J. King Saud Univ. vol. 1, *Architecture and Planning,* pp. 59-74, Riyadh (14090989)

Planning Responses to Aeolian Hazards in Arid Regions

Amjad Ali Rizvi
Department of Planning & Urban Studies, College of Architecture and Planning, King Saudi University, Riyadh, Saudi Arabia.

Key words: Abrasion, aeolian, aerodynamic, air infiltration, barkhans Building configuration, chemical stabilization, deflation, deposition, desert ecosystem, fencing, geomorphology, green belt, hamada, sabkhas, sand dunes, sand stabilization, vegetation stabilization, wind breakers

Abstract. On the assumption that understanding of the intensity of sand and dust movement and the problems arising therefrom, is essential to control aeolian hazard in and around urban regions of arid dry countries, this paper evaluates the nature of the aeolian phenomena, the kind and degree of attendant hazards, and the way urban planning and related design professions have been, and should be, responding to them. The informational context is the Arabian Peninsula, in particular the Kingdom of Saudi Arabia.

Aeolian problems have been compounded because, over the years, a new agent-man, has been added to the traditionally known forces of geomorphological change. The role of this agent whose expedient actions change the ecosystem of desert lands ought to be controlled. To this end, environmental impact analysis should include also the aeolian impact analysis of the site for urban development, and of the projects for infrastructural development.

Aeolian impact analysis would include geomorphological mapping and on-the-map identification of the hazard areas. This would help planners devise preventive siting measures such as avoiding important land uses on the paths of sand and dust laden wind or sand dunes. Also, such studies would help in adopting selective combative measures, such as surface stabilization through organic and inorganic materials, adequate fencing system, and suitable innovations in building configuration and design.

Urban and regional planning agencies should also institutionalise aeolian monitoring and study system, and assemble and map geomorphological data on a regular basis. Aeolian regulatory clauses in building codes and zoning and sub-division regulations should be introduced. In short, a bold and total approach would counter the hazards of aeolian geomorphology in arid dry countries.

Introduction

In the past few years, extensive work has been done on the morphology of uninhabited desert lands, but very few that relate to the inhabited urbanized and developing regions of this dry desolate eco-system. In such a system, the magnitude of geomorphological processes of wind origin are so overwhelming that they dominate all other environmental factors. Past and recent history of the desert and dry regions provides

ample evidence of the way biotic life and human settlements were destroyed by wind action affecting the movement of sand and dust, the processes of erosion and deposition, and the morphology of natural landscape and developmental features [1, p. 1].

Urban development also, in turn, disturb aeolian and fluvial processes which often destabilizes local geomorphology and undermines the structural strength of the built up features and urban and regional land uses. The resulting disturbance of desert ecosystem in and around urban areas creates conditions prejudicial not only to the physical development but often also to the sustenance of life in these environments. Thus, owing to wind related hazards, human and animal life is weakened and threatened; natural vegetation is reduced and destroyed; buildings are defaced and destabilized; communication lines are weakened and overwhelmed, and a host of other hazards are multiplied.

On the assumption that understanding of the intensity of sand and dust movement, and the problems arising therefrom, is essential to control wind-related hazards in and around urban regions of dry lands, this paper examines the nature of aeolian phenomena, the kind and degree of attendant hazards, and the way urban planning and related professions have been, and should be, responding to them. The informational and illustrative context is the Arabian Peninsula, in particular the Kingdom of Saudi Arabia.

Extent and Intensity of Aeolian Hazards

Hazards of sand and dust movement are common in dry arid lands, but their destructive effects are more pronounced in regions of active sand dunes, sand seas and areas geomorphologically destabilized by urban and regional developmental activities. These areas are in North Africa, Arabian Peninsula, Central and South-western Asia, Southwestern North America, Southeastern South America, and most parts of Australia (Fig. 1). These regions possess more than 350 cities containing one fourth of the world's population. Clearly, planning these cities and their environs in a relevant manner is important. Unfortunately in fact, they have been allowed to develop without regard to the highly significant desert environment phenomena mentioned above. This is a serious omission and must be restrained particularly in the Arabian Peninsula (Fig.2).

Urban-oriented geomorphology moves in sequential stages. At the pre-urban stage of development, as trees and vegetation cover are removed by building activity, evapo-transpiration is decreased and consequently the erosive power of wind is increased. As development proceeds and construction sites are rendered bare, land is eroded further and is aggraded downstream. Infiltration of water is decreased due to building-induced impermeability of urban land surfaces until at the final urbanized stage, the landscape is replaced by a completely paved impervious layer of asphalt, brick, stone and concrete. At this stage, run-off is discharged artificially through

