MALAYSIA ARCHITECTURAL JOURNAL

Malaysia Architectural Journal

Journalhomepage:
https://majournal.my/index.php/maj
e-ISSN: 2716-6139

Dhamma Arunachala: An Exemplary Self-Efficient and Self-Sufficient Centre

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ARTICLE INFO

Article history:
Received: 30 April 2024
Received in revised form
Accepted: 15 October 2024
Available online: 23 June 2025

Keywords:

Alternative Construction Technology, Passive Cooling Technique, Waste Water Treatment, Ground Water Recharge, Circular Economy

ABSTRACT

Climate Responsive Design is a key to developing resiliency in response to changing circumstances and unpredictable calamities due to climate change. In the Urban Context, architects are designing buildings with lack of co-relation between built spaces and natural environment, which is an unsustainable approach. The urban centres are developed in such a way that the services of facilities heavily depend on the market, consequently developing unsustainable culture. As a learning from our traditional lifestyle, we need to design a city responding to the natural surroundings and local resources rather than replicating rampant concrete jungles. We need to develop permaculture as a source of self-reliant economy in parallel with the other economic sources as well as improvise indigenous construction technologies with innovative ideas. There is a huge research gap between Indigenous ways of construction practices aided by contextual 'learning by doing' and the modern trend of construction. Filling the gap helps develop Self- sufficient Sustainable cities and provide adequate answers to complex challenges like climate change, natural disasters, pandemic situations etc. From the empirical perspective, it is difficult to achieve a complete balance between ecology and the human density in an urban context. However, there are some exemplary premises such as: Dhamma Arunachala, a Vipassana Meditation Centre in Tiruvannamalai, Tamilnadu, India. Located in Hot Equatorial region where temperature goes to above 35 Degree Celsius, the centre presents itself as an example of alternative ways of construction practices, application of Passive Cooling Technique, Food Production and Waste Water Management that makes the whole Centre Self Sufficient and Efficient.

1. Introduction
1.1 General

With the rapid boom in the Construction Sector, the necessity of Climate Adaptive Buildings is also soaring up. However, the mainstream market witnesses the same old way of construction technology irresponsive of ecological context of the built environment. Architects' designs are still realized on the factory-manufactured products. Materials with high embodied energy and design with significant operational energy are still major concerns, which leads construction sector to be a huge contributor to environment degradation. According to (Vishwonath, 2022), 50% or more environmental degradation is due to buildings. And, it's not surprising that the Cement Industry is one of the most carbon intensive industries accounting for about 8% of the world's carbon dioxide emissions (Rodrigues, 2010). As the Climate Change pushes the earth towards rapid temperature rise, demand for energy for cooling is expected to be double by 2027 from 2017's numbers and 57% of this demand will be from buildings (AEEF, 2018).

In order to counteract this situation, the arena of discussion often leads to various terms to frame out the concept of a sustainable urban area or a city, where the concept of "Smart City" or "Smart Community" is often on the centre. This drags to several other questions as followings: How to define a SMART COMMUNITY? What are the essential factors that truly make a COMMUNITY to be Called SMART? Is having all the facilities of infrastructures and having 24 hours access to the quality internet really satisfy the basic need of SMART COMMUNITIES? Does a system that provides food resource through a Departmental Store, detached with the original biological source, support the concept of SMART COMMUNITY?

As per the author's opinion, the continuous impact of Climate Change aggravated by possibilities of pandemic situations like COVID-19 in last few years has obliged to rethink about the "Self-sufficiency" as the central dogma of a Smart Community. And, the central question should be like this: How can we make a Community Self-sufficient and Efficient so that it can truly be smart?
Fig. 1 clearly depicts the connection between the concept of smart shelter and various other global challenges.

