INDIA - Country/Regional Monograph

Demographic Trends,Issues of Energy, Ecology and Housing

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Abstract

Against the background of India's demographic trends, issues of energy, ecology and housing have been examined. Work of research institutions and housing agencies has been reviewed and examples of climatogically significant housing projects have been illustrated.

Keywords
India; population; climate; energy; hierarchical spaces; housing; rural and urban settlements.

Introduction

In order to clarify the scope and dimensions of the issues relating to energy, ecology and housing In rural and urban settlements in India, It may be useful to examine the country itself briefly and to see to what extent its population patterns and available resources dictate the policies and priorities of its government.

Lying entirely in the northern hemisphere, India's mainland extends between latitudes 8°4′ and 37°6´ north and longitudes 68°7´ degrees and 97°25´ east and stretches approximately 3000 kilometres from north to south and from east to west.

Four decades ago, in the aid-1940s, the total population of India was approximately 350 million, with an urban component of 50 million. It is now double that figure, i . e . , 700 million, which i s almost equivalent to the combined population of the witole of Africa and Latin America, and allof it squeezed into an area no larger than a third of the u.s.A.' It has been estimated that, in another fifteen years, India will have approximately 1000 million people (1 billion) and its projected urban population of 400 million will be more than the entire population of either the U.S.A. or the U.S.S.R.

As for the resources, government statistics (Singh, 1975) indicate that the country's land area is 327 million hectares of which arable land available is of the order of 154 million hectares with about 41 million hectares of irrigated land. It i s estimated that the total irrigation potential of the country is only 107 million hectares. At present, the 550 million Indians living in 600 000 villages depend for their livelihood on the 154 million hectares of arable land, of which 113 million hectares are unirrigated. As . a result 40 per cent. of the rural population is surviving below subsistence level, hence the drift to towns and cities.

India's census figures also suggest that in this drift, villagers have a tendency to bypass the smaller towns which, like the villages, are also economically stagnant. Villagers travel directly to die middle level towns or metropolitan centres which offer prospects of employment, rather than the bright lights and so called superior amenities of large cities which are popularly supposed to act as a magnet. Cities are multi-functional in nature and their economic activity is diversified, the two factors which make them attractive to immigrants.

However, most cities in India, particularly larger metropolises like Bombay and Calcutta, are ill prepared to receive the migrants from rural areas. The majority of newcomers are unable to find areas where they can enjoy even the rudimentary amenities of city life - a good water supply, lighting, roads, means of removal of human and other waste. Instead they take their place alongside roads, railways lines, canals, rivers or any available neglected, unoccupied urban land offering easy access to a possible source of work. The type of work they undertake often decides the nature and place of their squatting areas.

In their attempt to build themselves some shelter, squatters are-handicapped by the absence of the traditional materials used in the villages. In the city they have to rely on materials such as packing cases, flattened tins and rusty corrugated iron sheets, often salvaged from factory waste or refuse dumps.

So, as far as housing Is concerned, the problem in India is twofold. The first is how to improve shelter for 40 per cent. of the rural population, which lives close to or below the poverty line. The second is what can be done to abolish or upgrade urban slums and squatter settlements and assure the orderly growth of existing and new towns and cities of India.

Against this somewhat chaotic scenario, India‘s leaders face what amounts to almost a superhuman task of planning human settlements for one billion people - a task to determine how and where they will live, work and move; produce their food and their shelter and develop a stable and balanced social and economic life.

Energy

In addition to housing, a problem which is beginning to concern India‘s policy-makers is the need for energy conservation.

In India (Sankar, 1980) the average per capita consumption of commercial energy annually is 0.189 tonne of coal equivalent which is one of the lowest in the world, particularly compared to the U.S.A where on average American consumes fifty-nine times as much. Of- the total energy consumption the share of-oil conssimption is about 45 per cent. and half of this is imported from other countries. This dependence on oil and the increasing demands on energy consumption made by the country’s expanding industries have created some real headaches for its leaders and policymakers.

In rural areas nearly 70 per cent. of energy is consamed as household fuel in the form of wood, cow dung and vegetable waste, and the rest in the form of human and animal labour. Architect Vinod Gupta of the Delhi School of Planning and Architecture has converned himself with the mechanics of power supply and sewage disposal which pollute the air and water in Indian settlements.**2** Gupta has put forward alternative methods of servicing which are more in tune with natural forces and which could help to achieve an ecological balance in the rural and urban environment of India.

The current work at the Central Building Research Institute (C.B.R.I.) at Roorkee is specifically aimed at the improvement of rural sanitation, and its research programmes into solid waste disposal systems, water supply and biogas techniques have made some progress. For

India's sprawling rural communities, biogas offers a vast potential. Ten years ago there were only 4000 biogas plants in the country. Now there are 100 000, a number which is still insignificant considering the need for energy conservation in a sector where cattle waste is wholly consumed as a household fuel.3 It has been estimated that one cow can meet the fuel needs of one person and India's cattle population is approaching 250 million. So, the importance of this source of energy is obvious.

It has also been found that costs fall and benefits rise steeply with the size of the biogas plant, i.e., the cubic metres of gas it can generate. There is therefore considerable potential for further research into large sized economical biogas plants.

In urban areas, however, the pattern is different. In addition to the transport and manufacturing industries, the building sector is one of the major consumers of energy. An examination of India's Five Year Plan (National Buildings Organisation, 1982) clearly indicates chat the country spends as much as 50 'per cent. of its development allocation on construction activities of one kind or another and of this nearly half again is spent on buildings and houses.

One of the current issues being debated within India's building industry concerns the regulation of heights of multi-storeyed buildings which require high energy consuming materials, such as steel, mechanical equipment and mechanical and electrical services. The aim (National Buildings Organisation, 1982) is to encourage building with low energy consuming traditional materials, such as bricks, lime, stone and timber, or to substitute materials, like flyash, pozzolane cement, fibre(instead of steel) reinforcement and structural clay bricks.

C.B.R.I. has also developed methods to increase the life of materials like mud and thatch, widely used in rural areas, by making them water-proof and pest-proof but their application has been limited to a few demonstration buildings in the Station's compound in Roorkee. It is heartening, however, to see the involvement of a number of non-govermental institutions in the use of low cost, low energy indigenous materials and techniques. Architect Ashish Ganju (1982) has listed a number of instances including his own contribution to the UNICEF programme of building low cost rural community centres in three distinct climatic regions, which will be discussed later in this paper.