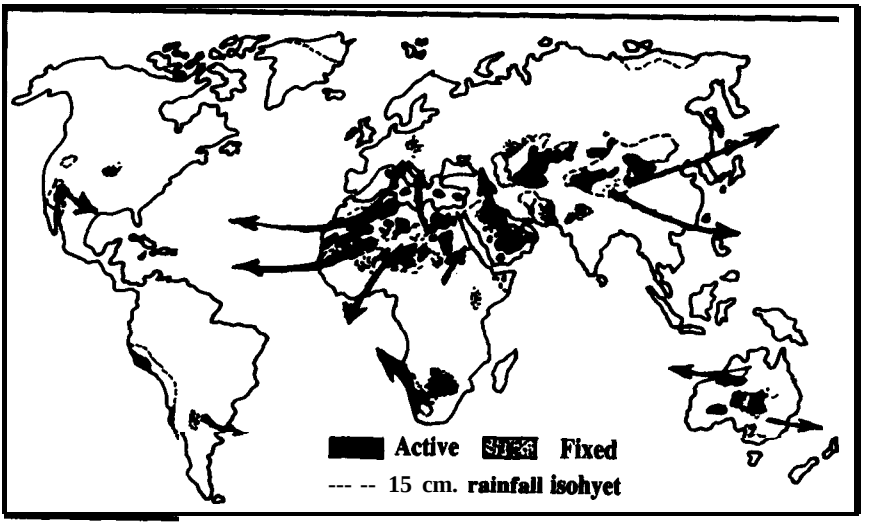


Fig. 1. Extent of active and fixed sand dunes and directions of dust movements [1, p. 1; 2, p. 225]

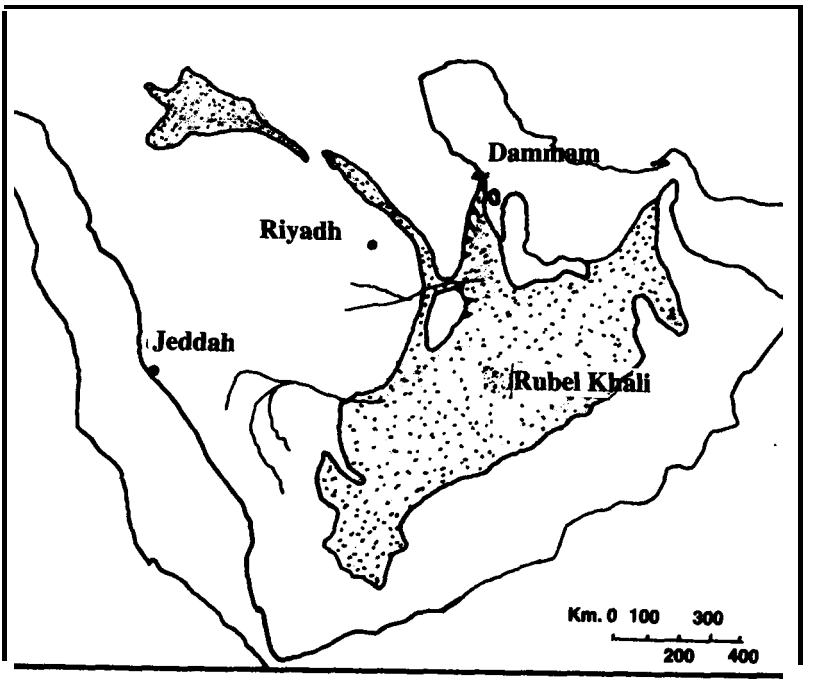
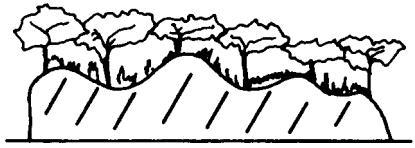


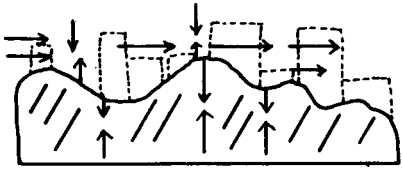
Fig. 2. Extent of recent done fields in the Arabian Peninsula [3, p. 265]

paved drains and conduits and sedimentation is decreased significantly on land surface. The windward periphery of the city, its open areas, its hollows, and spaces between buildings become depository of aeolian materials. The city must prepare itself to this changed phenomena resulting from the replacement of natural 1 and **scape** with the urbanscape (Fig. 3).

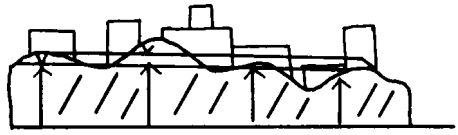


a. Pre-urban stages: Nature intact

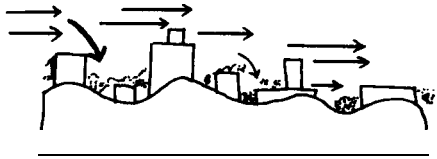
b. Early urban stage: Building activity starts



c. Urban stage: Evaporation transpiration decreases; erosive power of wind increases



d. Urban stage: Water infiltration is decreased due to impermeable urban land surface; run off discharges artificially



e. Urban stage: Windward areas, and hollows become depository of aeolian materials

Fig. 3. **Urban aeolian processes.**

In most parts of Saudi Arabia, geomorphological processes are marked by the movement of sand and dust which has reached alarming proportion in recent years for various man-made reasons. Overgrazing by camel and cattle has reduced bushes. Rock crushing, bulldozing, grading, jeeping, trucking and camel trailing have loosened top surfaces and thus accelerated sand and dust movements. As a consequence, built structures are abraided, building materials and utility structures are corroded; walls, columns and poles are pitted, fluted, grooved and are exposed to

corrosion; communication poles are sand blasted; glasses lose transparency; painted surfaces get damaged; mechanical equipments are worn; visibility is reduced; communication is disrupted; eyes and throat are infected; food is contaminated; animals are often suffocated and vehicular accidents are increased. In short, built-up areas are adversely affected and human safety is badly endangered.

