DISTRICT PRIMARY EDUCATION PROJECT (DPEP)

A GUIDE TO DESIGN FOR BETTER LEARNING ENVIRONMENT

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INTRODUCTION

Better design for educational infrastructure is a key thrust area under DPEP. The design of classrooms/schools is, in fact, the most important component that needs interventions.

Traditionally, the schools have been in the form of rectilinear boxes, reflecting very scant sensitivity to needs of the students and the teachers. Hence, classes are usually held in the open as it is a more comfortable environment than the school itself.

A school is probably the first built environment that a child interacts with individually, outside her/his family's domain. Therefore, it is important that a school is as comfortable and friendly as possible, both physiologically and psychologically. This will help in ensuring that more students come forward and continue to remain in the education system.

The terms 'child-centred', 'activity-based', 'user-friendly', 'state of the art' are usually stated as objectives of school/classroom design. Unfortunately, there had been little progress in translating these concepts into design-brief and thereafter into designs.

Kerala was the first state to initiate a debate on the issue. A workshop, in which policy-makers, educationists, teachers and architects participated, was organised in November, 1996. This was followed by a national level workshop on "Classroom Design Criterion" at Delhi, attended by eminent educationists and architects. Several meetings were conducted in Madhya Pradesh, Haryana, Uttar Pradesh and Orissa. The findings were more or less similar and served to orient both the client and the consultant to the needs of rural primary school/classroom.

The present document, "A GUIDE TO DESIGN FOR BETTER LEARNING ENVIRONMENT" is an attempt to collate the findings of all these workshops and present it in an explanatory manner. The guidelines are by no means comprehensive or prescriptive. It is envisaged that these guidelines will be enriched by the suggestions/comments/innovations proposed by persons interested in this topic, particularly DPEP personnel. At this point it is important to stress the fact that locale specific issues have not been included as they vary from state to state, though they must be considered.

Your comments and suggestions are welcome.
DESIGN OF ELEMENTS

Information on various functional and psychological elements are necessary for the design of a primary school. This section describes briefly such elements under the following heads.

Storage
Display
Chalkboard
Floor
Colour
Wall Decor
For disabled

The section ends with a checklist for the designers.
For activity-based learning system, sufficient storage must be provided in schools for stationery, teaching aids and equipment, which vary in quantity and type. Following is a list of materials required in a primary school.

### Teachers' Material
- Syllabi
- Textbooks
- Teachers' Manual

### Classroom Teaching Material
- Wall Maps
- Globe
- Educational Charts

### Learning Kit
- Science Kit
- Mathematics Kit
- Mini Tool Kit

### Classroom Play Material
- Jigsaw
- Games & Toys
- Blocks, Strips, Tiles

### Outdoor Games Equipment
- Skipping rope
- Balls, Badminton
- Air pump

### Books for the Library
- Reference Books
- Children's Books
- Magazines, Journals

### Musical Instrument
- Harmonium
- Manjira
- Tabla, Dholak

### Class Equipment
- Chalkboard
- Chalk, Duster
- Mats
01. Classroom

- Storage space in classrooms include a general storage for textbooks, classroom play and activity materials and individual storage for each child.

**General storage for teachers' use**

- Textbooks (40 numbers)
- Chalk box (inumber)
- Duster
- Blocks
- Tiles
- Jigsaw
- Games
- Toys
- Strips

**Individual storage for children's use**

- Small personal belongings (pebble, insect, picture, snail)

- Storage for shoes have to be provided outside the classrooms, preferably visible from inside.
CHALKBOARD

- Multigrade teaching implies different grades being taught by the same teacher simultaneously. This is practised because of dearth of teachers in the rural schools. At least two chalkboards are required in each class to facilitate this method of teaching.

- Chalkboards are also required for outdoor classes or school notices. Light and mobile chalkboards are required which can easily be transported in and out of the school.

- Chalkboards may be provided at a lower level for the children's use.

- Size and shape of chalkboard should be determined for their proper utilisation and convenience. A 1800 mm by 1200 mm (6 ft. by 4 ft.) board is generally recommended, the bottom being 600 mm (2 ft.) from the floor.

- Material is usually cement plaster. Colour of chalkboard is usually black, though green (using green oxide) is preferred for psychological reasons and to reduce strain on the eyes.
FLOOR

Flooring is an important factor in school design as a child subconsciously learns about various textures, colours, patterns through the variety of floor used, visually and by touch.

It is important that choice of material for floor should conform to safety of children and the convenience of maintenance. Hence, smooth finish for classroom floor is recommended.

COLOUR.

Children prefer primary colours, which may be used on the exterior. However, community's decision should be given high priority.

For the interior, white is recommended as this colour reflects light and increases the illumination level.
WALL DECOR

There are vacant external and internal wall surfaces which may be used for educational purposes.

- Students may be encouraged to paint pictures from their science, geography or social science books, which may be changed after some time and replaced with new ones.

- Folk art should also be encouraged. The local artisans may be asked to display their skills on the wall by painting or decorating it, which helps in creating an awareness among the young children about their traditional background.

FOR DISABLED.

A little thought for the disabled children during design process of primary schools will make these buildings more accessible to them.

A few simple things that will make movements easier for these children in school are -
CHECKLIST

- CLASSROOM STORAGE PAGE NO. 4
- TEACHER'S ROOM STORAGE PAGE NO. 5
- DISPLAY PAGE NO. 6
- CHALKBOARD PAGE NO. 7
- FOR DISABLED PAGE NO. 9

FLOOR PAGE NO. 8
COLOUR PAGE NO. 8
WALL DECOR PAGE NO. 9

VITAL

DESIRABLE
DESIGN OF SPACES

The school should be functional, comfortable and attractive, so that both teachers and students find it interesting.

In order to attain such environment, guidelines regarding the following spaces may be considered while designing primary schools.

Classroom
Verandah
Teachers’ room
School building
Services
Balwadi

The section ends with a checklist for the designers.
CLASSROOM

01. Size.

- Classroom size depends on the number of students, activity patterns and type of furniture.

The optimum size for a classroom of forty students in a teacher-centered teaching environment is at least about 30 sq. m. (320 sq. ft.) The activity-based teaching method involves group activities, and a classroom size should be modified to satisfy the functional requirements.

The size of a classroom should be sufficient to accommodate storage of study materials and teaching aids. For details, refer page no. 4.

- Though the objective of DPEP is to ensure 90% retention, at present the dropout level at second standard is quite high. One option would be to design classrooms with flexible partitions, so that the classroom size may be adjusted according to necessity, during the formative years of Universal Elementary Education.
02. Teachers' room.

- Teachers' room in a rural primary school functions as a multi-purpose resource room --- a place for teachers and principal to sit and meet, a library, a first-aid centre and a store for common school property. Storage space in teachers' room should be designed accordingly.
DISPLAY

- Display is an important item of classroom design, required for exhibiting teaching material and students' works.

01. For teachers

Display areas are required by teachers for putting up educational charts and maps. Strings and battens may be provided on walls from which these can be hung.