In India, organisations which are endeavouring to promote increased use of indigenous materials and techniques, particularly suitable for rural areas, include the government's own National Buildings Organisation Regional Housing Wings in different regions, which offer research facilities and technical advice to local people. Then there are voluntary organisations working in rural development operations, often acting as catalysts in mobilising community efforts.

Some of the Schools of Architecture, specifically the Delhi School of Planning and Architecture and the Ahmedabad Study Action Group, haves pecial options for the development of this kind of work. As for research, in addition to the, C.B.R.I. mentioned earlier, the Indian Institute of Science, Bangalore, has an appropriate technology research group - ASTRA. (Application of Science and Technology to

Rural Areas) - where scientists have been experimenting with cement, stabilised mud block, lime and surkhi (crushed bricks) plaster.

Housing

As mentioned earlier, there is an acute shortage of housing in rural and urban areas of India and much of what is available is of an extremely poor standard. It has been estimated that this shortage is approximately 94 mil.lion units and i s increasing at the rate of one million units every year. According to Jagmohan (1975), India has one of the highest congestion rates in the world. Approximately 20 per cent. of the families live in homes of 10 square metres. The Indian government's housing policies, despite good intentions, generally favour the middle and upper classes. In 1970 the Housing and Urban Development Corporation (HUDCO) was established to finance and develop urban housing estates and building material schemes/* The Corporation has made some headway In providing sites and services but i t s contribution to the building of housing units has been little? more than a drop in the ocean.

The government has also tried prefabrication. The- Hindustan Prefab Ltd company has been established to manufacture prefabricated houses but its product has not been wall received by the public because of the high cost of manufacture and delivery. The expense has proved well beyond the means of the poor majority whose needs are the greatest. This company mainly produces reinforced cement concrete components, pre-stressed concrete poles, foam concrete panels and partitions and insulation blocks.

Self-help

In recent years, the governments, both central and state, have all but given up trying to provide housing on a mass scale and have tended to use their meagre resources to upgrade the amenities and services of existing slums and squatter settlements, as well a8 to service new land for future growth. The aim is to leave it to the people themselves to build their shelters with whatever means are available to them. In many instances building codes and bylaws have been revised to allow this to happen, a move which indicatesthat authorities are now prepared to accept sub-standard dwellings legally.

Slum clearance schemes were launched as early as 1956 but were given a real boost in 1972 when, under the Central Scheme for Environmental Improvement in Slum Areas, the central government offered generous financial assistance to state governments to provide water supply, sewerage and drains, community baths and latrines, street lighting, widening and paving of existing lanes and footpaths. Under-this programme some token progress has been made to improve the *bustees* of Calcutta, the *chawls* of Bombay, the *charries* of Madras, and even attempts have been made to rehouse Delhi's 250, 000 poor who now illegally occupy *jhuggies* and j*honpries* on government and public land. However, despite these efforts, the main problem of the housing shortage in the country continues to present a major challenge. So it is understandable that India's housing authorities are more concerned with finance and land, the two key ingredients of housing, than with the issues relating to the environmental quality and physical comfort requirements of shelter for the poor.

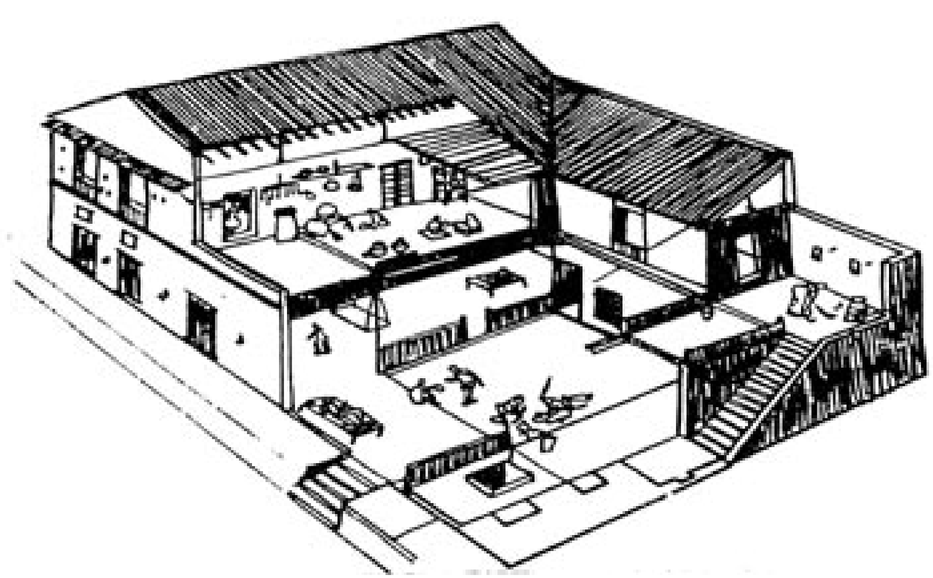
A low cost housing scheme which ubes India's warm climate as a basis for housing land development has generated considerable interest among housing experts i n third world countries. It was developed by architect Charles Correa (1974) who has been advising the government of the State of Maharashtra to develop New Bombay, a city of 2 million people on 22 269 hectares (55 000 acres) of land as an alternative to relieve the pressures on the old city.

Hierarchy of Spaces

Correa questions the basis on which many Western experts calculate the housing needs of people in Asian cities as being normally two small rooms and space for cooking and washing. He maintains that the room is only one element in a whole system of spaces people need in order to live. In a hierarchical system involving public and private areas, usable space is either enclosed, simply covered or open to the sky as appropriate to warm climates where a number of activities can and usually do take place outdoors. In the case of 'New Bombay' it has been estimated that 75 per cent. of these essential functions - cooking, sleeping, entertaining - can occur in private courtyards for at least 70 per cent. of the year. This gives a courtyard a utility coefficient of 0.75 X 0.70, i . e . , about twice that of a built-up room. Bearing in mind relative production costs of built-up rooms (materials, labour) and the courtyards (land prices, services), it is possible to trade off between them and thus determine the optimal pattern of housing.

Here the essential principle is that in a warm climate, space itself must be calculated as a key resource similar to building materials.

Understanding of this principle* which varies with different cultural/ climate contexts. Is but the first step to understanding the problem of low cost housing in India. It is over-simplistic to just build many rooms or housing units without appropriate concern with the spaces involved in the system; it i s an approach which is often unrelated to the needs of the people in warm climatic regions.



Left: Fig.1. Suryakant Patel's sketch of a typical house showing the different elements of planning and the pattern of living in an Indian settlement.