Massive deposition of sand and dust causes substantial coverage and often complete burial of young plants as well as such important urban features as trails, tracks, railway lines, roadways, pipelines, runways, landscaped areas and high valued land uses. There are historical and contemporary examples of the abandonment of settled areas as a result of such burials [4, pp. 207-208]. The Cost of containing these massive aeolian hazards are so prohibitive that the huge urban capita is often allowed to deteriorate(1). Also on regional scale, the top six inches of soil in Saudi Arabia is in a state of continuous motion and this reduces the upper fertile patch from vegetative embellishments even if water were available.

Saudi soil is in many parts sandy, salty, calcareous and porous, and therefore, a poor medium even for the minimal plant growth. The harsh climate combined with high alkalinity in salt-encrushed zones, such as "sabkhas" inhibit plant growth. The bare land surface or its top material, the "hamada", the massive sand dunes and the crescentic "barkhans" in static or dynamic forms are hazardous to urban and regional developments (Fig. 4). Worst of all, the lack of geomorphological knowledge on the part of planners, engineers and developers is often reflected adversely in the design of buildings, infrastructures and land use. In fact, it is often not realized that man himself is a geomorphological agent, for his urban based activities disturb geomorphological equilibrium(2). This can be illustrated by the fact that urban watershed

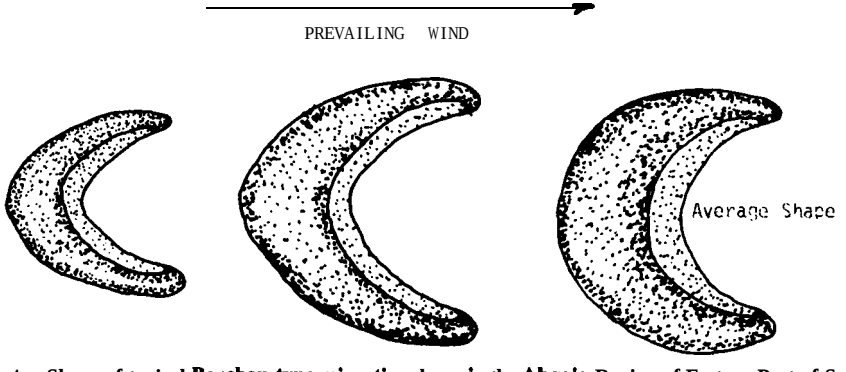


Fig. 4. Shape of typical Barchan-type migrating dunes in the Abqaiq Region of Eastern Part of Saudi Arabia [6, p. 29].

(1) For example, the abandoned Damascus-Medina Hejaz Railway has been buried by sand almost beyond recognition since it stopped functioning a few decades ago.

(2) For a persuasive advocacy of this thesis. [5, p. 165]

undergoes erosion five times higher than a rural watershed [5, p. 113] and makes huge material ready for transport and deposition elsewhere. Hence, the geomorphology-oriented policies for sand, dust and wind action processes will help restrain their destructive effects in the developing desert landscape such as those in the Kingdom of Arabian Peninsula.

Nature and Consequence of Aeolian Processes

If the destructive consequence of sand and dust movement around urbanizing regions is to be countered, it is essential that the nature and intensity of the aeolian processes, as well as the problems arising therefrom, be well understood. What follows is a brief discussion on the subject.

With its small grain size of 0.08 mm diameter, dust has lower specific gravity and higher cohesiveness than sand which has a grain size ranging from 0.08 to 2.0 mm diameter. Dust travels suspended in wind often lifting to great heights and forming an aerodynamically smooth cohesive surface, thereby allowing high velocity winds to entrain it. Sand, on the other hand, travels in hops and jumps, and rebounds near the surface in what is known as "saltation curtain", often gaining flight momentum from air stream. Through sifting action during the movement, sand is segregated from dust and are often built into superficial aeolian bedforms. Thus the dynamic action of wind and fine surface materials is crucial to the shaping of the desert landscape, and may be examined in terms of three related processes: deflation, transport and deposition.

Deflation

Deflation is the process whereby sand and dust are removed by wind action. It is induced by human actions which are initiated by preparation of land for urban and regional developments. The scouring action of deflation depletes soil constituents and weakens urban utilities and structures. It gains momentum by sedentarization of the Arab "beduins" and "tauregs" as well as by herding, grazing, ranching and drilling which renders land bare for removal by moving wind and water.