Display of other teaching materials like models and globes require horizontal surfaces. A low platform may be built for this purpose.

02. For students

Display area for children's works include vertical surface (for hanging their work) and horizontal platform (which also function as work platform).

- Display (both vertical and horizontal) should also be provided in teachers' room.
02. Shape.

- 'Child-centered' teaching method involves group and individual activities. The shape of the classroom should be conducive to these functions.

- A centric space is preferred over a linear one.

  ![Centric vs Linear Space Diagram]

  **Centric Space**
  
  THE DISTANCE FROM CENTRE TO FACES IS EQUAL OR ALMOST EQUAL. IN LINEAR SPACES, THEY VARY.

- Although square and rectangular rooms may be designed to suit the classroom requirements, other geometrical shapes like hexagons and octagons should also be used. Square, though simple to construct, requires elements to create more learning corners, whereas other polygonal shapes naturally offer more than four corners and hence, wall panels.

  ![Square, Trapezium, Hexagon, Octagon Diagram]

  **Square**
  
  Acute viewing angle from front seat, waste of space near teacher.

  **Trapezium**
  
  Viewing angle improved, waste of space avoided.

  **Hexagon**
  
  Viewing angle improved, waste of space avoided.

  **Octagon**
  
  Viewing angle improved, waste of space avoided.
03. Ventilation

Ventilation is an important factor to be considered for creating comfortable indoor conditions in classrooms. According to IS 8827:1978, level of ventilation in classrooms is six air changes per hour.

Ventilation level required in a classroom depends on the climate of a place and the time of the year.

- In cold climatic zones, little or no ventilation is required.
  
  ![Image showing small and protected openings](image)

- In warm-humid zones, ventilation is essential.
  
  ![Images showing classroom orientations and air movements](images)

  - Classrooms oriented towards prevailing wind directions
  - Low level jalousies ensure air movement at floor level
  - High level openings for hot, stale air to escape

- For detail information on ventilation in each climatic zone, refer appendix 1.
04. Illumination

According to IS 8827-1978, level of illumination at classroom desk-top and chalkboard is 150 - 800 lux. A general illumination level of 152 lux is recommended. At the same time, glare (i.e. unwanted light) should be avoided.

The methods of achieving proper illumination of indoor spaces in buildings include:

- Making the window size about 1/10th of floor area. Window size implies only effective open surface -- areas occupied by frames, shutter styles and bars etc should be neglected.

- Windows in room should be on two opposite walls to achieve uniform light in the interior.

- Care should be taken so that there is no glare from window shutters or chalkboards.

- High level windows to ensure better illumination.
• Roof lighting

• Jalis below window-sills allow light to reach students' working area on the floor.

• Direct sunlight in the interior should be avoided as it creates glare, except perhaps, in cold climate where sun is welcome for thermal comfort. North light is recommended for reading purposes as it is glare-free.

• A white or yellow wall on the North may be used to reflect sunlight into the interior.
05. Acoustics

According to IS 8827-1978, maximum acceptable noise level from external sources is 40 dB. The school building itself should be located at a maximum possible distance from noisy roads (in cases where any other site is not available). If possible, the windows should not face the direction of source of noise.

- Care must be taken while designing two adjoining classrooms so that noise from one does not reduce the audibility level of the other.

- The maximum distance of a student from a teacher should not be more than 7.0 m. (about 23 ft) in order to have clear audibility.

- Reverberation is an important factor to be considered, as higher the reverberation time, less is the percentage articulation of the words spoken.
VERANDAH

- Verandahs, courtyards and semi-open spaces are used as spill over areas. These spaces are used by groups to spread out in the activity based learning system, especially when the number of students are large (as in multigrade system).

- These spaces must be big enough to act as independent classrooms approximately 18.5 sq. m. (200 sq. ft.). In case it becomes necessary, these spaces should be easily upgraded into classrooms, using local masons and materials.

- Verandahs and courtyards must be protected from natural elements like rain, high wind etc; but at the same time must have enough light. For details on design features according to climatic considerations, refer appendix 1.
TEACHERS' ROOM

- A teachers' room in a rural primary school should be about 7.5 - 9.5 sq. m. (80 - 100 sq.ft.)