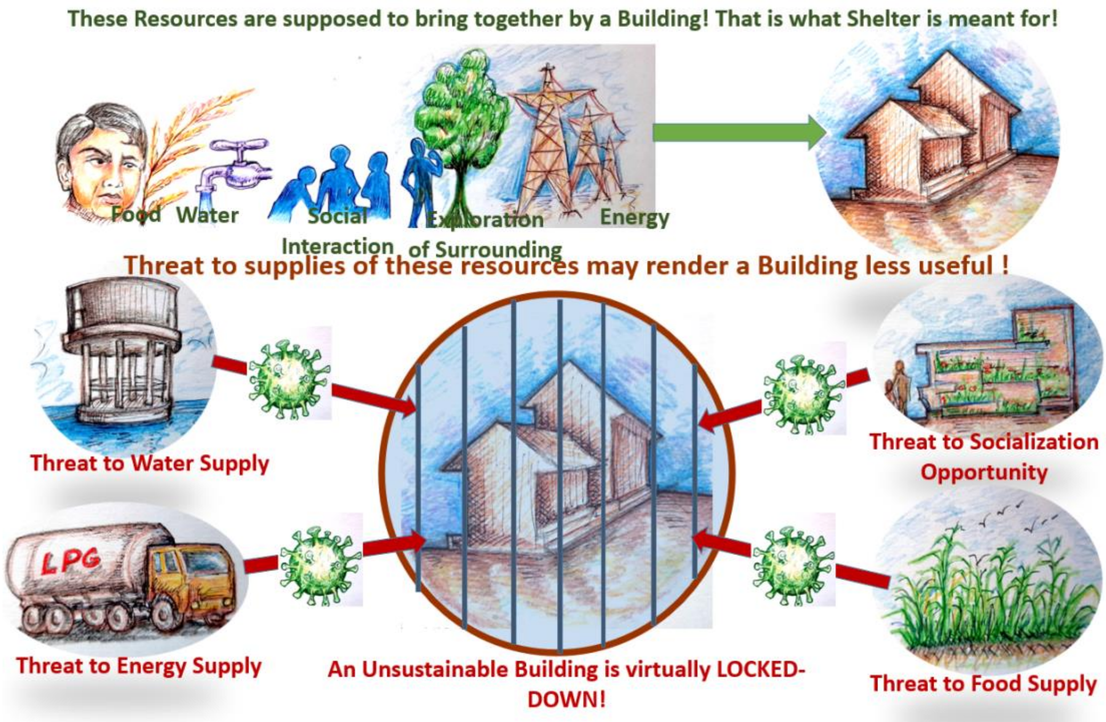

Fig. 1. A sketch showing the market based Urban Centre which was fully lockdown during pandemic and any other calamities which is unsustainable (Source: Author)

With this note, today's architects need to rethink holistically about the way buildings are designed and constructed. If we rethink and self-analyse ourselves, as Architects, Urban Planners and Designers, it is the right time to take initiatives to create Self-Sufficient, Self-Efficient and Self-Sustainable Built Environment for the future to balance with available limited resources. The present-day design and construction practices in Urban Context is still extremely unsustainable. To quote again, an urban centre is developed in such a way that a heavy dependence on market for operating and sustaining itself becomes inevitable.

1.2 Introduction to the Cast Study

The author believes that, in contrast to argument what can happen and what cannot happen, it is always prudent to take a case to study in detail so as to make sense of the practical relevance and the real-world challenges. On this account, it is always better to pick an instance backed-up by initiation of conscious stake and intentional effort. As an exemplary community, this research paper explores a meditation centre named Dhamma Arunachala which is located near Equator, Tamil Nadu, India. This project was the model example for Meditation centre not only for cleansing of human mind but also, to cleanse and manage the balance of ecosystem of existing environment. The centre is spread in seven acres of land (Gopalan, 2022). **Fig. 2** and **Fig.3** show pictorial view and conceptual sketch of the campus premises. The campus was founded in 2014 and is now a fully developed centre offering regularly scheduled residential courses in Vipassana meditation. Dhamma Arunachala is one of the three Vipassana meditation centres in Tamil Nadu (Dhamma Arunachala, Land and Location, 2024).

Dhamma Arunachala is located at Tiruvannamalai of Tamil Nadu, and is marked by $12^{0}13'$ latitude and 217m altitude (Google Earth, Dhamma Arunachala, 2024). The prevailing climate of this place is Tropical in nature characterized by annual average temperature of 27.4 ^{0}C peaking to slightly above 37.4^{0}C in mid-summer and falling to slightly below 18^{0}C in mid-winter (Climate-data.org/tiruvannamalai, 2024).

Fig. 2. Master Plan Image of Dhamma Arunachala. Source: (Gopalan, 2022)

Fig. 3. A conceptual 3-D sketch of the campus. Source: (Gopalan, 2022)

1.3 Synopsis of Literature Review

To meet the zest of the study, various books, articles and publications were reviewed. The Book "Sustainable Building Design, Application of Climatic Data in India" (Kabre, Sustainable Building Design, Application Using Climate Data in India, 2018) was thoroughly studied in order to get the idea of various climatic regions of India and strategies taken for Climatic Design. The inference for Dhamma Arunachala has been thoroughly explained in *Observation of Climatic Context* in the Section **Observation and Discussion**.

Similarly, "Alternative Building Materials and Technologies" (K S Jagdish, 2017) was reviewed to get idea on various alternative construction technologies used in India, typically Compressed Earth Block Technology, Ferrocement Channel Roofing, Jack-Arch Vault Flooring and Pot-filled Slabs, which are also the ones used in the construction of Dhamma Arunachala. Its implication is again discussed in *Observation of Key Construction Features* in the same section.

