ECOFRIENDLY CONSTRUCTION

With 32 "green" buildings, Seattle has become a leader in environmentally sensitive building and design. Green construction aims to reduce pollution and reduce dependence on non-renewable power and fuel sources.

- **GREEN ROOFS**: A thin layer of plants and soil on rooftops provide insulation, reduces stormwater runoff, stores carbon dioxide and creates oxygen.

- **ALTERNATIVE ENERGY**: Rooftop mounted wind turbines and solar panels reduce need for outside energy sources.

- **WINDOWS**: Windows and skylights provide natural lighting and heat. Glazed or double pane windows provide insulation.

- **BREEZES**: Trees and buildings create natural ventilation.

- **BUILDING MATERIALS**: Recycled building materials reduce waste. Building with recycled timber helps protect forests and using new tools and systems creates a healthier interior space.

HOW TO MAKE YOUR BUILDING GREEN

- **Recycle**: Reduce, reuse and recycle materials.

- **Rainwater**: Use rainwater for landscaping and irrigation.

- **Solar**: Use solar panels for electricity.

- **Green Roofs**: Use green roofs for insulation and energy savings.

- **Vents**: Vents prevent moisture buildup.

For A Sustainable Future

[Image]
COMPUTATION OF ANNUAL WATER REQUIREMENT (IN LITRES)

A. Water requirement for elephants can be capped at 250 litre (drinking) + 300 litre (Miscellaneous):

550 L/day/elephant. Hence, 550 x 365 days x 100 nos = 20,775,000 litres/year.

B. Domestic water requirement for Maharajah settlements:

100 elephants x 2 dependents x 100/Lpd x 365 days = 7,300,000 litres/year.

C. Annual requirement for staff (30 nos.) at 60 L/day and visitors (500 nos./day) at 50/L/day:

(60 x 365 x 30) + (50 x 365 x 500) = 91,25,000 + 6,57,000 = 97,82,000 litres/year.

D. Annual water requirement for Irrigation:

Site area x 1 mm/sqm x (365 - 30) rainy days x 1000 = 11,76,68,750 litres/year.

Hence, Water Closure needs to be achieved for (A + B + C + D) = 13,48,23,750 litres/year. This requirement can be reduced from water retained on site and from external water sources/ agencies.

ESTIMATED WATER RECHARGE AND RETENTION AT SITE

Site Area = 3,31,230 sqm,

Annual Rainfall = 600 mm/year,

Recharge possible after deduction of losses to evapo-transpiration and percolation 100-70% = 30%.

Therefore, recharge within site is = (Site Area + Area of higher elevation around site) x Annual Rainfall x Recharge percentage

(3,31,230 + 91,450) x 60 x 0.3796,800 litres/year.

But only 25% will be perennially retained: 0.4 x 7,96,800,000 = 3,18,7,400 litres/year.

Water that can be sourced from across the site (through a sluice network):

Annual rainfall x Area of site x Recharge percentage x Retention percentage:

0.6 m/year x 33,800 sq.m x 0.12 x 0.4 x 1000 = 8,11,200 litres/year.

Total sum of water available: 3,18,7,400 + 8,11,200 = 3,26,85,600 litres/year.

Therefore, the deficit is: 15,48,23,750 - 3,26,85,600 = 12,21,40,150 litres/year.

Note: Recharge percentage will see a rise in its figure every consecutive monsoon, after treatment of site. This should reduce the expected shortage of water.

POSSIBLE SOLUTION TO OVERCOME WATER DEFICIT

Water for irrigation, which forms a considerable chunk of requirement, will definitely be high in the first few years of development. Hence, it is preferable to phase out the development. The second phase for future expansion can receive minimal treatment for the first few years, till the recharge and retention percentage of water within the site improves.