- The functions and a few ideas about the design of a teachers' room are shown below.

```
TEACHERS' ROOM IS A RESOURCE CENTRE OF THE
SCHOOL. THE SPACE AND STORAGE HAVE TO BE DESIGNED
PROPERLY TO MAKE THE ROOM FUNCTIONAL, COMFORTABLE
AND ATTRACTIVE.
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- For details of storage in teachers' room, refer page no. 5.
SCHOOL BUILDING

Design of a school building implies integration of the classrooms, verandahs, teachers' room and in some cases, toilets and kitchens to form a whole building.

- The teachers' room should be accessible from the classrooms as well as from the entrance of the school building.

- In multi-grade teaching method, a single teacher teaches two or more classes simultaneously. This is easier with children of similar mental and physiological maturity. Hence, standards I and II form one cluster while standards III, IV and V form another. Classroom grouping has to be done accordingly.

GROUPING OF CLASSROOMS IN A PRIMARY SCHOOL
- The classrooms and teachers' room may be connected by a central courtyard. This space itself may be used as an additional classroom or spill over area. The various uses of a court are shown below.

The courtyard may be left open or covered according to requirements.

- All the rooms and spaces in a school building must have an optimum orientation. Refer appendix 1

- For layout of school building, refer page no. 28.
SERVICES

01. Toilet

- Toilets must be provided for boys and girls separately, each with preferably two urinals and one water closet. Refer appendix 2 for dimensions.

- Light and ventilation of the toilet should be good to facilitate maintenance.

- Various methods of sanitation, like ventilated improved pit latrine, double pit leech latrine, septic tanks and soak pits should be considered before selecting the appropriate system.

- For toilet layout on site, refer page no. 29.
02. Kitchen

Kitchens and stores may be designed in places where mid-day meals are supplied by the government. Kitchen has to be designed for cooking and storing food-grains, fuel and cooked food.

Refer appendix 2 for detail dimensions.

BALWADI

Balwadis are required in places where children are constrained to take their younger siblings (between ages 1 - 5) to school. Refer page no. 31 for layout.

The balwadi should be properly designed and oriented to create comfortable indoor conditions Refer appendix 1)

Provision must be there for storage of playing blocks and games and a sand-pit may be added.

Split levels should be avoided for the safety of children. Small wicket gates may be added to door openings for the same reason.
CHECKLIST

<table>
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<td>SIZE</td>
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<td>18</td>
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<td>TEACHERS' ROOM</td>
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- VITAL
- DESIRABLE

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SCHOOL BUILDING PAGE NO. 20
KITCHEN      PAGE NO. 23
BALWADI      PAGE NO. 25
SITE PLANNING

In order to design a successful and workable institution, the functional relationship among the various buildings and the open spaces have to be satisfied.

Guidelines for site planning have been described under the following heads:

Layout: general
- school building
- services
- balwadi
- open space

Landscape
Boundary
Miscellaneous

The section ends with a checklist for the designers.
LAYOUT: GENERAL

- A design of primary school should be prepared with the following and indicated on the master plan:

SCHOOL BUILDING
- Five classrooms with verandas and spill over areas
- One teachers' room

SERVICES
- Toilets
- Drinking water
- Kitchen and Store (optional)

BALWADI (optional)

OPEN SPACE
- Semi-open space for outdoor teaching etc.
- Open space for games, assembly etc.

- Layout of the spaces on a site should be such that they create a sequence (hierarchy of space) which begins with the entrance and the most public parts, then leads into the slightly more private areas and finally to the most private domains.
- The buildings have to be properly oriented to ensure comfortable indoor conditions without the use of energy intensive technical devices.

In hills, where the temperature can be low, sun penetration is welcome to heat up the classrooms.

In hot dry areas with strong winds and dust-storms, the courtyard layout plan will be appropriate, creating protected enclosed spaces.

In warm-humid tropical areas, the sun should be excluded from penetrating the windows by facing the building North-South. Ventilation is essential and the layout plan should allow for the prevailing winds to flow into and around the building.

For details on design features in the various climatic zones in India, refer appendix 1.
LAYOUT: SCHOOL BUILDING

- The school building should be preferably located in the semi-public zone of the site. There should be enough space all around the building to allow proper illumination and ventilation in the interior. Refer page no. 14, 15 for details.

- The entire school building is usually not built at once. Initially, only two or three classrooms with adjoining verandahs and spill over areas may be constructed and the rest may be completed in phases. Choice between vertical and horizontal expansion depends on local norms and availability of land.

- Services like toilet and kitchen may be attached to the school building. (Refer page no. 22, 23 for design details and page no. 29, 30 for layout).
Toilet is an essential requirement in a primary school in order to ensure the enrollment and retention of students (especially girls). For design of toilets, refer page no. 22.

- Toilets may be attached to the school building, or separated from it by a buffer zone. The privacy of the entrance to the toilets must be considered in either case. Avoid designing the toilet as an isolated unit, as this hampers maintenance.

- Availability of water in the toilets must be ensured (from taps or water reservoirs) for ablution and maintenance. The drainage and waste disposal may be through septic tanks, soak pits etc. in places where a sewer line is not available. These have to be located so as not to contaminate wells and ground water.

- Training of students regarding maintenance of toilets is essential.
02. Drinking water

Provision of drinking water on the site is essential.

- The drinking water point should be, preferably, a little distance away from the school building itself.

- The water from the gutter in the drinking area may be used for maintenance of toilets.

03. Kitchen and Store

- In cases where cooked mid-day meal is served, a kitchen-cum-store is necessary (refer page no. 23) with provision for water supply and drainage.

- In cases where food-grains are distributed, a store is necessary. (Refer page no. 23)
LAYOUT: BALWADI

- Balwadi should not be in the main school building as the noise made by the children may disturb the classes.