The hierarchical system of enclosed and open spaces in an Indian house has been clearly enunciated by architect Suryakant Patel. His sketch for a typical urban dwelling (Fig. 1) indicates differentelementsof planning and the pattern of living in a house which has been simply constructed with traditional methods of brick walls and country tiled roof. After a brief summary of various climatic zones in India, it is proposed to desct-ibe and illustrate selected examples of housing built at a low cost and with, in many cakes, an innovative approach to provide comfortable structures.

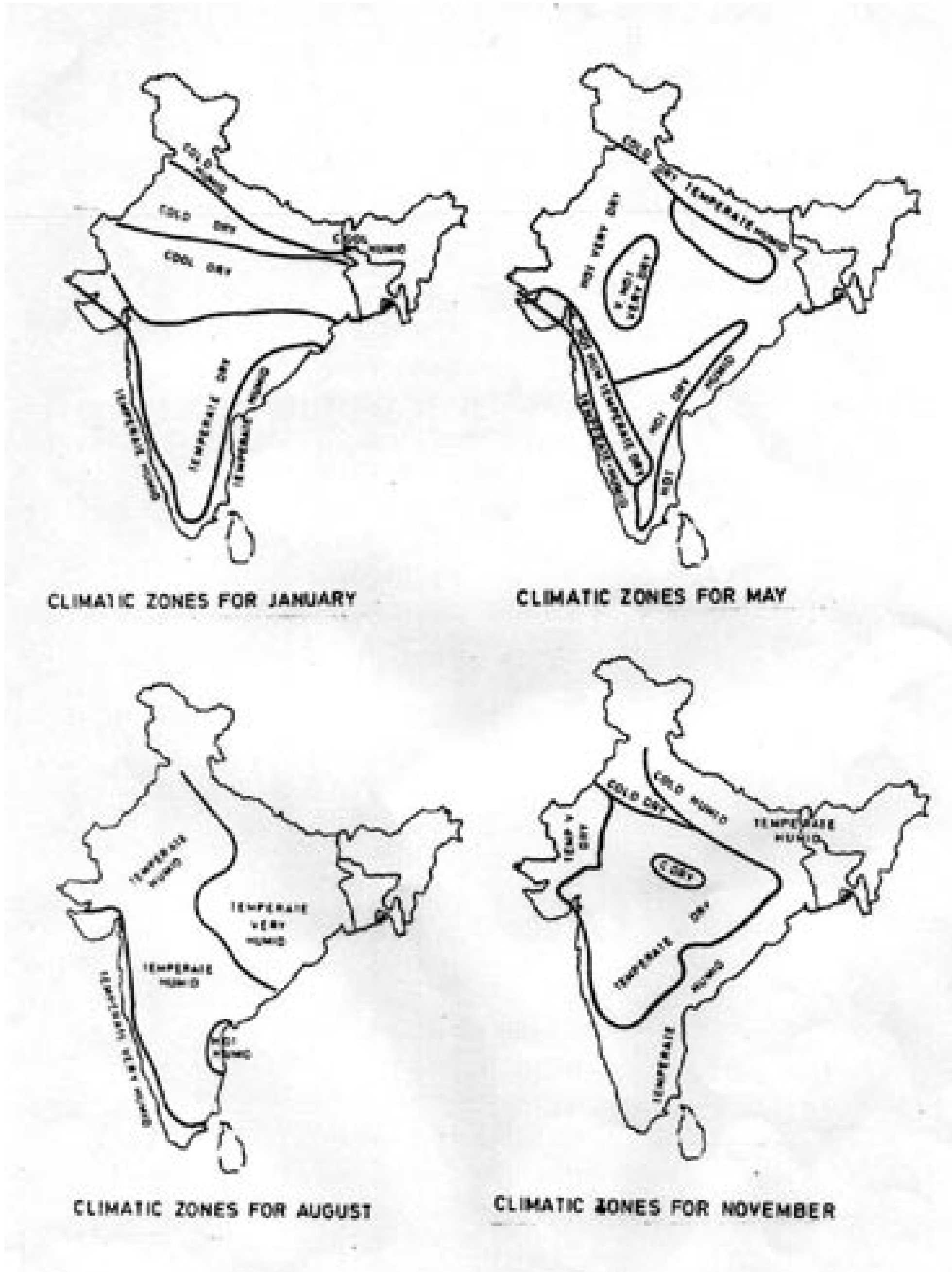
Climate

India experiences a wide range of climatic conditions ranging from extremely hot to very cold, but the bulk of its land mass experiences what is broadly described as tropical monsoon type with distinct winter seasons (January-February), hot summers (March-May), rainy south-western monsoons (June-September) and post-monsoons, also known as the north-east monsoon period in the southern peninsula (October-December) (Fig. 2).**5**

Rainfall is erratic, with heavy downpours in the north, east and parts o f the Himalayas and west coast, but very low rainfall in the desert and isolated valleys between Kashmir and Tibet.

Building designers usually classify three broad climatic types, namely hot, cold and mainly dry for regions like Rajasthan, Madhya Pradesh, Haryana and the Punjab; hot and humid for regions like Assam, West Bengal, Tamil Nadu, Kerala and other coastal areas; and cold and wet conditions in snowy mountain areas like Himachal Pradesh and Jammu and Kashmir.

In such an enormous land comprising coastal areas, rivers, plateaux and mountains, a number of micro-climatic phenomena occur which directly affect the people, the way they adapt to the climate and the way they live and build there. So their choices of materials and building techniques not only reflect the climate and topography of any one of the three major zones, but also exhibit a wide variety even, within a specific region or a state. For instance, according to Ashish Ganju (19821, in Salem district in Tamil Nadu buildings have stone walls



*Left: Fig.3 Climate Zones from Gupta, M.C. (1981) " India; Country Monograph in **Passive Cooling** - Proceedings of the International Passive and Hybrid Cooling Conference, Miami Beach, pp.890-908.*

and thatched roofs; the Thirunevelli district has clay tiled roof buildings; and the north Arcot district has mud walls and thatched roofed buildings.

The C.B.R.I. has an ongoing programme in the field of planning and design of buildings suitable for India's major climatic zones. It includes the development of appropriate orientation and reduction of energy consumption associated with lighting, heating and cooling. Studies in climatology and its application to building design have been conducted for some years and have already resulted in some significant scientific and well-reasoned reports and papers. Early work of physicists C.L. Gupta, K.R. Rao and T.N. Seshadri has been admirably extended by M.R. Sharma and S. Ali and others.

Perhaps the most important and of particular significance to environmental scientists is the publication (Seshadri & Others, 1969) of C.B.R.I.'s climatological and solar data for India aimed at architects and engineers. This comprehensive volume shows data from the Meteorological Department and Survey of India. Solar positioris defined in azimuths and altitudes at different times of a day and on different days of the year for places situated on a variety of latitudes covering the entire country are presented both in charts and tables. An appendix shows actual examples Indicating the full scope and use of shadow-throw data.

