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Climate responsive design principles in Dravidian temples: A case study of Nellaiyappar temple

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Recived

The main objective of this paper is to focus on climate responsive design strategies adopted in one of the Dravidian temples, the Nellaiyappar temple, Tirunelveli, as a case example., Temples were the main gathering space and also a source of recreation in the olden days. The Temple complexes are spaces with cultural vibrancy. The areas in and around the temple complexes are designed with consideration of the local climatic factors. Each space is designed per the activity, rituals held, and the climatic considerations of that region. In pursuing the investigation, the paper focuses on two main objectives. The first part of the study was to analyse the evolution of Dravidian temples with ages and its space planning within the temple complex. The planning of the temple complex and the materials used in the construction have crossed several transitions, starting from the rock-cut temples to structural temples. The evolution happened across various dynasties, from the Pallava dynasty to Nayaks. The second part of the study was to investigate the influence of climatic factors of the place on the planning of the temple and its precincts. Directly or indirectly, the climatic condition of the site controls the planning features and materials used in construction. Literature analyses of both objectives were done, and to examine them, Nellaiyappar temple, Tirunelveli, was taken as a case example. The study was done using a single method analysis that includes qualitative analysis. This qualitative study was done by a live case study visit to the temples, and further investigation was conducted by reading the plans, photographs, sketches, and sections. The entire temple complex was analysed qualitatively and found that responsive climate strategies were evident in the Nellaiyappar temple, and the design ideas may be adopted in modern temple typologies.

Keywords: Climatic design parameters, Climate responsive design, Dravidian temples, Nellaiyappar temple, Transition of worshipping spaces

Temple architecture in India has been broadly divided into three different styles Nagara, Vesara, and Dravidian style of architecture[1]. Nagara and Vesara style of architecture stretch in the northern parts of India. The Dravidian style of temple architecture is followed in the southern parts of India. The Dravidian temple architecture, dates back to the Vedic age, which evolved in the later ages[1]. In this paper, the sustainable design principles adopted in Nellaiyappar temple complex have been analyzed in detail. Dravidian temples are constructed with the sanctum (garbhagriha) that are typically identical and are stacked in a pyramid form with concentric pradakshina paths surrounding it. Apart from the main shrine (garbhagriha) and the mandapams some of the important elements seen in Dravidian temples are[2,3]

- The concentric rings of pradakshina path,
- The corridors which stretch along the pradakshina path with a series of colonnades,
- The temple tank (teppakulam),
- Open garden spaces (nandvanam),

These spaces are connected with the rituals performed, people's culture, and the climatic factors of the place. The pradakshina path or circumambulatory path as a religious and cultural element, is meant for people to move around the central shrine, relic and also to perform various religious activities. The worshiper moves in the clockwise direction with the central shrine on the right-hand side, proceeding in the south direction followed by a daily course of Sun. Some temples have more than one concentric ring of pradakshina path, and this happens mostly in temples which are built by more than one dynasty[2]. During festivals, the same pradakshina path is used for the

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temple car with the deity (sapparam) to move around the temple.

In tropical climates, the pradakshina path is also used as a buffer space, and it prevents the entry of radiation inside the innermost sanctum (garbhagriha), where the idol is kept for worship[4]. The mandapam next to the innermost shrine is the most active space of the temple, and people gather for worshipping the deity. So, these concentric rings of the pradakshina path act as a barrier space and prevent them from harsh climatic conditions outside. These paths are erected with a series of ornamented colonnades which exemplify the workmanship of the sculptors[5,6]

The play of light is also visualized in these Dravidian temples. The colonnaded open corridors allow light to penetrate the interior spaces of the temple[4].The innermost sanctum (garbhagriha) is considered to be the most sacred place in the temple. The name garbhagriha is Sanskrit denotes the mother's womb chamber. So, it is considered to be the place where the deity resides. The natural lighting in the temples reduce as we move towards the inner sanctum from the outermost pradakshina path. In such cases, natural ventilation is achieved by using clerestory windows, chimneys, light wells, and wind tunnel wherever needed. The clearstory windows provided will allow diffused and filtered light to enter the space, which reduces the intensity of solar radiation[7]. In a temple, the outermost pradakshina paths and corridors are considered to be public spaces in which natural ventilation is achieved by open colonnades. The mandapams in between the paths and sanctum are semi public spaces, and the innermost sanctum is a private space[7].Most of the Dravidian temples have temple tanks (teppakulams). The water needed for religious activities and rituals are fetched from the temple tanks. The tanks are approached by Ghats (flight of steps). These Ghats are also meant to be the space for ritual activities of the temple. The tanks are placed predominantly in the wind direction, which creates a mild breeze and enhances the microclimate of the place. Most of the tanks are having perennial water source which moderates the local climate of the space, and it harbors dense and varied flora, and it is also used for rainwater collection.

