The creation of a viable socioeconomic structure, to guarantee equity and lessen externalities that normally result from exploitations and interactions.
3. The inception of a socio-cultural structure, for conserving the legacy and culture of a given community.
4. Establishment of a viable infrastructure to delimit negative impact on the environment and encourage efficient use of resources.

It is sometimes difficult, if not impossible, to draw a line between the similarities and differences among people inhabiting a common region or a city, yet no two communities are the same or are under the same set of circumstances. This calls for caution in the use of indicators and integration of other parameters such as climatic variations, ecosystems, homogeneity of the people and their interactions or non-interactions. The overall political vision envisaged for a region in question and the development of a city needs to be centered on the relative coherence of its component parts, the governing policy and the driving socioeconomic aspirations. The same will translate to the neighborhood cells of a city. These concepts and the current trends in their execution can be organized around the framework of infrastructure, transportation and urban morphology. This somewhat loose coupling helps in translating a set of policies into quantifiable entities. This can be very useful in generalizing design approaches that could be useful in the course of a sustainable development scheme.

Transportation concepts

Most planners and policy makers look upon transportation as the most vital component of urban systems. It engenders variation of land use, and inherently supports the socioeconomic activities of a city. Though the overall layout of a transportation network can be the result of predetermined and planned land uses, it is susceptible to change with changing perspectives of users. Another dimension is the fast pace of technological developments. For a considerable period of time now, the automobile has been central to the planning of most transportation systems. However, due to increasing awareness of environmentally related pollution and other social malice that can be directly attributed to its effects, other modes of transportation are being experimented with. Yet it seems that flexible and convenient solutions are not in the immediate future, though some valid options, such as subways and monorails, have been satisfactorily deployed in many industrialized parts of the world. These options-like those that have preceded them-have not met the travel aspirations of a class of users who are constantly under the pressure of time. There have been two attempts to redress this, through conceptual revision of land use planning and traffic zoning in the early 1980s. Whereby, there was a shift towards desegregation of land use, in favor of compact planning, to minimize the need to travel across long distances for daily needs. Today, the move is towards alternative means of transport. In Japan, the US, and other parts of Asia, this has witnessed some success, chiefly as a result of subways and the introduction of monorails. In parts of Western Europe, such as is the case in France and Germany, the advent of the Magnetic Levitation Train has helped in fostering the cause of mass transit, as is the case in Singapore, and other parts of East Asia (Graham, 2000).

These developments are resource-intensive and way beyond the reach of countries within the arid regions, with the exception of a privileged few. Therefore, the development of a viable transportation scheme will still be dependent on the use of conventional systems with such sensitivity that gives major priority to pedestrian dominance over a wide range of the city center. The most suitable layout for a scheme will be an organic wedging of a primary concentric model, to adjunct neighborhoods. The success of Wright's Radburn plan (Kaiser *et al.*, 1995) and subsequent variants in utilizing neighborhood cell concepts, attests to its suitability in situations where it is desired to achieve a measure of sanity within the urban center and ensure both a clean environment and a healthy populace. The scheme should therefore comprise an inner pedestrian core, with controlled vehicular access reserved for emergency cases. Radiating collector lines will then form the spines, allowing interconnections of the city through a number of outer rings that will at the same time serve as bypass for heavy traffic not desired within the city

center. The element of success in such a scheme is the control of fringe growth within the adjacency of the major transit corridors, or marked green reserves, which could lead to the formation of sprawls.

Morphological concepts

Urban design schemes that constitute the basis for urban form call into play the essential elements of both socioeconomic, and socio-cultural dimensions of the city. To let people identify with a place and provide them with the sense of belonging, urban design schemes must be as committed as possible and as reflective as the aspirations of the community will allow. The major challenge, of course, is the adoption of a multicultural perspective in the case where diverse groupings, common across the Saharan belt and most of Central Asia, make up the majority of the population within an urban center. The schemes' goals and objectives will have to be centered on:

1. Integration of services, through a careful interconnection of the various land uses, by the means of integrating corridors of green belts, and the radial spines as depicted in the transportation scheme.
2. Encouragement of vertical zoning, through utilization of medium-height structures in the central circulation corridors.
3. The reservation of a central area, exclusively for the development of socio-cultural infrastructures with a general and public character.
4. The provision of neighborhood cells with extensive vegetation and low-density construction in as much of the city as possible.
5. Site layouts assuming cluster patterns, and buildings so oriented as to enhance the performance of wind corridors. Where courtyards are used, the principles of the wind scoop should be exploited to enhance the micro climatic environment of the courtyard.
6. The adoption of local building materials, and close scrutiny before any alternative is utilized.
7. Envisaging industrial developments, so worked out as to form the integral part of the city infrastructure within walking distance of not more than 30 – 45 min or the equivalent.
8. The development of an industrial unit, if not located within the circulation spines must be such that freight and other similar deliveries can be effectively carried out without compromising the operation of the city's traffic systems.
9. The design of all proposed developments should be tailored to encourage healthy living and mutual coexistence with the environment.
10. The planting of trees in residential units and other public areas, with the support of an appropriate irrigation scheme.