- Its orientation (refer appendix 1) and design (refer page no. 23) should create comfortable indoor environment for children.

LAYOUT: OPEN SPACE

- All the outdoor spaces that surround and lie between the buildings should be positive. Give each one some degree of enclosure --- surround each space with wings of building, trees, hedges, fences, arcades and trellised walks, until it becomes an entity with a positive quality and does not spill out indefinitely.
- Semi open spaces and shaded areas are used as outdoor classrooms, spill over areas and protected play area for the children (especially standard I and II).

- Unfragmented open space is used as assembly area and play-fields (e.g. ball games for standard III, IV, V).
LANDSCAPE

- Landscaping includes leaving old trees intact, planting new trees, caring for them and using them in such a way that the spaces which they form are useful as extensions of the building. Make the trees form rooms and spaces, avenues, buffers, shaded walkways and provide seats under them and mark them on the master plan.

- Care should be taken about the species of trees planted. Fruit trees and vegetable gardens may be grown and the harvest may benefit the school, faculty members and the students. Planting of medicinal herbs is also recommended (refer appendix 3).
BOUNDARY

Boundary of a school must be defined to create a sense of enclosure and ensure safety. It also helps to prevent encroachment of land at a later stage.

- The height of fencing may be low to simply provide a psychological definition of school premises, unless constrained by local conditions like safety from wild animals.

- Material for boundary wall construction should be chosen carefully. A masonry wall should be constructed only when constrained (e.g., if the site is near a highway to eliminate or reduce noise level). Brick jali, mud walls or green fencing (hedges etc.) may be constructed as boundary wall. Materials like barbed wire should not be used within reach of children.
MISCELLANEOUS.

A few additional facilities may be incorporated in the site, depending on requirements, local climate, resources and finances available.

01. Rain water harvesting.

It is possible to trap rain water from roofs and store it for utilising this as an additional source of water. To have this system operative, the building needs a sloping roof or a flat roof sloped properly, with gutter leading to storage tank and pipe from storage tank to outlet point. Maintenance consists of cleaning of gutters and tank at regular intervals.

02. Solar energy harnessing

Solar energy may be converted into electrical energy or heat energy and used in a variety of ways. Lamps can be lighted during night using solar cells marketed by the Government. The initial cost is high.
SITE SELECTION

A suitable site has to be selected before planning the layout and designing the school. This ensures, among other things, an easy access to the school and the safety of the children.

A number of factors determining the suitability of a site are discussed under the following heads, which need to be considered while selecting a site. The same applies for donated sites.

Location
Size
Shape
Topography
Sub-soil
Services
Noise
Safety

The section ends with a checklist for the designers.
LOCATION

- The site should preferably be a little isolated from the settlement.

- The school should not be located in any particular community. This ensures that children (especially girls) of all communities have equal access.

- The site should be within 1 km from settlement. This is particularly important for providing access to physically handicapped children who cannot travel great distances. For hills, the local norms should be followed.

The site should be well connected to the settlements. The access through fields & forests must be safe enough for children who travel to school daily.
A primary school consists of built up areas like classrooms, teachers' room, toilets etc., and open spaces for assembly, cultural activities, sports & outdoor teaching etc.

- The size of the site is determined on the basis of built up areas and open spaces and it is preferable to have a site size of one acre, as illustrated below. However, the site can be bigger or smaller depending on requirements of school and availability of land in the locality.

<table>
<thead>
<tr>
<th>BUILT UP AREA (sq. m)</th>
<th>SEMI OPEN SPACE (sq. m)</th>
<th>OPEN SPACE (sq. m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIVE CLASSROOMS 170.20</td>
<td>VERANDAHS, SPILL 170.20</td>
<td>SPORTS 2300.00</td>
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<td>(5 x 40 x 0.74 x 1.15)</td>
<td>OVER SPACE ETC.</td>
<td>ASSEMBLY 200.00</td>
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<tr>
<td>TEACHERS' ROOM 12.00</td>
<td>COURTYARDS, LAWNS 200.00</td>
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<td>TOILETS 10.00</td>
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<td><strong>TOTAL</strong> 192.20</td>
<td><strong>3722.00</strong></td>
<td><strong>3800.00</strong></td>
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</table>

TOTAL AREA = 192.20 + 372.20 + 3800.00 = 4062.4 sq. m. = 1 ACRE

SHAPE

- Sites of regular shape are preferred as this ensures proper utilisation of space.
TOPOGRAPHY

Topography of a locality has effects on the functioning of a school and following are the various aspects in this regard.

- A primary school must be protected from natural calamities and the site should be chosen accordingly.

- To ensure proper natural drainage of the site, it is preferable to have a plot on a land comparatively higher than surrounding areas.

- In hilly regions, sites with gentle slope should be considered, as otherwise, they are too expensive to develop. A part must be relatively flat so that it can be used as a play area.
SUB SOIL

- The bearing capacity of soil affects the cost of foundation. So, care must be taken while site selection to get a plot on good soil (e.g. 10 T/m²).

BEARING CAPACITY IS THE AMOUNT OF LOAD THAT SOIL CAN BEAR WITHOUT ANY DETRIMENTAL SETTLEMENT.

- Avoid filled up soil.

- Avoid soil with decomposed organic materials like leaves, animals etc.

- For expansive soil like Black cotton soil, specialists have to be consulted for selection and design of foundations.

- The Engineer in-charge should inspect the site and dig a pit of 1000mm x 1000mm x 1000mm to assess the soil condition.

- Use information on soil condition of the area that is available in local Government Departments.
SERVICES

As far as possible, site should be close to existing infrastructures like drinking water and electricity. This ensures that the connections can be made without much difficulty.

01. Water

Water should be available on the site as it is important for drinking, for use in the toilet and in construction works. In case of non-availability of any infrastructure, it should be provided by wells, hand pumps etc.