Estimated Water requirement for Hathi Gaon

<table>
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<tr>
<th>Requirement Category</th>
<th>Numbers</th>
<th>Drinking</th>
<th>Cooking</th>
<th>Toilet</th>
<th>Other</th>
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<tr>
<td>Elephants</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maharajah family</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visitors</td>
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<tr>
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<td></td>
</tr>
<tr>
<td>Other Staff</td>
<td>30</td>
<td></td>
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</tbody>
</table>

The estimated annual water requirement of this habitation including drinking, irrigation and bathing (for the elephants) is around 150 million litres. Scanty rainfall averaging less than 600mm per year renders water closure on site an unrealistic proposition. To reduce external dependency, design initiatives encourage the retention of the surface water and its recharge. A series of large, interlinked reservoirs at the central low-lying region of the site are to be fed by a network of vegetated swales, punctuated by retention basins and larger ponds.

Understanding that the total amount of rainfall incident on the site surface would not be sufficient to meet the water demands, it then became important to harness and redirect water from areas external to the site boundary through a system of swales. The external water sources identified were the surface run-off from the barren hill, the natural depressions along the site edges and certain key valleys flowing along the boundary.
The water harnessed in the site is treated through a series of reservoirs of varying intensities and an integrated swale system. The system of reservoirs in the site vary not only in their physical form but also in their relation to topography as they incorporate the existing slopes of the terrain with minimum modulation. The system of reservoirs thus developed bear a strong hierarchical relationship that is based on two conditions - the principles of water management and on the relationship between elephants and water. The first component are the pre dams that hold water before the overflow reaches them to the reservoirs that also act as communal spaces for the elephants' mud bath. The second are the drinking water reservoirs with steeper sections, limiting direct access to water. The third are the bathing reservoirs integrated with ramps to allow access into the water for the mahousis to bathe the elephants. Thus the reservoirs become not only a system integral to the sustainable design initiative but also one that shapes the social interactions of the inhabitants of the site.
Establishment of a balanced ecosystem in this degraded site formed the crux of the design policy, an approximation of the natural habitat of the elephants. The selection of species for multi-storied vegetation is derived from the larger region, more specifically based on the ecosystem of the Aravalli ranges. Zone-wise interpretation of the vegetation, such as the definition of the perimeter and microcrops of grasslands and wetlands, are characteristics that modulate visual access to the elephant habitat. The root system of the indigenous plant palette stabilizes the topsoil layer in this erosion-prone site in conjunction with other soil conservation measures.
The park/habitat is planned as an ‘acceptable system’ that is expected to evolve and grow in time by incorporating the existing ecology and then creating its own micro ecology. Time becomes an important factor in understanding the nature of the habitat as it allows processes - natural and social - to exchange and produce new relations, thereby enhancing the experience of the site.

The images illustrate the possible evolution of the nature and the spatial conditions of the reservoir with respect to ecological conditions over time and the associative relations that would emerge through it.

The approach to such a landscape articulation focuses on the conversion of a terrain that contradicts the ‘traditional’ vocabulary of its location but mediates and expresses itself to the larger ecosystem setting. Such a project in particular, probably stages a more impure and unstable organization of landscapes as it attempts to mediate between disparate and at most times un-comprehendable forces working within the territory.

The space produced is more the nesting of user demands against ecology and environment and moving further towards cultural and functional tendencies and adjacencies. Though the need and the functioning of the landscapes has an embedded quality and quantity, its appropriation remains more open ended due to the constant oscillations between the user and the consumer of the space.
Water as a Resource – Management

Gully Plug Treatment
It consists of an earthen embankment built across the intended slope so that maximum rainwater runoff from the field can be conserved. Length of embankment ranges from 100-300m (can be reduced as a part of demonstrative practice- a smaller catchment can be catered to)

- Shallow gravelly surface required
- Gently sloping plain with soils good for crop production
- Bund size depends on rainfall, catchment and soil type
- Provision of spillway to drain excess water
- Minimum 1:15 ration of khadin area to catchment required
- Good grass and plantations be maintained in catchment areas