With the same spirit, article on 'Waste Water Treatment Methodologies" (Manar Elsayed Abdel-Raouf, 2019) and Website on Ecological Waste Treatment (Ecological Waste Water Treatment, n.d.) were reviewed to get idea of various treatment systems used in the centre.

The Climatic context was studied via (Climate-data.org/tiruvannamalai, 2024) along with the personal experience of the author. The book on journey of Biome by Environmental Activist cum Engineer Chitra Vishwanath (Vishwonath, 2022) provided valuable guidance on looking into the concept of Ecological Design that helped in framing out the study work of Dhamma Arunachala premises.

2. Methodology

This manuscript is fashioned in form of a case study. The methodology taken in this article is through the site visit, direct observation and communication with the stakeholders who were operating the center, backed-up by the framework of Sustainable Community and Sustainable Technologies as informed by different literature studies. The Methodology could be summarized as following.

Step 1: Study of Climatic Context: This is done through direct experience of the weather type during the site visit, and on the basis of a first order climatic analysis from available data in the web site. Since no rigorous data were available to be input in the climatic simulation tools, climatic inference was taken on the basis of average data available from the web source (Climate-data.org/tiruvannamalai, 2024). Climatic Responsive Strategies were extracted from (Kabre, Sustainable Building Design, Application Using Climate Data in India, 2018) and compared with the applied strategies in the center.

Step 2: Observation of Construction material and Technologies: Since the concept of the whole center is based on the use of available natural material for construction, observations were made to relate the built structure with the available construction materials in the site and technologies used. Study was made on this basis. Articles and books were referred for framing out the Ecological Nature of the Meditation Centre.

Step 3: Observation of Architectural Design Features: Along with the suitable strategies suggested by the Climatic Context of Tiruvannamalai, observations were made on who the programmatic requirements effectively incorporated the climatic strategies to meet the operational goal of the complex.

Step 4: Observation of the Service Systems in the complex: Since the center claimed to have as much less impact to the environment to the possible, observation was made how this goal was achieved in various services such as energy supply, water harnessing and waste treatment. Also, the center claimed to be less dependent to the external for the food supply, observations were made how this goal is achieved. The observations were supported by the *communication* of the various stakeholders of the center typically who were involved in overall concept of the center and those who were involved in the operation, namely two central teachers who conduct the courses, the kitchen-holder, and people working in the center. Also, the YouTube videos provided by the center were studied and comprehended to make deeper sense of the concept and to bring clarity to the observations. As evidence, the author took pictures and has presented them to support the corresponding texts.

Step 5: Analysis and Discussion: Finally, the observations were compiled and evaluated on the basis of the literature review that provided framework on the concept Ecological Community and Sustainable Technology, firmly backed-up by author's own experience. Inferences were then made on the learnings that could be derived from the study.

3. Observations and Discussions

3.1 Study of the Climatic Context

The author was in Dhamma Arunachala in the month of March 2022 for seven days. As correctly predicted by the monthly temperature and humidity distribution, the subjective perception swinged between 'comfortable' during early morning time to 'high-warm with stuffy atmosphere' in the afternoon. Supporting the experience, for the location of $12^{0}13'$ latitude and 217m altitude (Google Earth, Dhamma Arunachala, 2024), the climatic map of India (**Fig. 4**) shows that the region possesses Warm Humid Climate. The first order analysis based on Climatic Data of Tiruvannamalai (**Fig. 5)** and Classification of Climate in India (**Fig. 6)** support the fact that the centre possesses Warm humid nature as depicted by Mean Monthly Maximum Temperature exceeding 30^{0}C and mean monthly relative humidity above 55%. The Köppen's major climates classification (Kabre, Classification of Climate, 2018) supports this to be Equatorial Monsoon Type which is again another way of saying Warm and Humid Climate.