02. Electricity

Electricity is required in schools for illumination during evening classes, fans etc. In areas where it is not available from the mains, it may be generated on the site by exploring alternate sources like solar cells, wind power or bio-gas.
NOISE

- A primary school site should be located away from major sources of noise like highways, railway tracks, factories, helipads/airports, weekly bazaars, places of worship.

- Noise means unwanted sound. According to IS 8827-1978, maximum acceptable noise level (in classroom) from external sources is 40 dB.

![Diagram showing noise reduction over distance]

Site should be at least 150 M from highways or railway tracks.

SAFETY

- Under all circumstances, a site should be away from hazardous features like HT lines, polluting workshops, major crossings, highways and railway tracks.
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VITAL

DESIRABLE
CONCLUSION

A primary school plays an important role in shaping the minds of young children. The classroom itself, along with the built environment of the school and its immediate surrounding as a whole, should be designed for this purpose.

In addition to such functional and psychological requirements, a school building should also be contextual. Context means the local materials and resources available, the climate, topography, social and cultural background of a particular place. The design and technology selected for a school should conform to these local conditions.

Moreover, a school should not be designed for its appearance on the inaugural day, but for its looks after a period of time. This implies that proper maintenance should be ensured. This can be facilitated by a good design.

Thus a primary school is a consequence of a holistic approach from its starting point.

The present book is a guide to the functional and psychological requirements of a primary school and the related design features. This should be read in conjunction with the data of resource mapping and books on cost-effective technologies and maintenance.
REFERENCES

1. DISTRICT PRIMARY EDUCATION PROGRAMME
Design guidelines for a 'Child Friendly Classroom', workshop held in New Delhi (27 - 28 January, 1997).

2. DISTRICT PRIMARY EDUCATION PROGRAMME
Design guidelines for primary schools in rural areas, workshop held in Chikka Gulla, Haryana (14-15 March, 1997).

3. DISTRICT PRIMARY EDUCATION PROGRAMME
Design guidelines for primary schools in rural areas, workshop held in Lucknow, UP (21 March, 1997).

4. DISTRICT PRIMARY EDUCATION PROGRAMME
Possible Design Guidelines for Child Friendly Classrooms, workshop held in Thiruvananthapuram, Kerala (5 November, 1996).


10. Interior and Exterior Modifications of classrooms - plausible modifications by .......

11. BIHAR EDUCATION PROJECT
12. ANDHRA PRADESH PRIMARY EDUCATION PROJECT
Construction Manual.

13. OPERATION BLACKBOARD.

14. A Manual to help design one and two roomed rural schools over a large area of Maharashtras, by Laurie Baker.

15. Handbook on Functional Requirements of Buildings (Parts 1-4) SP: 4(5 & T), 1987


17. Prashika: Eklavya's Innovative Experiment in Primary Education.

18. Climatic Zones and Rural Housing in India by N.K. Bansal, G. Minke, German-Indian-Cooperation in Scientific Research And Technological Development, 1995


22. A Pattern Language by Christopher Alexander, Oxford University Press, New York, USA, 1977

23. How the other half builds, Volume 1: Space, Research paper no. 9, December 1984, Centre for Minimum Cost Housing, McGill University, 3650 University Street, Montreal, P.Q. Canada, H3A 2B1


28. Planning and Design of School Buildings for self help projects by Finn & Olesen, Housing Research and Development Unit, University of Nairobi.

29. Design of Educational Buildings, Botswana by David and Mary Medd.


32. Come, Let's build our school by Tara Rao & Anil Achar, Basic & Primary Education Programme, Nepal.
APPENDIX I
CLIMATIC CONSIDERATIONS IN PRIMARY SCHOOL DESIGN IN INDIA

Building (including school) design and techniques have been developed over many centuries in all climatic zones - the aim being to provide more or less comfortable indoor conditions without the use of energy-intensive technical devices. One can benefit from certain climatic features and overcome those that are less favourable, merely by means of appropriate building shapes, location & orientation. Additional elements, like vegetation and water, may also be integrated into the design to improve microclimatic conditions.

Since different locations within large areas have very similar climatic characteristics, these can be grouped together to form a more or less accurately defined climatic zone, within which the climatic design requirements for buildings are generally the same, with minor differences only due to local environmental conditions.

India has six such climatic zones viz. hot-dry, warm-humid, moderate, cold-cloudy, cold-sunny and composite, as shown in the following figure.

CRITERIA FOR THE CLASSIFICATION OF CLIMATE

<table>
<thead>
<tr>
<th>Zone</th>
<th>Monthly Temp (°C)</th>
<th>Humidity (%)</th>
<th>Precipitation (mm.)</th>
<th>Clear Days (Nos.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOT-DRY</td>
<td>&gt;30</td>
<td>&lt;55</td>
<td>&lt;5</td>
<td>&gt;20</td>
</tr>
<tr>
<td>WARM-HUMID</td>
<td>&gt;30</td>
<td>&gt;55</td>
<td>&gt;5</td>
<td>&lt;20</td>
</tr>
<tr>
<td>MODERATE</td>
<td>25 - 30</td>
<td>&lt;75</td>
<td>&lt;5</td>
<td>&lt;20</td>
</tr>
<tr>
<td>COLD-CLOUDY</td>
<td>&lt;25</td>
<td>&gt;55</td>
<td>&lt;5</td>
<td>&lt;20</td>
</tr>
<tr>
<td>COLD-SUNNY</td>
<td>&lt;25</td>
<td>&lt;55</td>
<td>&lt;5</td>
<td>&gt;20</td>
</tr>
<tr>
<td>COMPOSITE</td>
<td>This applies, when six months or more do not fall within any of the above categories.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Following is a brief information on a few important locations, main climatic features and design features in each of the six zones.

## A FEW IMPORTANT LOCATIONS IN EACH OF THE SIX ZONES

<table>
<thead>
<tr>
<th>CLIMATIC ZONES</th>
<th>LOCATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOT - DRY</td>
<td>Jodhpur, Jaipur, Barmer, Bikaner (Rajasthan) • Bharuch, Dohad (Gujarat) • Akola, Sholapur (Maharashtra)</td>
</tr>
<tr>
<td>WARM - HUMID</td>
<td>Bombay (Maharashtra) • Calcutta (West Bengal) • Vishakapatnam, Madras (Tamil Nadu) • Pondicherry (Pondicherry Union Territory) • Dibrugarh (Assam) • Cuddapah (Andhra Pradesh)</td>
</tr>
<tr>
<td>MODERATE</td>
<td>Bangalore (Karnataka)</td>
</tr>
<tr>
<td>COLD - CLOUDY</td>
<td>Ootacamund, Kodakanal (Tamil Nadu) • Dalhousie, Simla, Kulu (Himachal Pradesh) • Shillong (Meghalaya) • Srinagar (Jammu and Kashmir) • Mahabaleswar (Maharashtra)</td>
</tr>
<tr>
<td>COLD - SUNNY</td>
<td>Mt. Abu (Rajasthan) • Leh (Jammu and Kashmir)</td>
</tr>
<tr>
<td>COMPOSITE</td>