Each of these according to land use can be included with the bio-diversity hub, wildlife corridor, agriculture and horticulture fields, plantations and demonstrative landscapes. Topography conditions for each as below:

**Nadi** - Pond used for storing water from a natural catchment area during monsoons. Natural surface depression which could have stone walls on either sides to enhance retention period. **Nadi** a seasonal water source with water availability ranging from 2 months to 6 months depending on catchment characteristics, run-off and surroundings. Sandy plains (site) can have deeper **nadi** with larger catchment area. Problems due to : heavy sedimentation, evaporation especially in dry seasons and seepage losses. For these, timely de-silting required, secondly if shady trees are provided near a **nadi**, the micro-climate can be enhanced to reduce evaporation losses, lesser surface area. Average water holding capacity of a **nadi** is 20000ltr (20m³)

**Khadin** - harvest of rainwater on farmland and subsequent use of this water-saturated land for agriculture. This practice can provide an opportunity to tae up rabi crops without the use of groundwater irrigation. Millets can easily be grown in **khadins** which can also help restore the field fertility.

Jodhpur currently comes under the critical zone for depleting ground water levels. The site specifically has hydro-geological conditions such that ground water is available at 24-27m below in unconfined conditions only. Hence the need to create surface water retention ponds using the traditional system of water harvesting. These can be combined with agricultural practices like **khadins**, **nadis**, **johads** at a smaller scale or lined features like **tanks** where rate of evaporation is also controlled.

Par - identification of a micro - catchment area **agor** within the site to create a **paar**. Here, **kuis** / beris/wells are dug with smaller mouths to contain evaporation losses. The number of **kuis** will depend on the type of catchment area, depth being around 6-8m. These could be more of artificial recharge wells that help tap run-off from surrounding areas. Water from these areas can be re-routed to use.

**Kuis/ beris-** dug next to tanks/ in **agor**/ to collect the seepage; usually 10-12m deep with **kuccha** structures, covered with wood planks.
ECOLOGICAL LANDSCAPES
BIO-DIVERSITY HUB

Bio-diversity hub deals with development and management of indigenous species of plants to regenerate natural landscape of the region. Best left undisturbed by heavy human interference, trails through this hub can be used for study purposes.

ECOLOGICAL RESTORATION OF NON-ARABLE LANDS

Starting with pioneering species of vegetation that occupy a piece of uninhabited land first, the regeneration process would continue with other native plant species of the region. As a buffer/transition from habited spaces for such areas, vegetation reserves for threatened species or medically important species, energy plantations or orchards, agriculture or horticulture, or grasslands/pasturelands can be proposed.

WILDLIFE CORRIDOR AND BIO-DIVERSITY HUB

**Trees**
- Prosopis cineraria - khejri
- Tecoma undulata - rohida
- Salvadora oleoides - Meetha jaal
- Acacia senegal Kumath
- Maytenus emarginata Kankera
- Balanites raxburchi Hingato
- Salvadora persica peelu
- Cordia gharaf Goandi
- Moringa concanensis Sargooro
- Acacia leucophloea – safed kikar
- Anogeissus rotundifolia
- Tamarix articulata-farash
- Azadirachta indica Neem
- Zizyphus rotundifolia Ber

**Shrubs**
- Capparis decidua Ker
- Leptadenia pyrotechnica Khimp
- Balanites aegyptiaca Hingota
- Acacia jacquemontii Bhu-bavali
- Zizyphus nummularia Bordi
- Acasia nilotica Babool
- Grewia tenax Gangeti
- Echinops echinatus Untkantara
- Fuuegia leucopyrus Ghatbar

**Herbs**
- Tephrosia purpura Buena
- Solanum surattense Bhuringni (Chhoti Kateli)
- Crotolaria burhia Sinia
- Fagonia arabica Dhamasa
- Indigofera cordifolia Bekria
- Aerva javanica Bui
- Cassia angustifolia Sonamukhi
- Corchorus depressus Cham ghas