Infrastructure concepts

The development and provision of infrastructure within an urban center is considered a key component of the success of an overall scheme. The most important elements that need careful analysis and judicious implementation are the energy and water schemes. The following goals and objectives should be established to assist in the exploitation of energy resources of the regions.

1. Solar Energy: For the use of households and related activities.
2. Biomass: For industrial use and related activities.
3. Wind: For agricultural and related activities.
4. Geothermal: For aquaculture and related activities

The provision of safe potable water for any community within the Arid Regions dominates the bulk of the literature dealing with sustainability. The techniques currently employed range from recycling wastewater for the purposes of irrigation, the desalination of seawater for both industrial and domestic provisions, as well as the incessant drawing of underground water for both domestic consumption and agricultural purposes. This last aspect is already raising concerns on the part of some experts who fear a complete depletion of the aquifers. To effectively plan for the use and management of water schemes within these regions, it is deemed best to adopt a comprehensive policy that wholly involves the populace right from the inception of a scheme to its implementation and upkeep. The following measures are proposed to ensure water conservation and maintenance:

1. Establishment of a community framework to initiate and implement the water scheme.
2. Establishment of a fresh water management policy by effectively monitoring the aquifer level and continuously seeking alternatives to its replenishment.
3. Institution of a water-rationing mechanism through communal incentives.
4. Establishment of recycling plants for industrial and domestic gray waters.
5. Establishment of programs for converting resulting byproducts into reusable capital returns such as methane, from biomass transformation.

In addition to the above, the collection and recycling of domestic and similar waste within the city could be put into effective outlets for employment as well as additional sources of revenue for the city. These three broad categories will require an adequate design approach for initiating a master plan to guide the establishment and implementation of the schemes. Additionally, it will require some understanding of the climatic, environmental, socio-cultural, socio-economic and the traditional urban fabric, as well as the policies governing them, such that each of them

can be appropriately tailored to the goals of a sustainable city.

Design approaches to sustainable cities

The design approach, as is the case with most planning schemes, is carried out within a given set of parameters. Often, planning draws from one school of thought or another. In the past decades, there have been multitudes of such theories, ranging from the popular Comprehensive planning, otherwise referred to as *Rationalism, through Incrementalism, Synoptic, Advocacy* and *Transactive* planning. In each of these, the idea was to provide a theoretical background on which to base the arguments of a planning scheme. Today, the arguments are more or less embodied within the framework of sustainable development, appropriately tailored to the use of a particular community. The logic of this amalgamation is apparent through a close examination of how this could be achieved. Fig. 2 details five principal stages through which a design is filtered to ensure that it meets all the demands of a proposed scheme, and, at the same time, produces the most suitable option. The design commences the moment a design brief is analyzed and converted into set objectives.

The objectives are then filtered through the following five points:

1. *Sustainable design objectives.* The goals and objectives of the brief are checked here vis-à-vis the desired outcome and how positive it is likely to affect end users, environment and the resultant natural balance, both in the short and long term.
2. *Sustainable design guidelines.* The sustainable design guidelines comprise a set of indicators specifically selected from the economic, social and environmental subsets to assist the refinement of a design brief (from step 1 above). The indicators help in establishing invaluable links among the economy, environment, and the society, without discounting the likely transformation of the environment through its continuous interaction with the end users' dynamism. The set of indicators are derived from the UN Database, Agenda21, Urban21 or similar references, to suit the purpose of a project. The range and scope should be allowed to expand and contract with respect to the climatic, environmental, socio-economic factors and the wide socio-cultural aspirations of end users.
3. *Sustainable design statements.* These are an amalgamation of the Design Guidelines with the scheme's design philosophy, to reflect a concretization of the design with respect to the site, its environs and all its future interaction with other systems. The statements should be listed and placed so as to provide planning development at the conceptualization stage and subsequent stages. This ensures a hold on key policy issues.