<td>New Delhi (National Capital Territory) • Allahabad, Kanpur, Dehra Dun (Uttar Pradesh) • Ambala (Haryana) • Hazaribagh (Bihar) • Khandwa, Raigarh, Ratlam, Bhopal, Jabalpur (Madhya Pradesh)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>HOT-DRY</strong></td>
<td></td>
</tr>
<tr>
<td>01. Typical Landscape &amp; Vegetation</td>
<td>Relatively flat; sandy or rocky ground conditions, scarce vegetation, generally consisting of grass, cacti or thorny trees and bushes, low water table.</td>
</tr>
<tr>
<td>02. Solar Radiation</td>
<td>Intense (800-950 W/m² per hour)</td>
</tr>
<tr>
<td>03. Mean Temp.</td>
<td>40 - 50 °C (mean max.) * 0 - 10 °C (mean min.) * 15 - 20 °C (diurnal variation)</td>
</tr>
<tr>
<td>04. Relative Humidity</td>
<td>Very low (25 - 40 %)</td>
</tr>
<tr>
<td>05. Precipitation</td>
<td>Low, generally less than 500 mm per year.</td>
</tr>
<tr>
<td>06. Wind</td>
<td>Dust laden local winds (often developing into sand-storms) in the afternoon, and isolated whirlwinds in the evenings.</td>
</tr>
<tr>
<td>07. Sky condition</td>
<td>Cloudless skies with high solar radiation, causing glare in dust laden air; occasional darkening of the sky due to sand storms.</td>
</tr>
<tr>
<td>08. Miscellaneous</td>
<td>Radiant heat emanating from the ground and surrounding objects during afternoons and evenings can cause considerable thermal discomfort.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>WARM-HUMID</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>01. Typical Landscape &amp; Vegetation</td>
<td>Generally low altitude, relatively flat regions with abundant vegetation.</td>
<td></td>
</tr>
<tr>
<td>02. Solar Radiation</td>
<td>Diffuse radiation due to cloud cover, intense radiation on clear days, dissipation of heat to the night sky prevented by clouds and humid air.</td>
<td></td>
</tr>
<tr>
<td>03. Mean Temp.</td>
<td>30 - 35 °C (mean max.) * 20 - 25 °C (mean min.) * 5 - 8 °C (diurnal variation)</td>
<td></td>
</tr>
<tr>
<td>04. Relative Humidity</td>
<td>High (70 - 90 %)</td>
<td></td>
</tr>
<tr>
<td>05. Precipitation</td>
<td>High, generally in excess of 1200 mm per year</td>
<td></td>
</tr>
<tr>
<td>06. Wind</td>
<td>Usually one or two prevailing directions, with velocities ranging from extremely low to very high (during rain storms).</td>
<td></td>
</tr>
<tr>
<td>07. Sky condition</td>
<td>Generally overcast (cloud cover ranging between 40 and 80%), causing unpleasant glare.</td>
<td></td>
</tr>
<tr>
<td>08. Miscellaneous</td>
<td>High humidity levels and low diurnal temperature variations cause great discomfort, if there is no air movement.</td>
<td></td>
</tr>
<tr>
<td>NO</td>
<td>CLIMATIC FEATURES</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>----</td>
<td>------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>01</td>
<td>Typical Landscape &amp; Vegetation</td>
<td>Generally hilly or high plateau region with fairly abundant vegetation.</td>
</tr>
<tr>
<td>02</td>
<td>Solar Radiation</td>
<td>More or less uniformly moderate all through the year.</td>
</tr>
<tr>
<td>03</td>
<td>Mean Temp.</td>
<td>$30 - 34 \degree C$ (mean max.) * $16 - 18 \degree C$ (mean min.) * $8 - 13 \degree C$ (diurnal variation)</td>
</tr>
<tr>
<td>04</td>
<td>Relative Humidity</td>
<td>Variable, between 30 and 80 %</td>
</tr>
<tr>
<td>05</td>
<td>Precipitation</td>
<td>Fairly well distributed over the year, total annual rainfall usually exceeding 1000 mm, relatively dry winters.</td>
</tr>
<tr>
<td>06</td>
<td>Winds</td>
<td>Variable, generally high during summer intensities and direction mainly dependent on topography.</td>
</tr>
<tr>
<td>07</td>
<td>Sky condition</td>
<td>Mainly clear, occasionally overcast with dense low clouds in summer.</td>
</tr>
<tr>
<td>08</td>
<td>Miscellaneous</td>
<td>Climatic conditions generally within a favorable range, which requires no special building designs to improve indoor comfort.</td>
</tr>
</tbody>
</table>

**MODERATE**

<table>
<thead>
<tr>
<th>NO</th>
<th>CLIMATIC FEATURES</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Typical Landscape &amp; Vegetation</td>
<td>Highland regions with abundant vegetation in summer.</td>
</tr>
<tr>
<td>02</td>
<td>Solar Radiation</td>
<td>Low in winter with a high percentage of diffuse radiation.</td>
</tr>
<tr>
<td>03</td>
<td>Mean Temp.</td>
<td>$20 - 30 \degree C$ (mean max.) * $-5 - 4 \degree C$ (mean min.) * $5 - 15 \degree C$ (diurnal variation)</td>
</tr>
<tr>
<td>04</td>
<td>Relative Humidity</td>
<td>Varies between 70 &amp; 80 %</td>
</tr>
<tr>
<td>05</td>
<td>Precipitation</td>
<td>Moderate, fairly evenly through the year; annual total around 1000 mm.</td>
</tr>
<tr>
<td>06</td>
<td>Winds</td>
<td>Generally intense, especially during rainfall; mainly dependent on topography.</td>
</tr>
<tr>
<td>07</td>
<td>Sky condition</td>
<td>Overcast for most part of the year, except during the brief summer period.</td>
</tr>
<tr>
<td>08</td>
<td>Miscellaneous</td>
<td>Summers are usually pleasant, with higher rainfall.</td>
</tr>
</tbody>
</table>

**COLD-CLOUDY**

<table>
<thead>
<tr>
<th>NO</th>
<th>CLIMATIC FEATURES</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Typical Landscape &amp; Vegetation</td>
<td>Highland regions with abundant vegetation in summer.</td>
</tr>
<tr>
<td>02</td>
<td>Solar Radiation</td>
<td>Low in winter with a high percentage of diffuse radiation.</td>
</tr>
<tr>
<td>03</td>
<td>Mean Temp.</td>
<td>$20 - 30 \degree C$ (mean max.) * $-5 - 4 \degree C$ (mean min.) * $5 - 15 \degree C$ (diurnal variation)</td>
</tr>
<tr>
<td>04</td>
<td>Relative Humidity</td>
<td>Varies between 70 &amp; 80 %</td>
</tr>
<tr>
<td>05</td>
<td>Precipitation</td>
<td>Moderate, fairly evenly through the year; annual total around 1000 mm.</td>
</tr>
<tr>
<td>06</td>
<td>Winds</td>
<td>Generally intense, especially during rainfall; mainly dependent on topography.</td>
</tr>
<tr>
<td>07</td>
<td>Sky condition</td>
<td>Overcast for most part of the year, except during the brief summer period.</td>
</tr>
<tr>
<td>08</td>
<td>Miscellaneous</td>
<td>Summers are usually pleasant, with higher rainfall.</td>
</tr>
<tr>
<td></td>
<td>Typical Landscape &amp; Vegetation</td>
<td>Mountaneous regions with little vegetation.</td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>02.</td>
<td>Solar Radiation</td>
<td>Intense with low percentage of diffuse radiation.</td>
</tr>
<tr>
<td>03.</td>
<td>Mean Temp.</td>
<td>17 - 24°C (mean max.) * -14 - 0°C (mean min.) * 20 - 25°C (diurnal variation)</td>
</tr>
<tr>
<td>04.</td>
<td>Relative Humidity</td>
<td>Consistently low (10 - 15 %).</td>
</tr>
<tr>
<td>05.</td>
<td>Precipitation</td>
<td>Very low, generally less than 200 mm per year.</td>
</tr>
<tr>
<td>06.</td>
<td>Winds</td>
<td>Occasionally intense.</td>
</tr>
<tr>
<td>07.</td>
<td>Sky condition</td>
<td>Fairly clear through the year with cloud cover less than 50%.</td>
</tr>
<tr>
<td>08.</td>
<td>Miscellaneous</td>
<td>Exceptionally harsh cold desert climatic conditions.</td>
</tr>
</tbody>
</table>

### COLD-SUNNY

<table>
<thead>
<tr>
<th></th>