Transport

Sand is transported by abrasive action at a 'saltation height' of one meter, while dust may rise to several hundred meters rendering the sky hazy and dull. In the eastern regions of Saudi Arabia, abrasion and transport is pronounced in summer under the impact of the high speed northerly 'shammal' winds. Abrading sand and dust-storms such as the Libyan 'ghibli' in Sahara and the Saudi 'belat' in the Arabian Peninsula disintegrate soil, increase surface erodibility, erode building materials, weaken utilities, damage mechanical equipments, and by reduced visibility, disrupts urban and regional transportation. In the western Hejaz region of the Kingdom also, the easterly 'samoun' wind is laden with sand and dust and causes like damage.

Sand and dust movement is a function of wind erosivity, which depends on the velocity, frequency and intensity of wind, and of surface erodibility which depend on

the kind of vegetation cover and type of surface soil. Since the 'ergs' of Sahara and Arabian Peninsula have minimally aggregated soil and almost non-existent vegetation cover, they produce maximum material in motion. Efforts have been made to predict their intensity through a host of surface and wind data [2, pp. 255–269]. Collection of these data and attendant researches should be organized in a big scale before deciding to adopt remedial planning measures. Woodruff and Siddoway developed a comprehensive equation for prediction purposes as follows [2, p. 269; 7]:

$$E = f(I', K', C', L', V')$$

where

E = computed soil loss (tons/acre/year)

I' = soil erodibility index

K' = soil ridge roughness factor

C' = climatic factor

L' = field length along wind erosion direction

V' = equivalent quantity of vegetation cover

The equation is universal in nature. It indicates the nature of data required for measuring wind erosion, and is useful for determining control measures for wind erosion [7].

Deposition

At the depositional stage, dust and sand bury plants, increase road and runway skiddings, contaminate household stuffs, and create bouts of allergy and discomfort. In the eastern and central Nejd regions of Saudi Arabia, for example, the settling dust before dawn and dusk causes allergical eye diseases due to viral and bacterial constituents in it [8, p. 34]. On transit or as sand dunes and 'draa', sands overwhelm urban infrastructures and cause desertification which depopulates settlements and increases migration, as in Algeria, Libya, Pakistan and Saudi Arabia.

The mechanism of dune formation and dune movement should be monitored and researched with the help of wind data, sand typing, surface profile and dune volume. This dune study also demands an organized data collection and assembly system which is almost non-existent in most dry developing countries such as Saudi Arabia. Given the necessary data on dune height, packing factor, sand flow, wind velocity, and moisture index, many empirical relationships have been suggested for calculating the rate of sand and dust movement and deposition which should help adopt alternative measures of control.(3)

(3) Some of these empirical relationships are reviewed [2, pp. 255-269; 9]

Planning and Management Responses

In recent years, there have appeared increasing number and kind of professional responses to geomorphological problems, notably aeolian hazards in countries with arid dry climate. Such responses have, however, been few and fragmentary. They have not been comprehensive enough due essentially to the lack of geomorphological perception in planning and design professions. Some of the existing practices and possible alternatives at urban and regional levels in Arab countries, notably those in the Arabian Peninsula have been reviewed.

First, at pre-urban stage of development, somewhat superficial site selection procedures have been in vogue. At its best, surface and environmental factors are accounted for, technical advice is sought and relief and hydrological areas of geomorphology are considered. Aeolian matters are examined more for design manipulations than for site selection decisions.

Second, at the early stage of urban development, equilibrium between building activities and geomorphological forces is disturbed. This stage is marked by a decrease in top soil layer, vegetation cover and evapo-transpiration, and a consequent increase in erodibility and erosive power of wind because earth digging and urban constructional activities render the surface bare.

Lastly at the final stage of urban development, streets are paved, culverts are built and the developed open areas are hardened, until the city is completely built and routine progressive developments follow. At this stage, responses to wind related hazards, wherever applied, take the form of dust prevention architectural devices; only rarely are the macro approach of aeolian-oriented land use disposition or the area1 safety devices for substantial urban development projects are adopted. The correct strategy demands a comprehensive geomorphological approach.

At the early stages, regional developments or site selection within regions must take into account tectonic, alluvial, fluvial and aeolian factors, and later the planned areas should be so designed as to avoid or minimize the effects of dust, sand and other wind related hazards following the external preventive methods as well as the internal compative techniques. Some of these techniques in vogue are reviewed here.

First, screening the entire settlement or a threatened built up area through a series of tree clusters, or a green belt as wind breakers in the windward side is a common method being used to avoid wind-related hazards (Fig. 5). Kabul, for example, is protected from dust storms by a necklace of picturesque greens. Ashkhabad is sheltered by a canal and green band on the path of hot dusty and sandy wind (Fig. 6) [10]. In the oasis towns of Al-Ahsa and Al-Hafuf on the eastern region of Saudi Arabia, outstanding results have been achieved with indigenous trees such as tamarisk as a