Sharma and Ali (1979) have also compiled a Thermal Stress Index for warm humid zones of India based on observations made In Calcutta and Madras during 1976, This study was specifically conducted for Unesco's Regional Office for Education in Asia and Oceania to assist that organisation's school design and building programmes. It confirmed the conclusion of many other scientists, that in such climates a major part of the thermal sensation is decided by the globe temperature alone and therefore building design must emphasise the control of globe temperature indoors and the provision of adequate air movement to offset the undue influence of higher globe temperatures.

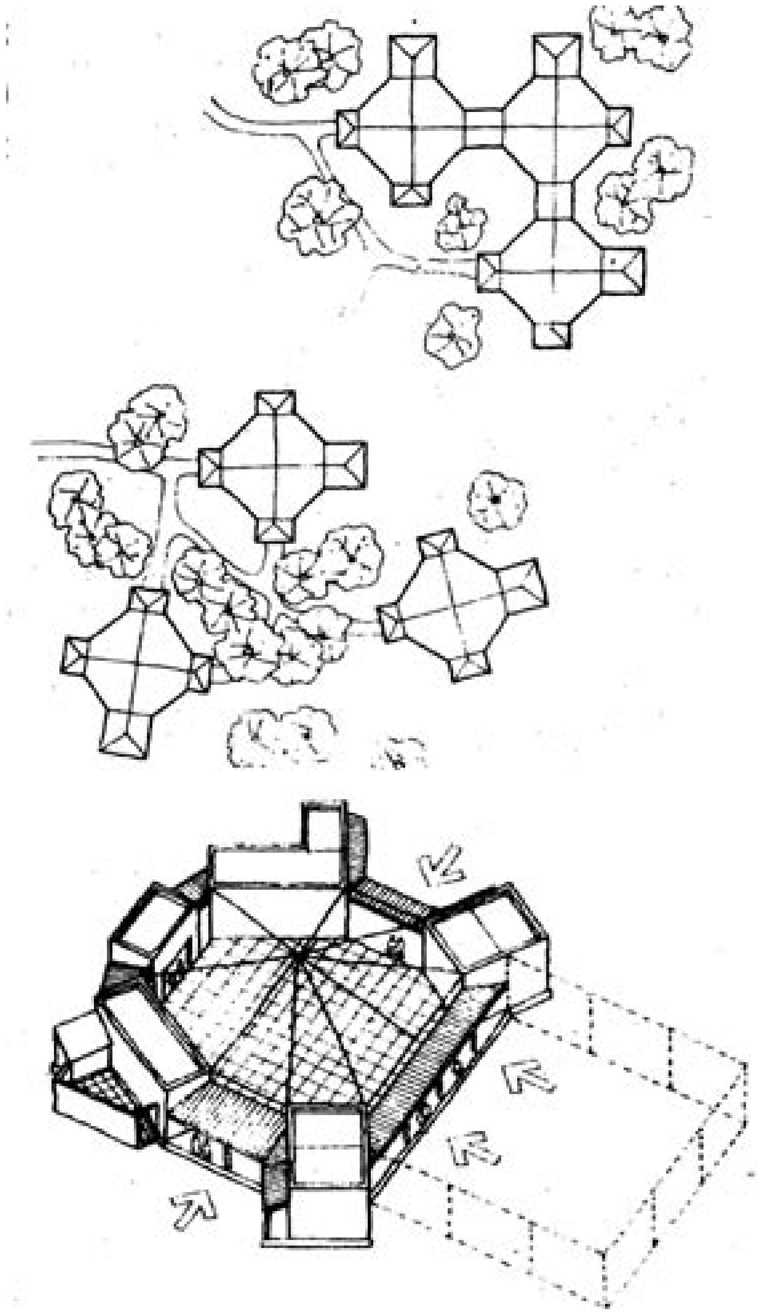
In addition to thermal studies Ishwar Chand and others (1971). also of C.B.R.T., have studied the distribution of room air velocities for different types of interconnection between rooms. They have come to the conclusion, for instance, that the average indoor wind velocity in a room is governed by the location of inter-connecting doors on its windward side and is almost independent of the location of those on the leeward side.

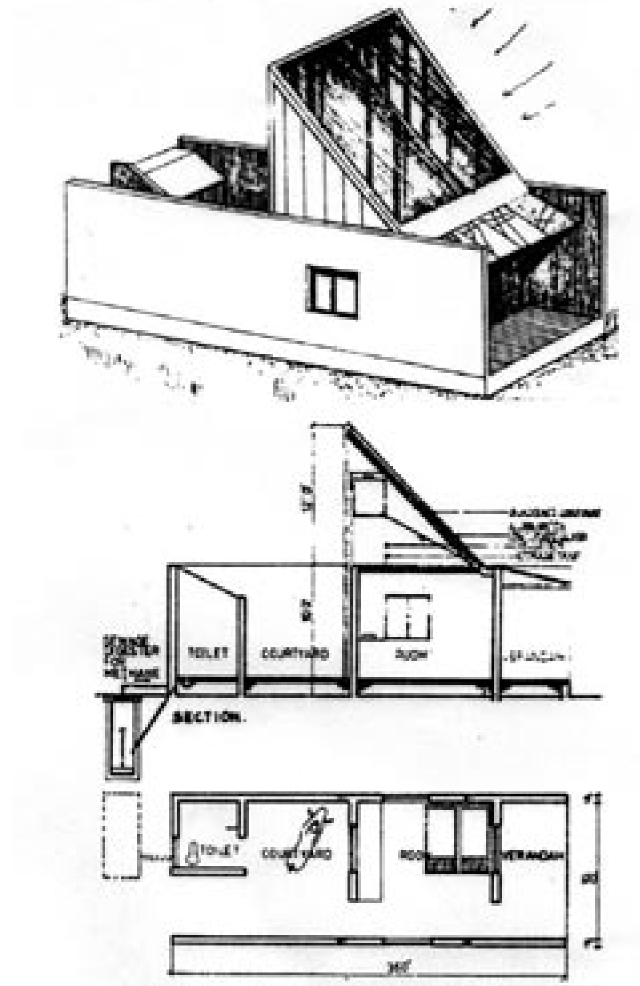
It is obvious from these reports that considerable data is now available to architects and planners in India to enable them to apply passive cooling control systems to housing and build in^. However, it seems that very little of this important information has found its way to the professional offices and government agencies. As the following examples Indicate, a beginning has been made which could well point the way to future development in rural as well as in urban areas.