<th>Typical Landscape &amp; Vegetation</th>
<th>Extremely variable landscapes, with rapid seasonal changes in vegetation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>02.</td>
<td>Solar Radiation</td>
<td>Intense in the summer and winter with a low percentage of diffuse radiation, but very low in monsoon with predominantly diffuse radiation.</td>
</tr>
<tr>
<td>03.</td>
<td>Mean Temp.</td>
<td>32 - 43°C (mean max.) * 4 - 10°C night (mean min.) * 3 - 22 deg°C (diurnal variation)</td>
</tr>
<tr>
<td>04.</td>
<td>Relative Humidity</td>
<td>In dry periods 20 to 55 %, in wet periods 55 to 95 %.</td>
</tr>
<tr>
<td>05.</td>
<td>Precipitation</td>
<td>Variable between 500 and 1300 mm per year, during monsoon reaching 250 mm in the wettest month. Little or no rain in the dry season.</td>
</tr>
<tr>
<td>06.</td>
<td>Winds</td>
<td>Hot and dusty during summer; strong winds in monsoon from south-east; dry, cold winds in winter from north-west.</td>
</tr>
<tr>
<td>07.</td>
<td>Sky condition</td>
<td>Varying, overcast and dull in the monsoon, clear during summer and winter. Occasional dust haze during the summer period</td>
</tr>
<tr>
<td>08.</td>
<td>Miscellaneous</td>
<td>Seasonal changes in relative humidity cause rapid weakening of building materials.</td>
</tr>
</tbody>
</table>
**03. DESIGN FEATURES IN EACH OF THE SIX CLIMATIC ZONES.**

<table>
<thead>
<tr>
<th>NO.</th>
<th>REQUIREMENTS</th>
<th>DESIGN FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>REDUCTION of heat gain</td>
<td>Orientation of smaller walls to East &amp; West • Small surface to volume ratio e.g. circular plan • Shading with overhanging roof &amp; large tree in courtyard • Avoiding openings, other than doors.</td>
</tr>
<tr>
<td>02.</td>
<td>INCREASE of heat loss</td>
<td>Ventilation by courtyard • Evaporation by vegetation, sprinkling.</td>
</tr>
<tr>
<td>03.</td>
<td>REDUCTION of heat transmission to interior</td>
<td>Thermal insulation of roofs &amp; walls e.g. thick walls, cavity walls • Reduction of air infiltration/ventilation by providing wind breaker fences against hot winds.</td>
</tr>
<tr>
<td>04.</td>
<td>BALANCE of temp. fluctuation</td>
<td>Massive walls, to increase time lag.</td>
</tr>
<tr>
<td>05.</td>
<td>CONTROL of humidity</td>
<td>by absorption/desorption of earth (mud) walls.</td>
</tr>
<tr>
<td>06.</td>
<td>INCREASE of heat gain</td>
<td>NIL</td>
</tr>
<tr>
<td>07.</td>
<td>REDUCTION of heat loss</td>
<td>NIL</td>
</tr>
</tbody>
</table>

**WARM-HUMID**

<table>
<thead>
<tr>
<th>NO.</th>
<th>REQUIREMENTS</th>
<th>DESIGN FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>REDUCTION of heat gain</td>
<td>Small surface to volume ratio e.g. circular plan, low wall height • Shading by roof overhang &amp; verandahs.</td>
</tr>
<tr>
<td>02.</td>
<td>INCREASE of heat loss</td>
<td>Ventilation by courtyard, high level openings near roof, windows facing wind direction, through thin walls &amp; roof.</td>
</tr>
<tr>
<td>03.</td>
<td>REDUCTION of heat transmission to interior</td>
<td>Thermal insulation of roof.</td>
</tr>
<tr>
<td>04.</td>
<td>BALANCE of temp. fluctuation</td>
<td>NIL</td>
</tr>
<tr>
<td>05.</td>
<td>CONTROL of humidity</td>
<td>Absorption/desorption through mud walls, floor.</td>
</tr>
<tr>
<td>06.</td>
<td>INCREASE of heat gain</td>
<td>NIL</td>
</tr>
<tr>
<td>07.</td>
<td>REDUCTION of heat loss</td>
<td>NIL</td>
</tr>
</tbody>
</table>
01. REDUCTION of heat gain
   Orientation of smaller walls to East & West • Shading by roof overhangs, trees, chujjas etc.

02. INCREASE of heat loss
   Ventilation through courtyard, windows facing wind direction, high level openings close to roof.

03. REDUCTION of heat transmission to interior
   Thermal insulation of roofs.

04. BALANCE of temp. fluctuation
   NIL

05. CONTROL of humidity
   NIL

06. INCREASE of heat gain
   NIL

07. REDUCTION of heat loss
   NIL

---

**COLD-CLOUDY**

01. REDUCTION of heat gain
   NIL

02. INCREASE of heat loss
   NIL

03. REDUCTION of heat transmission to interior
   NIL

04. BALANCE of temp. fluctuation
   Massive wall.

05. CONTROL of humidity
   Absorption/desorption by mud walls, earth berm construction, i.e back filled earth between house and hill.

06. INCREASE of heat gain
   Orientation of larger walls towards South • Direct heat gain by providing unglazed sheltered spaces like verandahs or windows towards south for green house effect • Indirect heat gain by exposed thermal storage walls.

07. REDUCTION of heat loss
   Thermal insulation by thick walls & roofs • Air cavities under roof by means of false ceiling • Shelter from wind & reduced ventilation by providing small openings or movable shutters, buffer zone around verandahs in windward direction or locating building on leeward side of hill or low entrances • Small exposed surface area (circular, square) or vaulted shape.
<table>
<thead>
<tr>
<th>No.</th>
<th>Requirements</th>
<th>Design Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>REDUCTION of heat gain</td>
<td>NIL</td>
</tr>
<tr>
<td>02.</td>
<td>INCREASE of heat loss</td>
<td>NIL</td>
</tr>
<tr>
<td>03.</td>
<td>REDUCTION of heat transmission to interior</td>
<td>NIL</td>
</tr>
<tr>
<td>04.</td>
<td>BALANCE of temp. fluctuation</td>
<td>Massive walls.</td>
</tr>
<tr>
<td>05.</td>
<td>CONTROL of humidity</td>
<td>Thick walls.</td>
</tr>
<tr>
<td>06.</td>
<td>INCREASE of heat gain</td>
<td>Orientation of larger walls towards South &amp; West, Direct heat gain by providing windows facing South, West &amp; East, Indirect heat gain by providing exposed thermal storage walls.</td>
</tr>
<tr>
<td>07.</td>
<td>REDUCTION of heat loss</td>
<td>Thermal insulation of roof &amp; walls, Shelter from wind &amp; reduced ventilation by providing protected entrances, compound walls close to building to reduce exposure to cold winds.</td>
</tr>
</tbody>
</table>

**Cold Sunny**

<table>
<thead>
<tr>
<th>No.</th>
<th>Requirements</th>
<th>Design Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>REDUCTION of heat gain</td>
<td>Small surface to volume ratio (square etc.), Low wall height, Shading by trees in courtyard, overhanging roofs, verandas, Small openings.</td>
</tr>
<tr>
<td>02.</td>
<td>INCREASE of heat loss</td>
<td>Ventilation by courtyard, High level openings, Evaporation by vegetation, Springkling water.</td>
</tr>
<tr>
<td>03.</td>
<td>REDUCTION of heat transmission to interior</td>
<td>Thermal insulation of roofs, walls, Control of air movement by moveable curtains on windows.</td>
</tr>
<tr>
<td>04.</td>
<td>BALANCE of temp. fluctuation</td>
<td>Massive walls.</td>
</tr>
<tr>
<td>05.</td>
<td>CONTROL of humidity</td>
<td>Absorption/desorption through thick mud walls.</td>
</tr>
<tr>
<td>06.</td>
<td>INCREASE of heat gain</td>
<td>Direct heat gain by providing space like verandah (sheltered from wind).</td>
</tr>
<tr>
<td>07.</td>
<td>REDUCTION of heat loss</td>