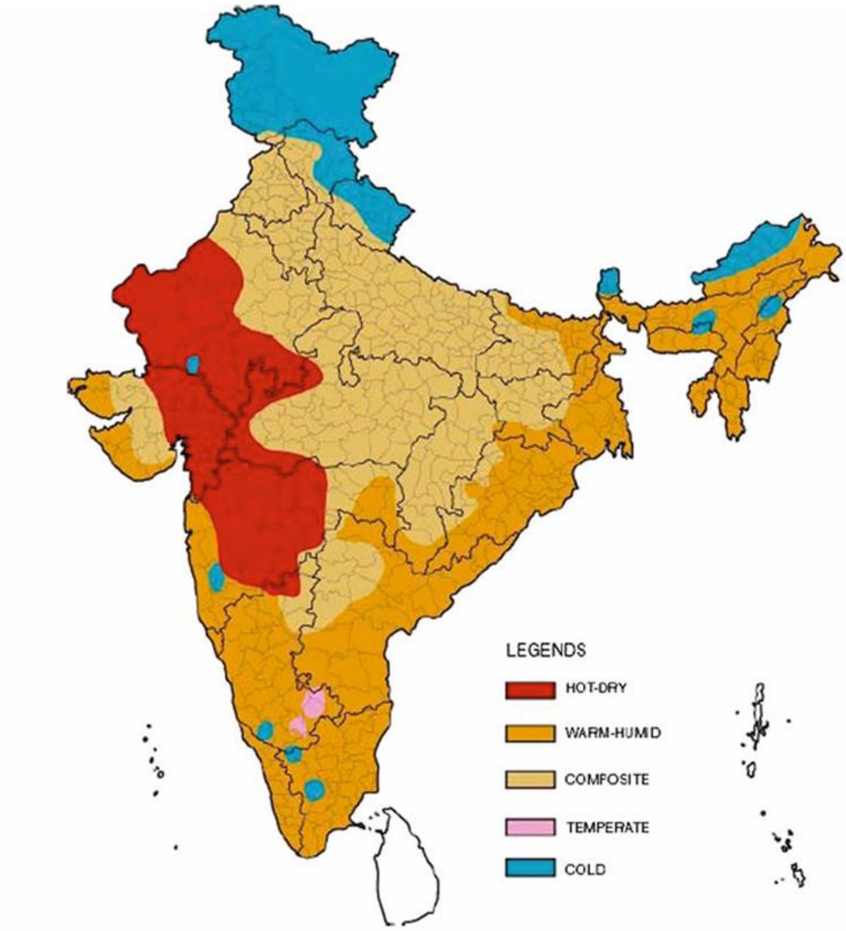

Fig. 4. Climatic map of India. Source: (Kabre, Classification of Climate, 2018)

The climate responsive design approach for such climate reflects configuration which maximally saves themselves from the radiation, and at the same time, adequately provide air movement for physiological cooling. The buildings are made with one or two bays only to allow proper penetration of air. Interconnection between rooms and corridors are made for unresisted flow of air. Hence, the strategies mostly suitable for this climate type are 1. Insulation on wall and roof, 2. Reflective roof surfaces, 3. Adequate ventilation on Attic Space, 4. Generous Windows for wind movement but provided with shading devices to block the sun (often expressed as a ventilative jaali), and 5. Avoidance of high humidity sources (Szokolay, 2014).

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature °C (°F)	23.3 °C (73.9) °F	25 °C (77) °F	27.5 °C (81.5) °F	29.9 °C (85.9) °F	31.3 °C (88.4) °F	30.2 °C (86.4) °F	29.6 °C (85.3) °F	29 °C (84.2) °F	28.5 °C (83.3) °F	26.6 °C (79.8) °F	24.6 °C (76.2) °F	23.4 °C (74.1) °F
Min. Temperature °C (°F)	18 °C (64.4) °F	18.8 °C (65.9) °F	21.2 °C (70.2) °F	24.6 °C (76.3) °F	26.5 °C (79.7) °F	26.3 °C (79.3) °F	25.8 °C (78.5) °F	25.2 °C (77.4) °F	24.6 °C (76.3) °F	23.1 °C (73.5) °F	21 °C (69.8) °F	19.3 °C (66.7) °F
Max. Temperature °C (°F)	29 °C (84.2) °F	31.8 °C (89.2) °F	34.6 °C (94.3) °F	36.6 °C (97.9) °F	37.4 °C (99.3) °F	35.4 °C (95.7) °F	34.7 °C (94.4) °F	34 °C (93.1) °F	33.4 °C (92.2) °F	31.1 °C (87.9) °F	28.8 °C (83.8) °F	27.9 °C (82.2) °F
Precipitation / Rainfall mm (in)	10 (0)	7 (0)	15 (0)	27 (1)	67 (2)	65 (2)	65 (2)	92 (3)	117 (4)	154 (6)	125 (4)	67 (2)
Humidity(%)	69%	62%	58%	59%	53%	55%	55%	58%	62%	73%	76%	73%
Rainy days (d)	2	1	2	3	8	8	8	10	10	14	10	5
avg. Sun hours (hours)	7.3	8.4	9.3	10.0	11.0	11.0	10.5	10.3	10.0	8.7	6.9	6.3

Data: 1991 - 2021 Min. Temperature °C (°F), Max. Temperature °C (°F), Precipitation / Rainfall mm (in), Humidity, Rainy days. Data: 1999 - 2019: avg. Sun hours

Fig. 5. Climate Data of Tiruvannamalai. Source: (Climate-data.org/tiruvannamalai, 2024)

Climatic zone	Mean monthly maximum temperature (°C)	Mean monthly relative humidity (%)
Hot and dry	Above 30	Below 55
Warm and humid	Above 30	Above 55
	Above 25	Above 75
Temperate	Between 25 and 30	Below 75
Cold	Below 25	All values
Composite	Each climatic zone does not have same climate for the whole year; it has a particular season for more than six months and may experience other seasons for the remaining period. A climatic zone that does not have any season for more than six months may be called as composite zone.	