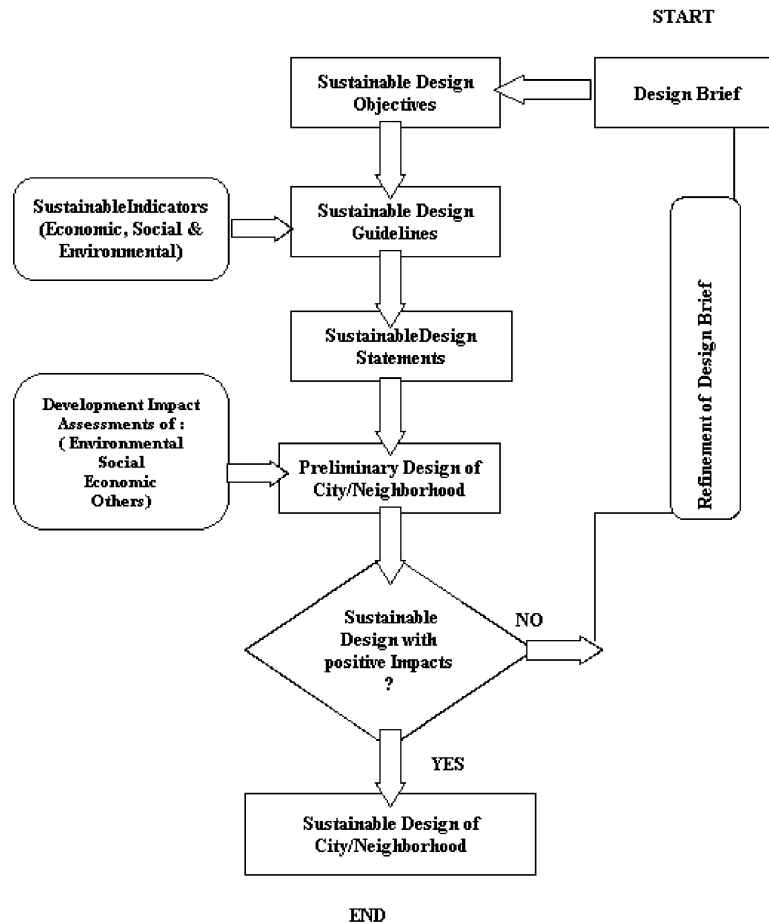


Figure 2 Sustainable design approach

4. *Preliminary design.* The preliminary design is a stage that determines the selection of alternative designs based on their compliance with the key elements of impact assessments. The alternative schemes are repeatedly checked to ensure that only schemes that provide the best option in terms of compliance with the environment, socio-cultural, socioeconomic and other predefined elements, are retained for further evaluation.
5. *Sustainable design scheme.* From stage 4 above, the design is assessed as to whether it is sustainable and possesses positive impact on the environment and end users. If not, it is looped back to the design objective phase and further filtered down the line until a satisfactory design is achieved. A satisfactory design scheme is retained for implementation. At the same time, this stage allows the impact of the external milieu (SEA) on the project to be established, as a compliment to the EIA of the project.

Table 1 provides short-listed issues involved in the selection of master plan indicators to match a particular design environment for a city or its constituent part. The table indicates cross tabulation of objectives,

issues, and approach to sustainable design. Conventionally, it is sometimes necessary to include the weight for each associated rating in the selection criteria. The first section addresses general master plan elements and the second addresses development concerns within the arid regions. The whole framework is summarized (Fig. 3), illustrating the overall concept of arriving at sustainable-cities design within the arid regions.

Concluding remarks and discussions

The sustainable development examples surveyed earlier, allude to some measure of sustainability of cities within the arid regions. However, were these to be compared to their fulfillment of the master plan and development issues as listed in Table 1, then the shortcomings of each case could be immediately apparent, in comprehensively tackling issues of sustainability. As a result of not addressing all the issues, there is the feeling that the overall level of sustainability is somehow below average, due to emphases in some areas at the expense of others. For instance, the case of the developments at both Toshka and Dubai are highly ambitious and tend to emphasize

Table 1 Issues of sustainable with respect to elements of master plan and development concerns