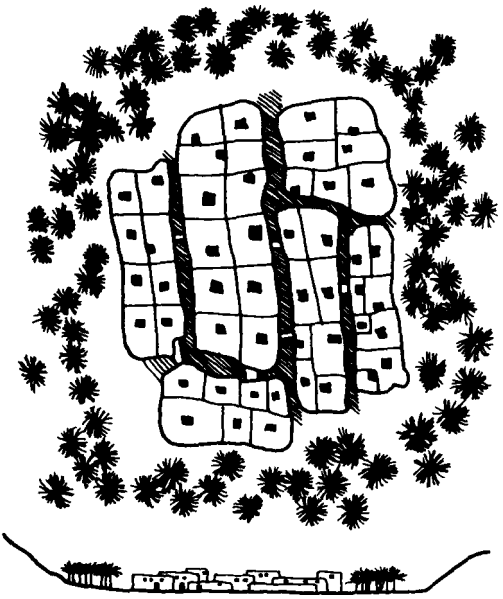


Fig. 5. A wadi village protected by thick growth of palm trees all around [8, p. 491

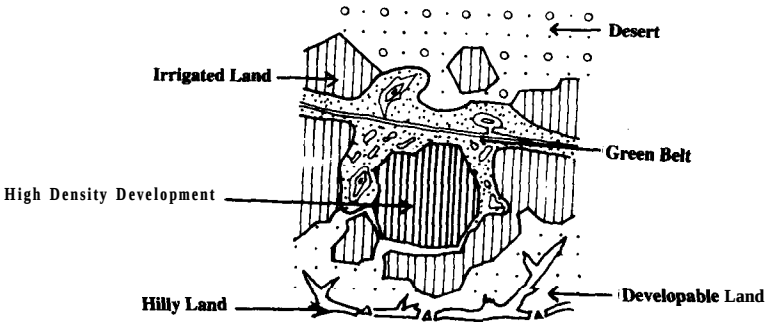


Fig. 6. Protection of asbkbabad from aeol in hazard [11, p. 52]

screening band. These somewhat costly but easily affordable devices in the water deficient countries of the Arabian Peninsula significantly reduce shear stress and act as sand and dust traps. Yet, notwithstanding their notable success in many countries, such possible devices are rarely used to advantage on big scale in the vast arid lands.

Second, inside the cities, apart from land use manipulation, extensive landscaping with local water-resistent centepede species as well as ubiquitous gravel and stones are useful media to be extensively used for reasons of health, aesthetics, micro-climate and aeolian abatement. Amongst the Saudi Arabian cities, Jeddah is aggressive in this regard [12, p. 55] as is Riyadh, notably in its King Saud University Campus and Diplomatic Quarters. However, such examples of landscaping are exceptions rather than a general rule in arid dry countries.

A close look into urban planning and development activities of the arid dry cities suggests that the urban land use is methodically planned and the structure of the city is meticulously designed with all factors in mind except the aspects of sand and dust movements. In land use layout openings are placed across the sand laden dusty wind, or their blowing path and saltation curtain intervened with adequate structures-, screens, fences or xerophyte trees. Unpaved roads are asphalted and dirt roads are stabilized with gravel beds so as to reduce sand and dust erosion and accumulation.

On architectural level, many innovations are in vogue. Thus, blind walls are used. Doors and windows are reduced or designed in directions that face or minimise sand and dust penetration. Combative rather than preventive measures are more common. Thus, air-filtration systems such as storm doors, shutters and weather stripping are fitted to buildings, and of late, desirable building materials on external walls or surface polishing are applied so as to abort sand erosion as well as corrosion on exposed surfaces.(4)

Again, building configuration in dusty, sandy dry lands are designed with environmental factors other than those of aeolian nature. Researches are being conducted and design guidelines are being made available in this regard. For example, Gandemer has shown aerodynamic effects of different building configurations on deposition, abrasion and discomfort from flying sand and dust (Fig. 7). Thus, low horizontal long buildings produce bar effect with deposition and abrasion on leeward side; converging buldings result in venturi effect with discomforting abrasion on converging areas; parallel buildings with different heights have deposition on windward side and abrasion on other sides; enclosed buildings give mesh effect with in and out deposition and abrasive affect on obtuse sides; buildings with openings have gap effect with abrasion immediately across and deposition further down;

(4) For example, a locally manufactured light weight cem-filled glass re-inforced concrete (GRC) is being increasingly used in Saudi Arabia for its resistance against erosion and corrosion. Reported in: Arab News (October 14, 1986).

comer effect of depositional nature occurs on elevations and facing wind and abrasive effects occurs on comers, sides and gaps; high and low building have deposition on leeward side and abrasion on the other side; parallel buildings set in linear fashion show channel effect with deposition at the entry and flying dust and sand further down; finally, a high rise building amidst old traditional houses gives rise to depositional zone before the wind facing elevation, a growing tendency in most central sections of the cities of the Arab world (Fig. 7, A-l) [13, pp. 423-432] these aerodynamic processes producing different aeolian results illustrate the type of experimental research required and may serve a useful guideline for planning and urban design.