<td>Thermal insulation with thick walls &amp; moveable curtains on windows, Shelter from wind &amp; reduced ventilation by small openings, curtains, compact planning, Small exposed surface area by low wall height, Square plan etc.</td>
</tr>
</tbody>
</table>
APPENDIX 2

ANTHROPOMETRICS

Body and reach characteristics of people are of key importance in design. Anthropometry is the name used for the science of measurement of human body and its movements in space.

Following page illustrates such data that are applicable for primary school design.
## APPENDIX 3
### A NOTE ON TREES

### SHADE

<table>
<thead>
<tr>
<th>Tree</th>
<th>Height Range</th>
<th>Diameter Range</th>
<th>Trunk</th>
<th>Environment</th>
<th>Flowering</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banyan</td>
<td>20-30</td>
<td>30-30</td>
<td>Umbrella</td>
<td>Bright red in (Dec-Jan)</td>
<td>Sand loam clay</td>
<td>Hardy, fast growing, gigantic, throws out aerial roots, good for avenues</td>
</tr>
<tr>
<td>Casurina</td>
<td>7-8</td>
<td>25-30</td>
<td>Conical</td>
<td>Tiny brown cones</td>
<td>Loam clay</td>
<td>Can be pruned to make hedge; tolerates salinity, hardy</td>
</tr>
<tr>
<td>Karanj</td>
<td>5-6</td>
<td>12-15</td>
<td>Flat dome</td>
<td>Tiny white spray (May-June)</td>
<td>Loam clay</td>
<td>Tolerates salinity and wetness</td>
</tr>
<tr>
<td>Neem</td>
<td>10-15</td>
<td>24-36</td>
<td>Irregular</td>
<td>White/yellow flower (Dec-Jan)</td>
<td>Sand loam clay</td>
<td>Hardy, fast growing shade, values leaves used as mosquito repellent</td>
</tr>
<tr>
<td>Palmira</td>
<td>10-20</td>
<td>10-30</td>
<td>Tall with crown</td>
<td>N/a</td>
<td>Loam clay</td>
<td>Slow growing, ornamental, often started indoors</td>
</tr>
<tr>
<td>Pipal</td>
<td>7-12</td>
<td>18-24</td>
<td>Irregular</td>
<td>N/a</td>
<td>Sandy loam clay</td>
<td>Hardy tree that can be propagated by planting seeds and cuttings</td>
</tr>
<tr>
<td>Rain-tree</td>
<td>6-7</td>
<td>20-25</td>
<td>Umbrella</td>
<td>Pink puffy flowers (Mar-May, Dec-Jan)</td>
<td>Loam clay</td>
<td>Fast growing, splendid shade, needs well drained soil, fosters growth of lac insects</td>
</tr>
</tbody>
</table>

### FLOWERING

<table>
<thead>
<tr>
<th>Tree</th>
<th>Height Range</th>
<th>Diameter Range</th>
<th>Shape</th>
<th>Flowering</th>
<th>Environment</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asoka</td>
<td>5-6</td>
<td>5-10</td>
<td>Conical dome</td>
<td>Red clusters in Jan-Feb</td>
<td>Loam or clay</td>
<td>Used medicinally, considered sacred by Buddhists and Hindus</td>
</tr>
<tr>
<td>Copper pod</td>
<td>6-7</td>
<td>20-25</td>
<td>Conical dome</td>
<td>Yellow flowers (May, Sept)</td>
<td>Sandy loam rock</td>
<td>Hardy and quick-growing, tolerates salinity, used for furniture making</td>
</tr>
<tr>
<td>Flame of forest</td>
<td>12-15</td>
<td>10-15</td>
<td>Irregular</td>
<td>Orange clusters in Jan-Mar</td>
<td>Loam</td>
<td>Hardy forest tree, slow growing, sweet smelling flowers</td>
</tr>
<tr>
<td>Plant</td>
<td>Height</td>
<td>Spread</td>
<td>Growth Shape</td>
<td>Flowers</td>
<td>Soil Type</td>
<td>Water Needs</td>
</tr>
<tr>
<td>------------------</td>
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<td>-------------</td>
</tr>
<tr>
<td>Frangipani</td>
<td>4-5</td>
<td>6-9</td>
<td>Irregular</td>
<td>White flowers in Mar-June</td>
<td>Loam</td>
<td>Needs little water, leafless for long periods, sweet smelling flowers</td>
</tr>
<tr>
<td>Gulmohar</td>
<td>6-7</td>
<td>15-18</td>
<td>Conical / Umbrella</td>
<td>Reddish orange flower (Feb-Mar)</td>
<td>Sandy loam</td>
<td>Graceful and pleasing tree</td>
</tr>
<tr>
<td>Horse cassia</td>
<td>5-6</td>
<td>15-18</td>
<td>Conical / Flat/dome</td>
<td>Pink clusters in May-June</td>
<td>Sandy loam</td>
<td>Cattle do not eat the brittle branches of this hardy tree</td>
</tr>
<tr>
<td>Indian coral</td>
<td>6-7</td>
<td>15-18</td>
<td>Irregular</td>
<td>Large scarlet in Feb-May</td>
<td>Loam</td>
<td>A spiky tree, leafless before and after flowering</td>
</tr>
<tr>
<td>Indian cork</td>
<td>6-7</td>
<td>20-25</td>
<td>Elongate</td>
<td>Small white flower (Apr-Nov)</td>
<td>Loam</td>
<td>A delicate soft wood tree</td>
</tr>
<tr>
<td>Indian laburnum</td>
<td>6-7</td>
<td>9-12</td>
<td>Conical</td>
<td>Bright yellow in Apr-June</td>
<td>Sandy loam</td>
<td>A fast growing tree</td>
</tr>
<tr>
<td>Jacaranda</td>
<td>6-7</td>
<td>18-21</td>
<td>Dome</td>
<td>Purple flowers in Mar-Apr</td>
<td>Loam</td>
<td>Prefers cooler weather, grows poorly in hot climates</td>
</tr>
<tr>
<td>Queen's flower</td>
<td>5-6</td>
<td>15-18</td>
<td>Dome</td>
<td>Purple flowers in May-June</td>
<td>Loam or clay</td>
<td>Needs care and watering, flowers twice yearly</td>
</tr>
<tr>
<td>Red silk cotton</td>
<td>7-9</td>
<td>24-30</td>
<td>Irregular</td>
<td>Large red flower (Jan-Feb)</td>
<td>Loam</td>
<td>Forest tree, flowers when leafless</td>
</tr>
<tr>
<td>Tulip tree</td>
<td>6-7</td>
<td>18-21</td>
<td>Irregular</td>
<td>Large orange flower (Mar-Apr)</td>
<td>Loam</td>
<td>Good for avenues, needs plenty of water</td>
</tr>
<tr>
<td>Variegated bauhinia</td>
<td>5-6</td>
<td>9-12</td>
<td>Irregular dome</td>
<td>Purple and white flower (Feb-Apr)</td>
<td>Loam</td>
<td>Delicate tree</td>
</tr>
<tr>
<td><strong>FRUIT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Banana</td>
<td>1</td>
<td>3-6</td>
<td>Tall with crown</td>
<td>Fruit almost all the year</td>
<td>Loam or clay</td>
<td>Cultivated through root grafts, lasts only two years</td>
</tr>
<tr>
<td>Chiku</td>
<td>5-7</td>
<td>12-15</td>
<td>Dome</td>
<td>Fruit almost all the year</td>
<td>Clay loam</td>
<td>Needs care and water, good shade tree</td>
</tr>
<tr>
<td>Coconut</td>
<td>...</td>
<td>12-24</td>
<td>Tall with crown</td>
<td>Fruit almost all the year</td>
<td>Sandy loam</td>
<td>Suitable for hot-humid climate, tolerates salinity, needs plenty of water</td>
</tr>
<tr>
<td></td>
<td>8-12</td>
<td>10-15</td>
<td>Irregular</td>
<td>Fruit at end of monsoon</td>
<td>Loam</td>
<td>Very fast growing, fruit cooked and eaten as vegetable</td>
</tr>
<tr>
<td>-------</td>
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<td>-----------</td>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td>Indian almond</td>
<td>7-8</td>
<td>20-25</td>
<td>Layered</td>
<td>Fruit at end of monsoon</td>
<td>Loam clay loam</td>
<td>Attractive tree that tolerates some salinity, very fast growing</td>
</tr>
<tr>
<td>Mango</td>
<td>3-10</td>
<td>12-18</td>
<td>Dome</td>
<td>Fruit in summer</td>
<td>Loam clay</td>
<td>Good shade tree, many varieties exist</td>
</tr>
<tr>
<td>Papaya</td>
<td>1-3</td>
<td>3-6</td>
<td>2-5</td>
<td>Tall with crown</td>
<td>Loam</td>
<td>Bears fruit for about three years, good for kitchen gardens, very short life</td>
</tr>
</tbody>
</table>
ABBREVIATIONS USED

mm.  millimetres
ft.   feet
sq. ft.  square feet
sq. m.  square metres
ht.  height
m.  metres
°C  degree centigrade
nos.  numbers
W/m²  watts / square metre
T/m²  tons / square metres
etc.  etcetra
temp.  temperature
>  not greater than
\&  and
km.  kilometre
• THE END OF THE BEGINNING •