Rural Building

One of the most heartening developments relating to village improvement concerns UNICEF proposals for the construction of multi-purpose rural community centres which could act as bases for development workers and provide a focus for community activities. These centres are being constructed in twenty selected villages in various regions and emphasise community involvement, low cost, local materials and indigenous building techniques. The programme has been inspired by a paper, “Multipurpose Village Centres” by architect Laurie Baker (1982) and the technical solutions have been developed by architect Ashish Ganju (Fig. 3). Ganju’s (1982) proposals have been admirably summarised in a publication which lists, in simple terms, design approaches based on climatic considerations, available construction options and planning principles.

The design and building of rural houses is normally dependent on the skills and resources of the villagers themselves but over the years some attempts have been made to explore building types which indicate a radical departure from the traditional practice. One such example is architect Devapriya Mukerjee’s (1976) experimental solar energy low cost house which offers a possible answer to satisfy the energy needs of a typical Indian farmer and his family. (Fig. 4.) The house is a simple one-room courtyard type covering 40 m². The roof is sloped at 45° facing south and is suitable for a 25° latitude location. In this prototype, apart from using solar pumps for irrigation, Mukerjee proposed a recycling system for sewerage waste to produce biogas and methane for cooking and lightixg.



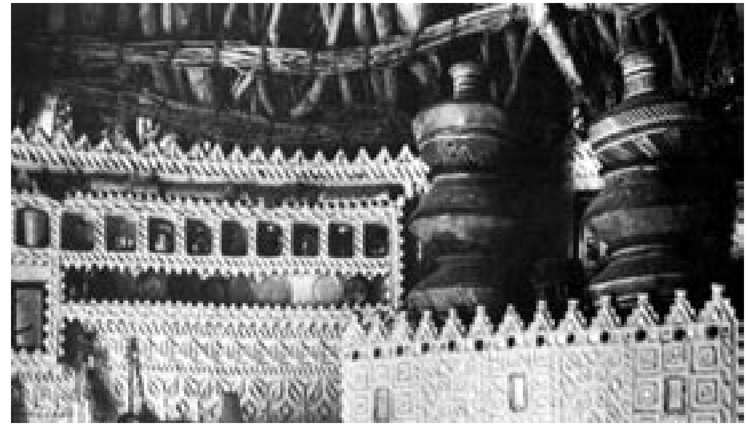


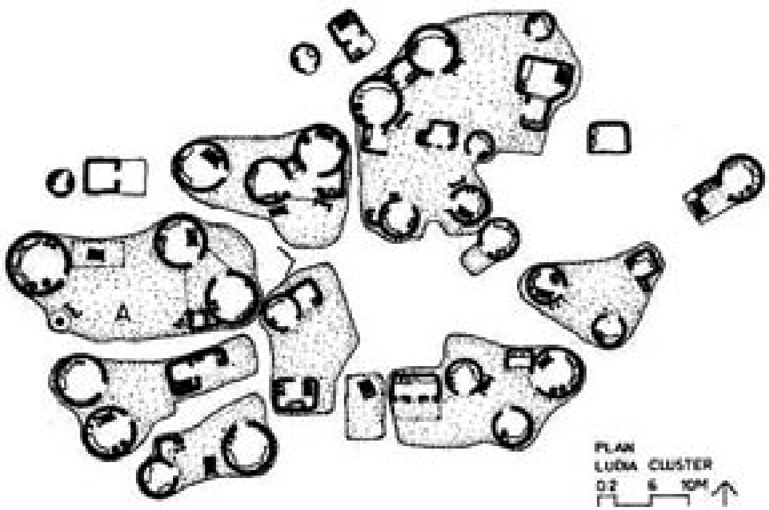
Left: Fig.3 Low Cost Rural Community Centre by Ashish Ganju.

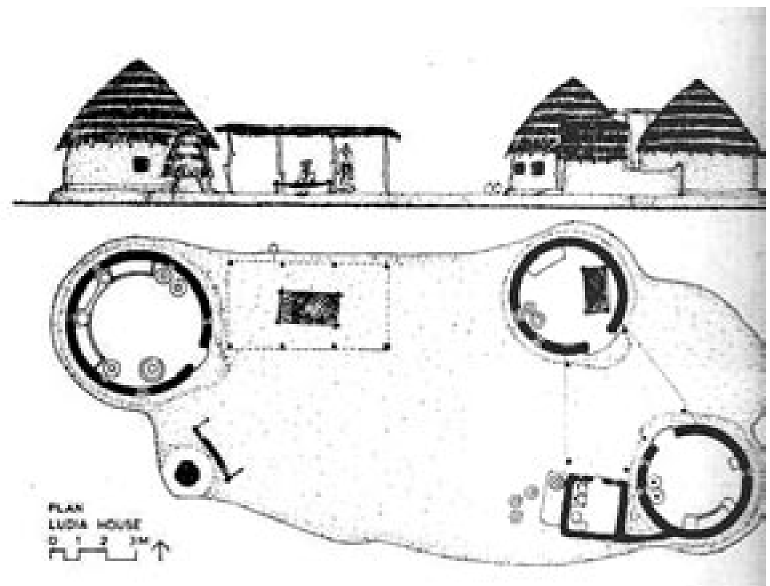
Above: Fig. 4.Experimental Solar Energy Low Cost House design by Devapriya Mukerjee.

Recently a number of academics and professionals in India have begun to record and analyse the traditional rural buildings which may offer a lesson to those concerned with the improvement of village environments. Rural housing in India is the result of an evolutionary process which is intimately related to the society, the technology and the climate of the place. In a land of such diverse climates and topography, cultural patterns and lifestyles, the range of rural building types is extensive.

Architectural schools have started a programme of studies of indigenous generic forms and a good example of this can be seen In an excellent study of rural houses of Banni in the north-western region of Gujrat in Western India. (Fig. 5). The land at Banni is flat, the climate is hot and dry and the people, mostly Moslems, live in a series of hamlets. A standard round hut forms the basic dwelling unit which is combined with rectangular secondary areas, some covered and others open to comprise the basic living complex for an extended family. These are juxtaposed in a subtle division defined by private, semi-private and public domains. All private spaces, covered and open, are on a raised platform and everyone respects their importance. Architect Kulbhushan Jain (1977) who compiled this study, maintains that these Indian hamlets, though similar in many respects to those found in Africa; have some important differences. There are no separate spaces for wives, for instance, because polygamy is uncommon, and also there is no public storage in the form of granaries. The similarity of form is essentially the result of the restriction of available materials to mud and thatch, and in some instances steins from the need to satisfy similar climatic requirements.