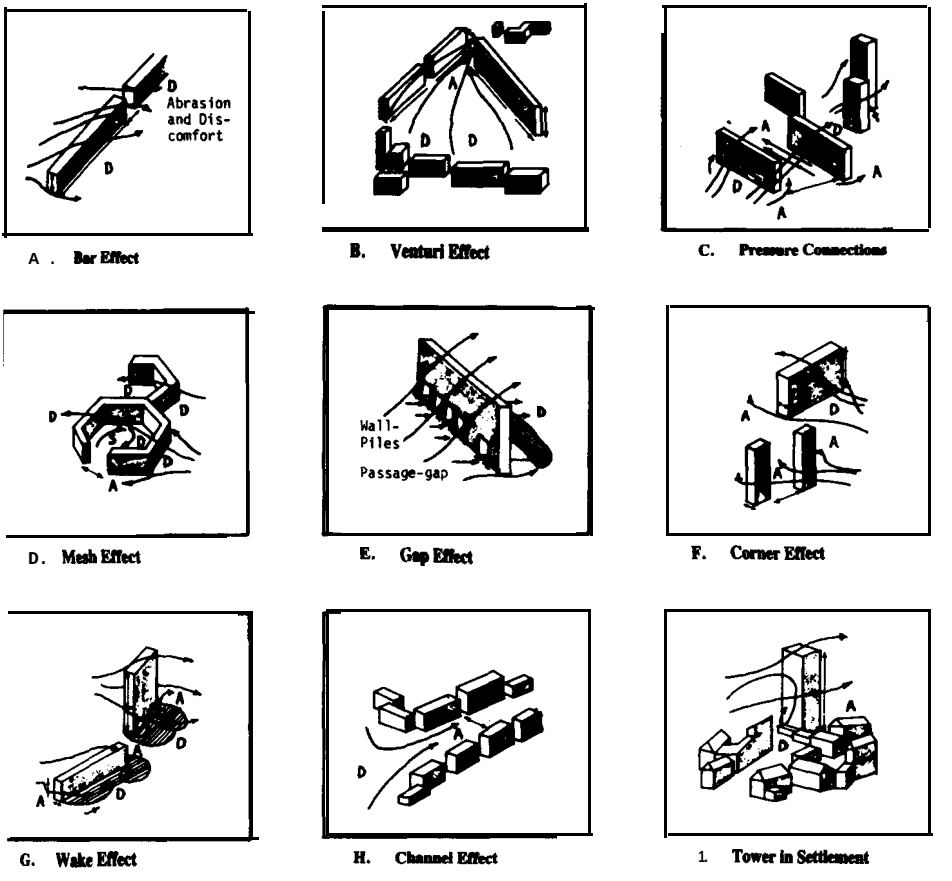


Fig. 7. **Aerodynamic effects of building configuration on deposition of sand (D) and abrasion and discomfort** resulting from **flying sand** dust (A), **modified from [13, pp. 423-432]** by **[2, pp. 270-271]**

On the regional scale or in the urbanized areas outside the built up areas of the cities, there is the raw land in plain undulating or hilly form. Structurally, they may be inselberg, **hamada,** reg, serir, sand dunes and sand seas. They are all formed by wind action. In order to develop and conserve these areas, one has to reduce the effects of deflation abrasion and deposition discussed above. The possible solutions being adopted in areas in, or adjacent to, important projects are related to the treatment of land surface with water, plants, gravel, stones, oil and chemical sprays.

As regards water, it is deficient in these lands and can be used only in big projects within urban areas. Gravel is ubiquitous, and if used in a professional manner, is an inviting landscaping media in the aquatically and vegetationally deficient Arab Peninsula. Crude waxy and asphaltic oil have been used fairly extensively and successfully in the oil-rich eastern regions of Saudi Arabia as sand and dust binders (Fig. 8). So are the chemical sprays of resin-in-water and gelatinized starch solution for surface stabilization.

Fig. 0. Dune Stabilization by Oiling

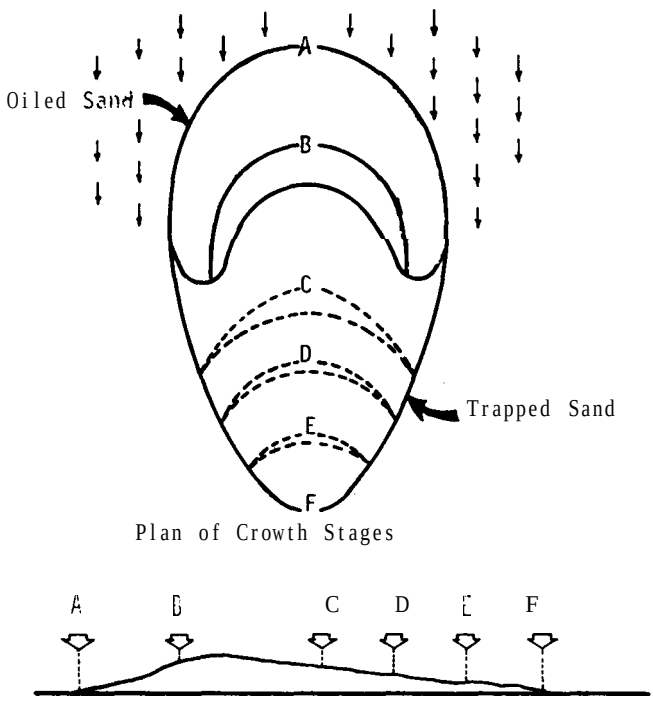


Fig. 8. Dune stabilization by oiling [2, pp. 286-287; 6, pp. 1541-1573]