Source BIS (2016, Part 8 Building Services, Sect. 1: lighting and natural ventilation, clause 3.2 basic zones, Table 2)

Fig. 6. Climatic Zones of India. Source: (Kabre, Classification of Climate, 2018)

3.2 Observation of Key Constructional Features

Apart from the intentional effort to make climate responsive, there was also a significant constraint in the budget of the centre. This led to the necessity of adoption of strategy in order to make the project cost effective both during construction and the operational. As the maximum temperature goes above +35^{0}C during peak summer, it conventionally implied the need of Air Conditioning System which is both energy and cost-intensive in operation. This constraint has ultimately developed to follow the idea of Passive Cooling Technique. The major constructional features are discussed as following.

Foundation: The foundation of a typical building was made of rammed earth using 94% of the local soil and 6% of cement (**Fig.7**). Rammed Earth Technology could provide compressive strength of as much as 150 N/mm^2 (K S Jagdish, 2017). The cement provides stabilization against water as well as adds strength to the densified earth.

Fig. 7. Stabilized Rammed Earth Foundation used in Building Construction of Dhamma Arunachala.
Source: (Gopalan, 2022)

Wall: Walls were constructed using Compressed Stabilized Earthen Blocks (CSEB) which is again stabilized with 6% of cement like in foundation (**Fig. 8**). The cement percentage is slightly higher than the usual application (which varies from 3% to 5%) (K S Jagdish, 2017) owing to the soil type and rainy climate. The embodied energy of CSEB is negligible except for the cement added, as the soil used is local and the machinery used is the manual press Auram 3000. Therefore, there is no external energy for machinery operation. Unlike the burnt bricks, stabilized earth blocks do not need to be fired in the kiln and are usually ready for use after 10 days of curing (Herald, 2022). In addition, the walls were just slightly plastered with natural soil and are mostly exposed to present their natural constructions.

Fig. 8. Compressed Stabilized Earth Blocks (Walls) and Auram-3000 used to produce CSEB
Source: (Gopalan, 2022)

Floor: The floor system was constructed with Jack Arch Vault in residential unit. Jack Arch Vault allow to use thin layers of bricks to carry load because of its arch shape (K S Jagdish, 2017). The lobby area was constructed with concrete slab with mud pot, making it a filler slab, to reduce the amount of concrete (**Fig.9**). This provided both optimization in construction as well as articulation of space.

Fig. 9. Jack Arch Vault (Left) used as a floor system in the room and Filler Slab (Right) used in floor slab system in the corridor. Source: Author

Ferrocement Roof: The principle of ferrocement roof is to optimize the structure through the benefit of its geometry (K S Jagdish, 2017). Ferrocement Channel uses rich cement mortar over the double layered Chicken Wire Mesh, molded in Parabolic Shape that helps carry load efficiently and thus reduces materials, limiting to minimal amount of cement and steel. The ferrocement channels in the center were used as roof and also provided overhang so as to create shade and protection against rain water.

Fig. 10 shows precast Ferrocement Channels placed for curing. Source: Author

Fenestrations: The fenestrations were provided with ferrocement shuttering which were merely an inch thick, which aided in saving a huge amount of timber, **Fig. 11**.

Fig. 11. Door using Ferrocement shutter. Source: Author

3.3 Observation of Key Architectural Design Features

The Architectural Design features address the programmatic requirements of different buildings which had beautiful integration of bioclimatic features. The observed features are explained as following.

Male and Female Residential Units: The capacity of residential students for each of male and female residential units was 20 students, giving total capacity of 40 students. Each of the residential units, a separate for male and female, was a two-storey building, the units being organized in a courtyard system. The courtyard provided mutual shading to the units, and at the same time was provided with diagonal pathways for ample ventilation so that there is generous flow of air across as seen in **Fig.12**. To provide further shading from the bright sky, a huge tree was provided whose variety didn't add much to the humidity, **Fig. 13**. The structural system was load-bearing system constructed with Compressed stabilised Earth Block Wall. Jack Arch Vault Roof was used to avoid the use of RCC slab and less use of Cement and Rebar. Corridor Floor Slab with mud pot as filler was also for less use of concrete and it gave unique aesthetic appeal to the corridor.