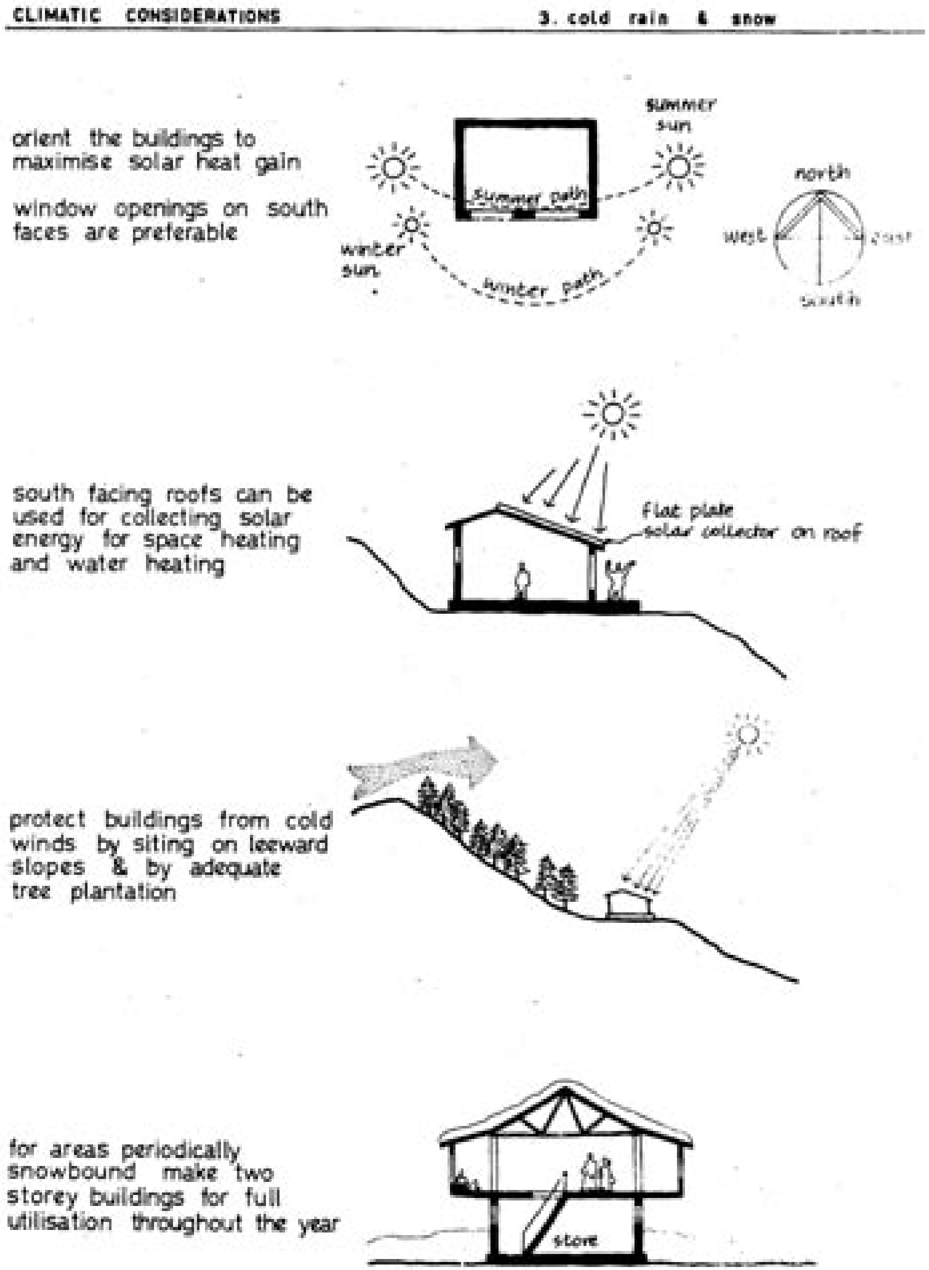
Generic House - marked ‘A’ on Plan of Ludiya

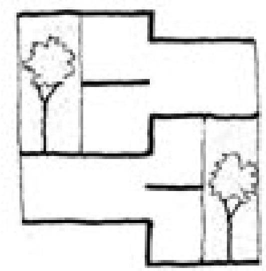
Fig.5; A study of traditional rural housing at Banni in the north western region of Gujrat in Western India by Architect Kulbhushan Jain.

In a colder climate of mountain regions, such as Kashmir, rural people have traditionally built two-storeyed structures using locally available timber and stone. Fig. 6 shows a typical Kashmir! house and lessons for designers summarised by Ashish Ganju (1982). During the brief summer season, people live and work downstairs in rooms of massive mud and stone construction which are cool and well insulated by the upper storey. In winter during the snow season and also during the monsoonal wet. conditions, people move upstairs to protect themselves from the damp environment below. The upper portion of the dwelling is not. only dry and well ventilated, but also has a balcony around it for relaxation during the sunny period.