The aquatically thirsty desert lands pose tremendous problems for vegetational stabilization. Sand dunes which are the common features in such environments are mobile and therefore, defy vegetational stabilizational approach. But in most other areas, including even sand dune infested ones needing urgent conservation and improvement, this measure would help if judiciously studied and applied. There is a vast amount of xerophytic plants and surface covers available for use. These need a minimum amount of water. Such desert plants as acacia, yellow oleander, asparagus, tamarisk, banyan and cacti succulants are soil binders; melia azedarch, china berry, hena, hebiscus, rosa senenusi, nerium oleander, date palms, bougainvillia and prickly bear may be used for erosion and dust control. Vegetational stabilizational measures are being applied with great success in some parts of Saudi Arabia. For example, Hafuf and Al-Ahsa areas in the Kingdom's eastern regions display the successful use of indigenous, mostly tamarisk, trees which have permanently stabilized sandy areas and dunes and helped change the local ecosystem in an exemplary manner [8, p. 5].

Also, some areas with traces of past vegetation which need protection are conserved by natural recovery method. This method is used in areas with enough ground water and low deflation. The areas should be conserved artifically by planting selected species through contour ploughing, strip cropping, fertilizer use and mulching and their erodible surfaces be sheltered against control erosion.

Next, fences of various design and material are in use as wind break and wind diversion that reduce erosion and deposition. Fences can be designed with materials of required porosity for effectiveness. Their angle can be changed to promote desired diversion, and their profile can be changed to create varying impounding effects in sand dune areas.

Fencing and surface treatment approaches for dune stabilization is resorted in specially threatened areas needing protection. Other methods, such as flattening, transporting and trenching that are used in some areas are temporary measures because the blowing wind soon recreate aerodynamically suitable surfaces similar to the original surfaces. Therefore, such dune treatment devices can be used in special and localized areas and not on a big scale .(5)

Conclusion

Examination of the aeolian or wind related aspects of geomorphological scene in arid dry countries such as the Kingdom of Saudi Arabia has shown that the problem is serious enough to warrant attention by planning professionals who have thus far considered it to be outside their traditional preoccupation. The problem is also

(5) A variety of practical measures of the kind reviewed have been experimented and applied in Saudi Arabia with notable success [6, pp. 31-32].

becoming serious due to the increasing threat of desertification, sedentarization and culturization of dry landscape. Thus, it is essential to create perception of wind-related problems in planning, design and building professions.

Of equal importance is the disturbing observation that under the craze for rapid development, man himself, apart from natural forces, has become an agent of geomorphological change. Hence, the role of man whose expedient actions change the macro or micro ecosystem in desert lands ought to be controlled. To this end, environmental impact analysis should envelop wind impact analysis of the site for urban development and of the projects of builidng and infrastructural nature.

This analysis would include geomorphological mapping and prior identification of areas of wind hazard with the help of field surveys and remote sensing imagery. Given this study, preventive siting measures can be adopted, such as avoiding major important land uses on the direction of sand dune movement, or allocating green uses on the path of sand laden winds.

In Saudi Arabia and other Gulf countries, combative measures such as surface stabilization through water, plants, gravel, stone, oil and chemical sprays are being adopted in selected areas. Sand and dust infested structures are being transposed and threatened areas stabilized by extensive plantation of indigenous water resistent xerophyte species including ground cover. Built-up areas and urban projects are being protected by fences of various design and materials. Threatened or even destroyed ecosystem is being recovered by natural and artificial methods. Building configurations and their spacing and openings are being designed in such a way that the disfiguring and often distructive effect of wind hazards on structures is contained and its discomforting impact on urban inhabitants is minimized.

However, isolated measures in selected areas are not enough. Urban and regional planning agencies such as the Kingdom's Ministry of Municipal and Rural Affairs should also institutionalize aeolian monitoring and study system at their level. National agencies such as the Geological Survey and the Department of Meterology should collect, record and update geomorphological data on a continuous basis, and make them available to land development agencies.@) Also national and local agencies such as the MOMRA and local municipalities should enact and introduce aeolian regulatory clauses in building codes and in planning, zoning and subdivision regulations.(') In short, a comprehensive approach is essential if the vast

(6) These data can go a long way in developing a dust warning system in desert lands which can help deter many accidents and resulting loss. Berrit and Hyers found positive correlation between the enactment of dust warning system and traffic accidents [14].

(7) In effect, according to verstarren, aeolain -oriented risks are serious enough to merit adoption of hazard zoning [15, p. 152).

tries such as Saudi Arabia are going to protect their inhabitants from the wind-related hazards of geomorphology and to conserve the raw beauty of their desert landscape.