**Climbers and creepers**
- Cocculus pendulus Pilan
- Citrullus colocynthis Tumba vel
- Clerodendrum philomidis Arni

**Grasses**
- Cenchrus biflorus Bhurat
- Desmostachya bipinnata Dab
- Cenchrus ciliaris Dhaman
- Lasiurus sindicus Sewan
- Panicum antidotale Grama
- Aristida adsensionis Lapla

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AUROVILLE 2013    Mohan S Rao    -    RESOURCE MANAGEMENT
Corridor is a linkage between habitat patches of wildlife. For an intervention of a huge scale like this campus design in an almost virgin landscape requires incorporation of wildlife corridors through the site to prevent an abrupt end to animal movements that have been going on since a long time. A continuous corridor may be required for large mammalian or even smaller reptilian species. For birds and certain other animals, stepping stones, discontinuous habitat patches might suffice. The site is inhabited or visited by species like blackbucks, chinkaras, gerbils, sand rats and reptiles. These corridors can be studied and visited by trails running parallel to the corridor without disturbing the fauna inside. Two kinds of corridor have been provided for:

**FAUNAL MOVEMENT FOR FORAGING ON THE GROUND**

Continuous stretch of land 30 to 50 m wide runs from one end of the site to the other creating a conduit for black-bucks, chinkaras and habitats for gerbils, sand rats etc. The development of landscape is based on the scrub forest found in Jodhpur and nearby areas. Various species of plants required for feeding and shelter have been recognized and incorporated in the design of a wildlife corridor.

**FAUNAL MOVEMENT WITH STEPPING STONES**

Distance for movement between stepping stones (habitat patch or foraging ground) is determined by the ability to see each successive stepping stone by animal species. A maximum of 30-50 m space has been provided between agricultural fields, pasture lands, plantations of fruit bearing trees, bio-diversity hubs etc. The space has been incorporated as open grounds, scrub vegetation etc. for clear visibility between two patches.
In a broader sense, green infrastructure consists of the inherent natural green resources as well as the built infrastructure comprising of storm water drains, waste water utilization set ups etc. which can be merged with the surrounding landscapes.

**NATURAL**
- Ecological corridors:
  - Wildlife corridors
  - Bio-diversity hub
- Special vegetation reserves:
  - For threatened species
  - For medically important species
- Buffer plantations:
  - Shelterbelts and wind breaks
  - Woodlands 'orans'
  - Orchards
  - Energy plantation
  - Horticulture
  - Agriculture

**BUILT**
- Storm water collection:
  - Surface run-off (paved surfaces)
  - Roof top run-off
  - Reed beds
  - Water harvesting structures
- Waste water and sludge treatment and re-utilization (DEWAT)
  - Settling tanks
  - Underground chambers
  - Gravel filter (constructed wetlands)
  - Polishing pond (constructed wetlands)
  - Vermicomposting pits
  - Biogas chambers
- Circulation:
  - Pedestrian
  - Cycle
  - Vehicular

**Other Services**

**LEGEND**
- Green infrastructure
- Built infrastructure
- Buffer area around protected watersheds
Green infrastructure comprising of the natural elements will have ecological corridors and demarcated native vegetation areas.

An ecological corridor will be either a movement corridor for the smaller and bigger mammals with islands of vegetation along, or part of the biodiversity hub.

A typical ecological (wildlife) corridor of 50m stretch consists of:

- 10m wide swale as a movement corridor
- a berm (1-2m high) on either or both sides of the swale, rather than just a depression, to exaggerate the slope and enhance the surface run-off into the swale; also for burrows / hollows of smaller mammals;
- vegetation specific to tolerance towards water as also drought conditions (native species) and provide food and fodder for mammals and avifauna;
- leguminous (nitrogen fixing ability) vegetation along the swale and waterbodies
- immediate buffer spaces between the swales and the surrounding areas of min. 10m
Wetlands integrated with the Open Space Development