Objectives/Elements	Issues	Approaches to sustainable design
Master plan	◆Policies	Political vision to ensure continuity of plan. Allow for public participation and reviews
	◆Land use	Determine suitability, location/space requirement, and holding capacity for various uses such as industrial, commercial, residential and institutional
	◆Infrastructure	Make provision for and establish viable communication, transportation and water/power systems within the various land uses
	◆Urban design	Provide imageability, intelligibility, connectivity and articulated architectural forms within the various land uses
Development concerns	◆Natural resources	Determine the quality and quantity of water/energy supply necessary to sustain development within the city and appropriate methods of exploitation
	◆Local/global link	Determine and establish the modalities of dealing with local policies that reflect on global concerns, the relative impact of global action on people and proposed projects
	◆Environment	Determine and sustain air quality, ecological balance, the extent of waste generation and appropriate means of management
	◆Population	Determine the population characteristics, its social values, cultural norms, socioeconomic potentials and relevant employment schemes

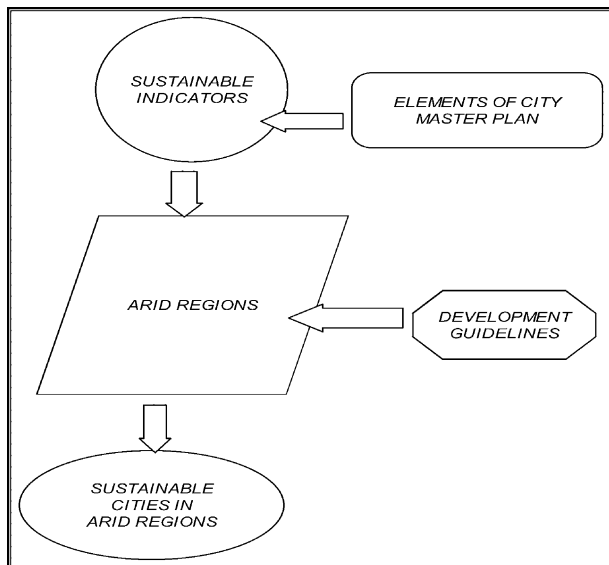


Figure 3 Design framework to sustainable cities

infrastructural development, with a major transformation of the environment within which they are to exist. The two cases are strong on the policy level, but rather wanting in the face of cultural parameters. Similar trends are noticeable in the case of the developments at the Gulf of Aqaba and the Central Asia

Region. However, more emphases are geared towards cultural preservation and natural resources conservation. Morocco, on the other hand, seems to have taken a central position emphasizing almost all the key issues of the rest. With the exception of the developments at Dubai and the Gulf of Aqaba, there is almost no mention of any morphology in the rest of the cases examined. This is partly explained by the background of surveyed literature, as well as the attitudes of the respective authors involved in their production, that seemed skewed or at most infrastructure or energy-biased.

A further observation of the areas of concentration in the cases examined reveals that dominant ideas seem to be on infrastructure issues, followed by conservation of natural resources. The population factor seems to have been somewhat sidelined in the majority of cases examined, except in the development at Toshka, which seems to make employment an excuse of displacing a substantial number of people to the project region, though this happens to be a critical matter relevant to planning and implementation of the concept of sustainability. Dubai, to an extent, makes an attempt to track its population growth and relate it to the projection of the job market. It is perhaps the only case that shows a link between local agendas in relation to a global outreach, as its potential investment in desalination plants directly translates to the

supply of fresh water to Russian Black sea resort of Gelenjdik.

The above analyses have traced the various issues involved with the definition and establishment of sustainable indicators appropriate for applications to the design and management of a city within arid regions. A survey of relevant literature shows that the problem of population structure, energy resources, waste disposals and especially the availability and distribution of potable water, pose increasing threats to the survival of the present generation as well as compromising the needs of future generations. These problems have prompted the establishment of key frameworks within which the problems of any given city within such a region could be adequately addressed. A flow-chart process (Fig. 2), is introduced as well as a reference checklist (Table 1) that should provide a suitable guide to the selection of the necessary indicators relevant to a project under study. However, this is not a fixed approach to the problems of planning for a sustainable city in the arid regions, rather it should serve as a pointer towards a means of uplifting relevant researches and application of concepts, tailored to the needs of the challenges in an otherwise difficult, yet potentially important region of the world.

In conclusion therefore, the development of any city within the arid regions needs a careful study of the sustainable indicators that will assist in the day-to-day management of the city or adoption and implementation of proposed development plans, such that the essential components of socioeconomic, environment and socio-cultural parameters are kept within a reasonable balance. By following a strategic framework, such as that proposed, this can be realistically achieved within the scope of sustainable development, appropriately tailored to the needs of any communities involved.

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