Fig. 12. Male Residential Unit (Left) and Female Residential Unit (Right). Source: Author

Fig. 13. Courtyard of Female Residential Unit. Source: Author

Meditation Cell: As per the author's experience with Vipassana Meditation Centre in different parts of India, a typical Vipassana Meditation Cell complex usually has a common language of having individual small room units organized in a circular fashion, gradually stepped over in tiers, around the central stupa. A typical vocabulary of a compactly arranged cells contradicts with the climatic features of Tiruvannamalai. In Dhamma Arunachala, there were 80 units, topologically replicating the concept of a Vipassana Cell Complex, but innovatively integrating climate responsive features to suit its locale, **Fig. 14**.

The most striking observable features was a carefully thought air-pathway to provide ample air movement across the cell complex. The units, that otherwise would have been hermitically sealed in a typical system, were inter-connected so that the air could flow freely across each other. The outdoor relatively cool air was dragged through corridors, spread over each unit, and naturally vented out through the top of central stupa as the warm air gets sucked up through stack effect. Furthermore, the whole cell complex was interpenetrated by ventilative jails, boastfully showing off its climate responsive feature artfully integrated into the cell architecture of Vipassana Meditation, **Fig. 15**.

Fig. 14. The Meditation Cell Complex. Source: Author

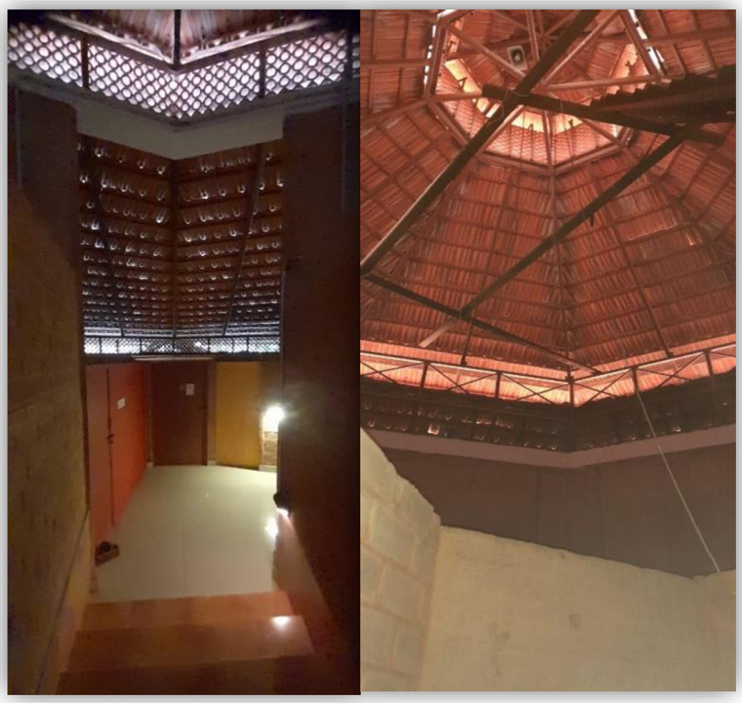

Fig. 15. The Ventilative Jaalis over Cell Units (Left) and Pathway for Stack Ventilation on the Centre of the roof (Right) . Source: Author

The meditative environment was uninterrupted though challenged by high temperature as the experienced temperature drop was as low as 8 deg C. The hierarchical arrangement of cells and the centralization of stupa perfectly matched with the requirement of naturally driven air-movement. Again, the main structure was made out of one-foot thick Rammed Earth for the core wall and CSEB for the partition wall. Roofing was with the Mangalore tiles over steel truss, which was of light weight and didn't allow to enter the heat inside. Overhang as a strong hat helped to protect from radiation and rain. According to the central teacher, for six years it went through different weather conditions such as heavy monsoon and high heat, but the structure boastfully sustained all.

Mediation Hall: The Meditation Hall was designed for almost 100 students, and was the most densely populated space in the whole center, **Fig. 16**. Gaining thermal comfort without any mechanical means was challenging as compared to other buildings in the complex. On the other hand, the hall needed to be isolated from the surrounding noise to obtain the meditative environment. This challenge was creatively tackled through forced ventilation using low-power fan coupled with nocturnal cooling. From the first half of the morning to the evening, when the meditation session was most intense, the windows were made closed and air movement was provided through the low-powered fans from outside, **Fig. 17**. Furthermore, the double glazing was used in windows kept the heat out. The programmatic requirement perfectly matched with the passive strategy as the serious meditation time coincided with the climatic isolation time. During late evening and night, the windows were opened to allow relatively cool night air to take away stored heat during the day time so that the structure acted like a heat sink. However, owing to relatively low diurnal range and being warm humid in characteristic, this strategy was not as effective as the generous ventilation strategy.

Fig. 16. Main Meditation Hall. Source: Author

Fig. 17.
Double Glazed Windows in the main Meditation Hall (Left) and Lower Powered Fan for forced ventilation (Right). Source: Author

3.4 Observation of Building Services

The Centre tried to incorporate all the building services to have as lesser environmental impact as possible. The most notable features were Bio-gas Plant which fuelled kitchen, Biological Waste Water Treatment Plant, Ground Water Recharge and Solar Energy.