Urban Housing

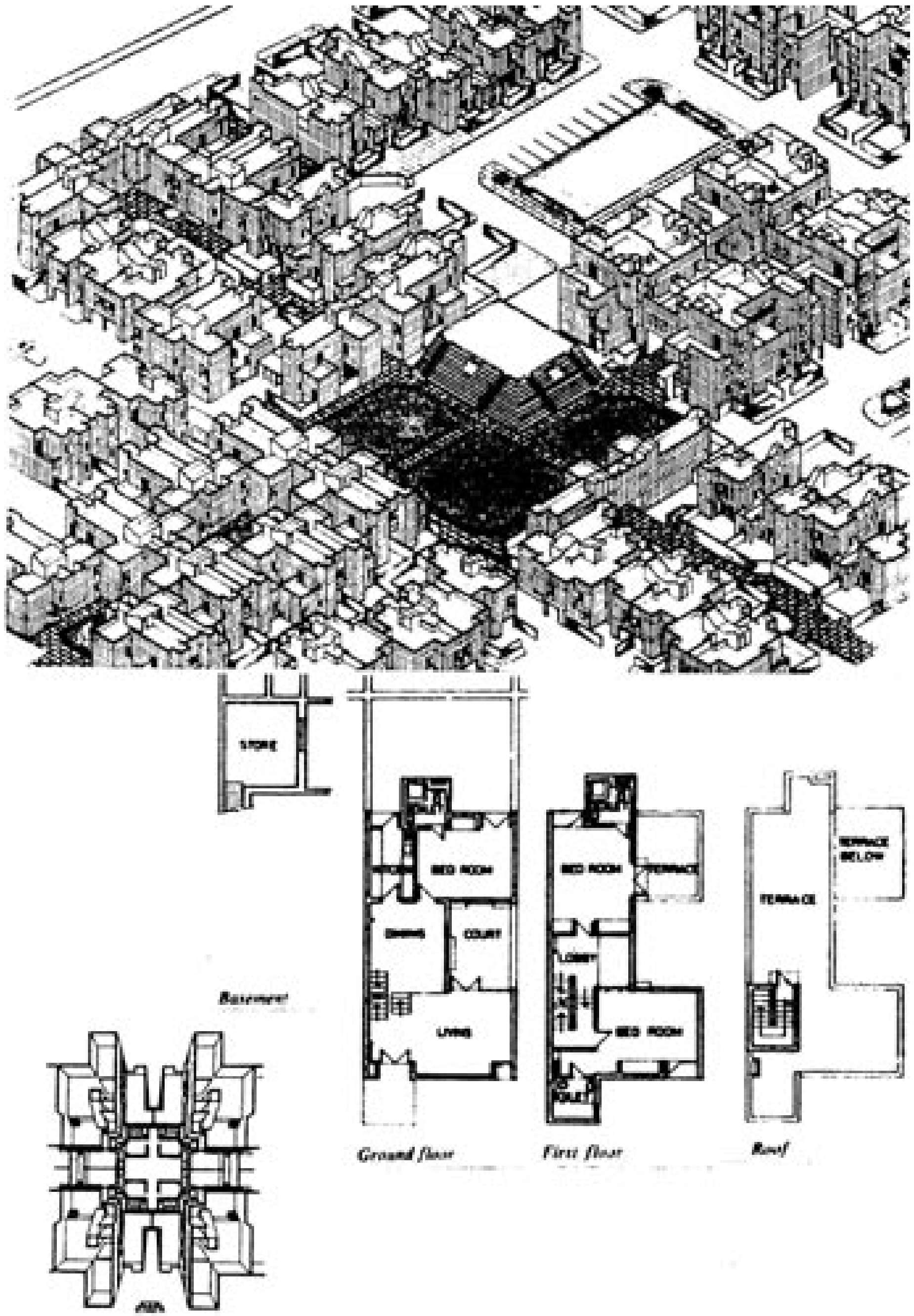
In large metropolitan centres such as Calcutta and Bombay, where land is at a premium, there has been an increasing trend towards multi-storeyed office and apartment buildings which generally rely on air conditioning to create agreeable conditions in a warm and humid environment. However, recently some architects have attempted to use passive coolinq systems by adding generous terraces for outdoor living. In the example shown in Fig. 7 Architect Correa has created double-storeyed garden terraces as an intermediate zone between the dwelling units and the outside to cope with the conflicting demands of cross-ventilation and views on the one hand, and monsoon winds, rain and afternoon sun on the other. These terraces lend themselves for use at appropriate times of the day and season, and thusfulfil an important function for living in a warm and humid



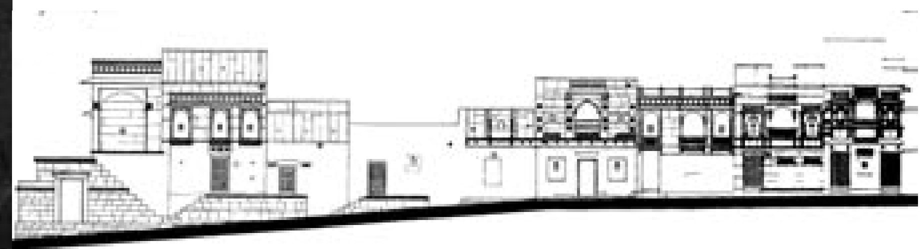


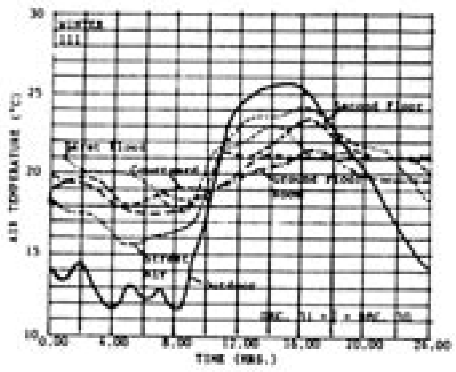
Left: Fig6. Climatic guidelines for rural development workers in colder mountain areas by Architect Ashish Ganju of UNICEF, New Delhi.

Above: Fig.7. Multistoreyed apartmewnts in Mumbai by Architect Charles Correa.



Left: Fig.8. Low rise high density housing in Delhi by Architect Raj Rewal.





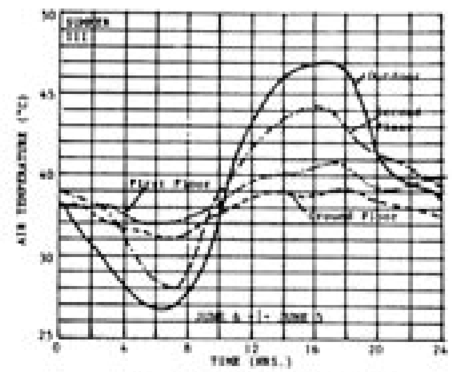


Fig. 9 Studies of Climatic characteristics in Jaisalmer, Western Rajasthan, by Vinod Gupta of Delhi School of Planning and Architectyure.

Climate

The hierarchical system of enclosed and open spaces which is characteristic of India's warm climatic region and which suits the cultural requirements of the people is particularly evident in the traditional urban settlements which show an extension of this concept beyond single dwelling units to more public spaces. Here the role of the traditional lane (*gali*) is extremely important. It is usually narrow, shaded and cool. Here recreational and commercial activities blend with access to private spaces, thus ensuring a balanced, intinate environment: typical of an Indian *mohalla*, or neighbourhood unit.

A walk through any old Indian town clearly reveals this intimate link between housing, entertainment and commerce, something which has been largely ignored by present day town planners in India. Some signs of a breakthrough have been evident recently when architect Raj Rewal (1982) undertook to apply these traditional urban characteristics to low rise high density housing complex inDelhi.**6** (Fig.8). The scheme was primarily planned in order to build 700 units as a part of the Asian Games Village. Here Rewal has linked neighbourhood-centred public scaled courtyards with a system of narrow shaded pedestrian alleys which are entered through gateways that also serve as bridges between roof terraces, all elements of facets of India's traditional urban settlements such as Jaisalmer in Rajasthan. It is a major departure from the current design of group housing in India which is usually three to four storeyed flats providing 30 to 40 housing units per 0.4 hectare. Such houses have no privase courtyards once considered essential for outdoor living and sleeping and even the roof space is far too small. Rewal's housing provides an alternative where a separate identity and a wide range of open spaces are guaranteed to individual owners, in a city which experiences a fairly harsh climate.