References

[1] **Pewe, T.L. (ed).** ***Desert Dust: Origin Characteristics and Effects*** on Man. Boulder: Geological Survey of America, 1981

[2] Cooke, **R.U., Bnmsden, D., Doornkamp, J.C. and Jones, D.K.C.** ***Urban Geomorphofogy in Dry Lands.*** Oxford: Oxford University Press, 1982

131 **Brook&Id, M.F. and Ahlbrandt (eds).** ***Eolion Sediments and Processes.*** Amsterdam: Elsevier Science Publishers, 1983.

[4] **Biswas,** M. *and* **Biswas, A.** ***Desertification.*** New York: Pergamon Press, 1980.

[5] **Nir, D.** ***Man: A Geomorphological Agent, An Introduction to Authropic Geomorphology.*** **Dor**decht: Reidel Publishing Co., 1983.

[6] **Kerr, R.C. and Nigra, J.O.** ***Analysis of Eolian Sand Control.*** New York: American Oil Company, 1959.

[7] Woodruff, **N.P. and Siddoway, F.H.** "A Wind Erosion Equation". ***Proceedings of the American Soil Science Society, 29*** **(1965),** 602-608.

[8] **Talib, K.** ***Shelter in Saudi Arabia.*** New York: Martins Press, 1984.

[9] ***Cook,*** **R.U.** ***and*** **Warren, A.** ***Geomorphology in Deserts,*** London: 1973.

[10] **Golany,** ***G. Desert Planning.*** London: Architecture Press, 1982.

[11] **Rimshaw, A.R.** City Building in Hot Climatic Zones. In: ***G. Golany, Desert Planning.*** London: Architecture Press, 1982.

[12] **Farsi, S.** ***Jeddah: A Changing Ecosystem.*** Research Publication No. 4 Jeddah: Jeddah Municipality, 1393.

[13] **Gandemer, J.** "Wind Environment Around Buildings: Aerodynamic Concepts." ***Proceeding of the 4th International Conference on Wind Effects on Buildings and Structures,*** (1977).

[14] **Berrit, B. and Hyers, A.** "Evaluation of Arizona Highway Dust Warning System" in T. Pewe, [I, p. 284].

[15] **Verstarren, H.T.** *Applied Geomorphology*. Amsterdam: Elsevier Publishing Co. 1983.

حركة الرياح غير المرغوبة، وتأثيرها على التصميم والتخطيط العمراني في المناطق الصحراوية الجافة

أمجد علي رزقي
أستاذ مساعد، كلية العمارة والتخطيط، جامعة الملك سعود
الرياض، المملكة العربية السعودية

ملخص البحث. عندما يتسنى لنا تفهم حركة الرياح وما تحمله من غبار وأتربة، وما تسببه من تحركات رملية حول مناطق العمران في الأراضي الصحراوية الجافة، فإنه يمكننا التحكم في الخطر الناتج عنها. وهذا البحث يتضمن تقييما لظاهرة حركة الرياح المحملة بالغبار والأتربة، وما يترتب عنها من أخطار، وما يجب أن يراعيه المهندسون المعماريون والمخططون في تصميماتهم لتفادي هذا الخطر في الجزيرة العربية عامة وفي المملكة العربية السعودية خاصة.

وللأسف فإنه على مر السنين نجد أنه قد تفاقمت مشكلة حركة الرمال والأتربة، حيث قد أضيف عبث الإنسان كعامل جديد إلى القوى والعوامل التي تغير من التركيبة الجيولوجية للأرض في سبيل ما يوافق منفعته ومتطلباته . . . الأمر الذي يجب الوقوف في وجهه وعدم التمادي فيه . . . الخ. وعليه، فعند القيام بتخطيط أو تصميم مشروع معين، يجب أن يضاف إلى التحاليل البيئية التي يقوم بها المصمم لأي موقع، هو مدى تأثير حركة الرياح المحملة بالغبار والأتربة على المشروع المراد تصميمه والمرافق التي تخدم عليه . . . وتتضمن هذه التحاليل إعداد خرائط للتركيبة الجيولوجية للموقع، وتحديد أماكن الخطر للرياح المترية بها حيث مثل هذه التحاليل سوف تساعد المخطط أن يبتكر الحلول المناسبة في الموقع ليجنب مخططه أو تصميمه احتمال أن يكون في مسار الرياح المحملة بالغبار أو الرمال أو حركة الكثبان. كما أن هذه التحاليل سوف تساعد المصمم في اتخاذ الخطوات اللازمة لتثبيت التربة بواسطة استعمال المواد العضوية وغير العضوية، وباستعمال نظام الأسيجة المناسبة، وبابتكار التصميم والتكوين المناسب للمباني.

كما يجب على هيئات التخطيط والمهتمين بالأبحاث القيام بدراسة، وتجميع الخرائط والبيانات الخاصة بالتركيبة الجيولوجية، والعمل على تحديثها ورصد المتغيرات المستجدة بها، كما أنه يجب أن تتضمن لوائح التخطيط واستعمالات الأراضي، وقوانين المباني ما يبين الاهتمام بفهم التركيبة الجيولوجية لأي موقع يجب اتخاذ خطوات شاملة وحاسمة لمجابهة خطورة حركة الرياح المترية، والرمال والكثبان في البلدان الصحراوية ذات المناخ الجاف.