Biogas Plant: This biogas plant produced gas from all the kitchen organic waste like leftover of food, waste vegetable etc. The whole cooking gas was based on the gas from this plant, so no additional LPG gas is used for cooking purpose, **Fig.18**.

Fig. 17. Double Glazed Windows in the main Meditation Hall (Left) and Lower Powered Fan for forced ventilation (Right). Source: (Gopalan, 2022)

Waste Water Treatment Plant: Inspired by Namibia which constituted 35% of all drinking water is treated waste water, and by Singapore where 40% of all water used is reclaimed water, the Dhamma Arunachala Centre adopted a rigorous waste water treatment plant completely following the biological process, **Fig. 18**. Furthermore, the Standards of Discharge compared to the earlier Standards stipulated by Central Pollution Control Board, called for adoption and integration of new technologies in India with low life cycle cost, which is clearly mentioned in the order. The National Green Tribunal is making mandatory rule for the waste water treatment for the townships (Gopalan, 2022).

Fig. 18. Ecological Waste Water Treatment Plant. Source: Author

In order to meet this standard, Dhamma Arunachal adopted the treatment plant with four consecutive chambers: the waste water first flows to the settler where sludge gets sedimented at the bottom to be left with water with organic and inorganic soluble and the float, **Fig. 19**. This, afterwards, flows to the anaerobic baffle rector where the organic waste gets biologically decomposed through anaerobic bacteria. The waste further flows to the aerobic filter tank to get acted by aerobic bacteria. To accelerate the aerobic degradation of the organic waste, the waste water is brought through Vortex, an invention of Schamberger Vortex, where air is stirred to the water for better aeration, **Fig. 20**. The treated waste water was significantly improved as compared to the input water (**Fig. 21**), and was primarily used for irrigation purpose (**Fig. 22**). Furthermore, so that there is no impedance in the biological treatment of the waste, the sanitary system was systematized through use of Probiotic Chemicals in Water Closets (**Fig. 23**), Ash Soap for cleaning hands and Natural Detergents for washing clothes.

Fig. 19. Schematic Diagram of Ecological Waste Water Treatment Plant. Source: (Gopalan, 2022)

Fig. 20. Vortex for better aeration of the Waste Water. Source: (Gopalan, 2022)

Fig. 21. Waste Water before and after treatment. Source: (Gopalan, 2022)

Fig. 22. Treated Waste Water used for irrigation. Source: (Gopalan, 2022)

Fig. 23. Use of Probiotic for cleaning toilets. Source: (Gopalan, 2022)

Rain Water Management and Ground Water Recharge: Rain Water Management was done through channelling of collected rain water from buildings towards artificial ponds before it converted to unmanageable storm. For water canal, there was no cement and concrete work, so all water gets absorbed by the ground and the remaining water flowed to the pond. As a result of this, the water get recharged in to different places. Water from the roof top, water flowing in the ground and from the neighbouring land is collected and used for the ground water recharge, which results in sufficient recharge of borewells and wells, **Fig. 24**.

Fig. 23. Ground Water Recharge by the Rain Water Harvesting through the pond. Source: *(Gopalan, 2022)*

Pathways: Even the pathways were constructed with conscious choice of environmental technology, **Fig. 24**. For 500 liters of earthen concrete, 50 liters of cement (8 % of cement) were used in the mix and 4-inch-thick pathway was paved, compacted with vibrator. Since the top layer was the earth surface, it did not absorb and reflect the heat much from the pathway. This contributed in programmatic requirement of the center as the meditators, while walking on the pathway, had to do so bowing down towards the pathways that now reflect less light and radiate less heat. According to the author's experience, it was very soothing and very comfortable to walk even in high temperatures.

Fig. 24. The pathway paved with Earthen Concrete. Source: *(Gopalan, 2022)*

4. Conclusion:

It seems that Dhamma Arunachala has justified ecological way of building infrastructure as well as the way of living as far as possible the existing knowledge has allowed. Apart from the infrastructure, most of the green vegetables were organically grown in the complex itself, surplus being collected from the nearby village. The market was far away from the centre, so the centre was completely detached from the perspective of the food supply. This completes a comprehensive concept of Ecological Building and Ecological Living: a model of Self-Sufficient/ Self-Efficient Community. A comparison between the alternative strategy adopted by the centre and the conventional strategy could be summarized as in the following table, **Fig. 25**.