A typical unit type illustrated here has been designed on 7 metre frontage with an approximate ground coverage of 145 metres. It has central and rear courtyards to provide light and ventilation. The units can be linked together to form a street, create squares or generate clusters. The entrance gates punctuate the sequence of spaces around communal courtyards. The dining room and bedrooms are located 1.5 metres above, living room level creating a well lit and ventilated basement store. Two bedrooms on the first floor have easy access to roof terraces. The doorway at roof level allows for the natural circulation of air. Roof terraces are an important feature of these houses; the parapet walls on the roof level have narrow vertical slits (*jalis*) which allow for air movement but ensure privacy.

Jaisalmer studies

Inspiration for this kind of housing approach is available in most traditional sctllements. One such settlement, Jaisalmer in western Rajasthan, is unique. Because of its isolated location, this medieval town has managed to retain its original character, mainly developed during the 15th and 16th centuries, and hence offers an interesting case study. It has been the subject of a number of planning and climatic studies conducted by staff and students of the Delhi School of Planning and Architecture. Vinod Gupta's (1983) investigation of the passive cooling systems of Jaisalmer is of particular interest to environmental scientists who are concerned with building in hot and dry climates.

His study reveals some Interesting passive design characteristics of its buildings and the way they help to overcome the problem of the severe, desert summers. Natural cooling systems in Jaisalmer include dense clustering of buildings, sun control through orientation and structural projections and cooling of sunlit surfaces by the use of fins. Builders of the town have also employed massive construction for roofs and walls and courtyards and other air ducts for ventilation. Gupta observed the thermal behaviour of four different types of existine buildings, the most efficient of which was the large multilevel town-house (*haveli*), an example of which is shown in Fig. 9. He found that in *havelis* the amplitude of ground floor air temperature was no more than 3.5C, while the outdoor temperature fluctuation was of the order of 15° . The maximum indoor temperature was 8°C lower than the outdoor maximum. The people of Jaisalmer kept ventilation apertures open all day. This caused the buildings to warm up during the day but the air movement also provided greater thermal comfort.

The most interesting finding was that in nearly all the buildings, there was a time lap of twenty-four hours which was contrary to the present belief that the time lag in a building should be so arranged that peak indoor temperatures could be reduced by letting cool night air into the buildings. In Jaisalmer, the greater time lag was also accompanied by a smaller decrement factor, which reduced the heat flux entering the buildings. The courtyard system, extensively used in Jaisalmer, ensured ventilation through the buildings even during periods when the outdoor conditions were calm, provided the buil-ding temperatures at such time were higher than the outdoor temperatures and ventilation was desirable. Gupta's observations on urban climate are also interesting. The street layout and massive construction of Jaisalmer was effective in reducing summer street temperatures by as much as 2.5°C. Gupta found that during winter, however, the maximum street temperatures were about the same as outdoors while the night time temperatures were 3°to 5° higher than outdoors.

Conclusion

India poses an enormous challenge to architects and environmental scientists, both in the scale as well as in the complexity of its problems associated with energy, ecology and housing. At a superficial glance, the country presents a chaotic picture. Assessed from the point of view of highly industrialised and high energy-consuming societies, it is somewhat of a mystery and, according to some, should have collapsed ages ago. Yet it survives. There is obviously a substantial reservoir and capacity among Indian people to adapt to difficult conditions around them. In view of India's size and growth of population there are considerable pressures on its limited resources available; but despite some wastage, Indians not only consume far less energy than do people in developed countries, but they also recycle everything. In India every item is passed through several hands and fulfils a variety of needs before it finds it way to the rubbish heap.

Buildings in towns and cities may not have adequate passive cooling controls but they form only a fraction of the construction activity in the country. In India's 600,000 villages where 80 per cent. of the population still lives, people intuitively use natural control mechanisms which have been developed and refined over hundreds of years.

No doubt, with increasing urbanisation and industrlisation of the country, the problems of energy, ecology and housing are bound to increase in the coming decades and in this context the pioneering work of the research scientists and professionals mentioned in this monograph is likely to assume increasing importance. However, the extent to which their work is likely to be effective wi ll largely depend upon the way they can communicate their ideas to the people of India to implement them in their housing and building programmes.

*Paper 'Country/Regional Monograph India' delivered at **Passive and Low Energy Ecotechniques Applied to Housing** the Third International PLEA Conference, Miami and Mexico City, Mexico, August 8-11, 1984 Proceedings published by Pergamon Press.pp 340-359.*

Sources of Figures

Fig. 1. Suryakant Patel; Fig. 2. M.C. Gupta; Figs. 3 & 6. Ashish Ganju; Fig. 4. Devapriya Mukerjee; Fig. 5. Kulbhushan Jain; Fig. 7. Charles Correa; Fig. 8. Raj Rewal; 9. Vincd Gupta;

Notes

***1**. According to the 1981 census, the total population of India was 684 million, with an average density of 221 people per square kilometre, rising to 654 in Kerala and falling as low as 44 in Sikkim; refer Government of India (1982) **India Reference Manual**, Ministry of Information and Broadcasting, New Delhi, pp.1-12,*
*The Tiiaes (1980) **Atlas of the World** Indicates that the total land area of India is 3 287 593 square kilometres (1 269 346 square miles) and that of the U.S.A. is 9 363 132*

square kilometres (3 615 123 square miles).

***2.** Gupta, V. (1983) Delhi School of Planning and Architecture. Personal Communications.*

***3**. Verma, N. and Basu, S. (1982) Division of Rural Building and Environment C.B.R.I. Roorkee. Personal Communications.*

***4**. HUDCO, see **Shelter**, Official bi-yearly newsletter, Lodhi Road, New Delhi.*

***5**. Government of India (1982) India Reference Manual, New Delhi, p.4,; also see Gupta, M.C., (1981) "India: Country Monograph" in Passive Cooling, Proceedings of International Passive and Hybrid Cooling Conference, Miami Beach 1981, American Soc. of the International Solar Energy Society, pp.890-908.*

6. The climate of Delhi is maximum temperature 44° C; minmum temperature 6°C; mean 25°C; R.H. maximum 50 per cent.;R.H. minimum 20 per cent,;mean R.H. 35 per cent.

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