Conventional Strategy	**Sustainable Strategy**
Pillar and Beam Foundation requires foundation	Rammed Earth does not require foundation
Walls: Bricks+Plastering+Paint	CSEB+No plastering+ No Painting
Roof: RCC Roof (High Steel and Cement, Form Work)	Ferrocement Channels (No Formwork, Aesthetic Value, Low Cement and Steel Consumption, 80% Natural Filling Material)
Doors: Wood	Ferrocement Doors
Water Tanks: RCC or PVC Plastic	Ferrocement (Less Cost than the other alternatives)
Energy: Fire Wood, LPG, Coal, Petrol, Diesel	Energy: Sun, Wind
Air Cooling: Air Conditioning, Desert	Air Cooling: Natural Passive Cooling Methods

Fig. 25. Comparison between Conventional Strategy and Sustainable Strategy. *Source: (Gopalan, 2022)*

In spite of all the goods, the centre was still learning and converting, a never-ending loop of learning and adapting. From this perspective, the author observed few places for improvements which are listed as following.

Need of further improvisation on Ventilative Strategies in the Residential Units: Though the centre had well-kept effort of ventilation strategy for physiological cooling such as through permeable courtyard, the residential units, though were single bays, themselves were not provided with cross ventilation as the rare part of the room opposite to the courtyard were provided with bathrooms. Furthermore, these attached bathrooms, since not actively vented out, acted as the source of humidity to the rooms ultimately increasing stuffiness and hence compromising comfort. Therefore, each unit was virtually a single aided ventilation though the configuration of having a single bay favours cross ventilation. So, the ceiling fans were unavoidable whole night for the physiological cooling. A little tweak on arrangement of rooms could have significantly improvised the physiological cooling and thus would lead to less reliance on the ceiling fan.

Need of further improvement in envelope in the Residential Units: The roof was still the major source of heat as the overhead heat from the sun was allowed to penetrate through uninsulated ceiling. Though there was a clear strategy of removing collected hot air beneath the ceiling through over-head ventilation, the strategy posed insufficiency to counteract radiative heat from the ceiling surface. So, insulation, either resistive or reflective, seems to be the only way out to combat this situation.

A Contradictory Cooling Strategy in the main Meditation Hall: Nocturnal Cooling is the strategy applied where the night-time temperature is significantly low and the clear sky is prevalent. However, because the climatic feature of Tiruvannamalai is Warm-Humid, there is no significant gain in the heat loss while adopting nocturnal ventilation. A low powered external fan providing a forced-ventilation was not speedy enough, nor directed to the body, for the physiological cooling. The closed windows during the day, though helped to keep the external heat out, seems to become the cause of accumulated internal heat from about a hundred people inside. This comfort issue was directly experienced by the author. Instead, if free flow of air was provided through generous cross ventilation, the problem would have been better solved

Apart from these details, the new endeavours like Dhamma Arunachal needs to be vigilant about the information on the possible challenges that the new trends in climate change could likely to bring about, and how to adapt with that. For every such settlement, now, there should be a keen observation on the pattern of the new effects due to the climate change such as extremely high temperature (https://www.indiatoday.in, 2024), heat waves, cloud-burst and flash flood those are likely to be in the hilly areas (https://www.downtoearth.org.in, 2024) (Dhamma Arunachal lies in the hilly area as the name ‘Arunachala’ implies, which means ‘Hill’). In this sense, the meditation centre seems to be still inadequate in dealing with possible extreme temperature without relying on artificial means, and without intervention on the core bioclimatic strategy concept. Building forms responsive to flood should also be seriously considered. The author believes that any new community should take serious reference of a comprehensive adaptation program of the place.

As final words, in the context of mindless building irrespective to environmental context, the author finds Dhamma Arunachala presents itself as an epitome that could inspire many other such endeavours. As the sustainability of a system depends upon its ability to learn and adapt, the Dhamma Centre seems to have prudently internalized this principle. In spite of these observed weakness, Dhamma Arunachala presents itself as an exemplary of Self-sufficient and Self-efficient Centre.

Acknowledgement

This research was conducted through the effort of the authors themselves without aid of any grant or funding.

We would like to express our gratitude to Mr. Pramode Bhabe and Mr. Santhana Gopalan for allowing us to visit and research the Vipassana Meditation Centre complex and facilitating us with the necessary data.

We would also like to thank Mr.T. Aayappan co director, senior masonry technician and faculty member of the Auroville Earth Institute for his insightful training on alternative construction technology.

We would also like to thank Er. Mr. Dharmesh Jadeja from Dustudio, Auroville Earth Institute, TamilNadu for allowing us to visit his iconic studio constructed with alternative technology.

We would also like to thank Ar. Chitra Vishwanath, founder of Biome Environmental, Vidyaranyapura, Bengaluru, India, for giving us valuable time and allowing us to visit her own residence and studio and boosting our energy to research on more on alternative construction technology.

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