Literature study

Due to factors such as the socio-cultural changes and the climatic factors, the temple spaces evolved. Nguyen *et al.*[11], conducted a study to understand the climate responsive design strategies of vernacular housing in Vietnam. By doing so, they found out the effectiveness of such an approach in energy savings and the implications of external factors in maintaining the indoor temperature.

According to Kumar, Dalal & Chillar[6] the tradition of ancient Indian temples is closely tied with the socio-economic value of the people. The author further elaborates on the integral relationship between the symmetry and structural stability in ancient Indian structures.

From the study conducted by Anuradha Mukerji[4], we can clearly illustrate the religious importance of light in south Indian temples. The author also tries to establish a relationship between various other components of the temple architecture located in southern parts of Tamil Nadu. To understand the fundamental importance of natural lighting in temple structure, the author trace back into history. Different Dynasties followed a different set of design principals. By conducting a multi-method analysis of those structures over a period, the author derives compulsive evidence about the impact of light in the construction of ancient temple architectures. From the Literature Studies, it is clear that very few researches have been done in the area of building science with sustainable principles, especially in the South Indian temples. The main focus of the study is to document, analyze, and understand the passive design principles followed in south Indian temples with a case study of the Nellaiyappar temple.

Methodology

In order to satisfy the objectives of the article a qualitative research was held by taking a case example of Nellaippar temple and analysed using various climatic parameters.

Location-Tirunelveli

Tirunelveli is a landlocked district lying in the south of Tamil Nadu. It is surrounded by Virudhunagar district in the north, the Western Ghats in the west, Kanyakumari district in the South, and Thoothukudi. It coordinates between 8° 44' 28.3992" N & 77° 41' 40.6536" E. The Tamirabarani river divides the city into the Tirunelveli quarter and the Palayamkottai area. The climate here is tropical. When compared with winter, the summer has much more rainfall. The average annual temperature is 29 deg. May is the warmest month of the year, with 31°C. December is the coldest month of the year. The

driest month is July, with 13 mm of rain. In November, the precipitation reaches its peak, with an average of 195 mm[12].

Description of the Temple Complex

The Nellaiyappar temple was constructed in the 7th century by the Early Pandyas, devoted to God Nellaiyappar, the avatar of Shiva. There are two different shrines for god Nellaiappar and goddess Kanthimathi in the complex. They are two independent structures with spaces in between located inside the temple complex. It was connected by a chainmandapam in 1647 by the Vadamalaiappa pillaiyan[12]. The temple complex consists of two consecutive pradakshina paths with colonnaded corridors running along with it. The main sanctum (garbhagriha) is located at the center with other shrines surrounding it. The temple is approached by four gateways on all the four directions accessed by four temple car streets. According to Dravidian architecture, lighting and ventilation play a major role in categorizing various zones in temple hierarchy. In Nellaiyappar temple, the outermost pradakshina paths are open corridors that are surrounded by a garden and public spaces. The next pradakshina paths are partially ventilated using the clerestory, lightwells, light shafts,and chimneys. The innermost sanctum (garbhagriha) is considered to be the most sacred space which has no access to natural lighting and ventilation[4].

The Kanthimathi goddess shrine is connected to the Nellaiyappar shrine by a series of mandapams. This mandapam is ventilated by employing clerestory windows that open into garden spaces on one side and temple tanks on the other. It has one pradakshina path around the sanctum with colonnaded corridors. On the western side of the Nellaiyappar temple is the Dancing Hall (Thamirasabhai), which is approached by a colonnaded mandapam.

This mandapam ends up with an open space where the Dancing hall is located. The public spaces in the temple complex are 30% of the total site area. These open spaces are used as garden spaces. The flowers used for the temple rituals are taken from these garden spaces. (Fig. 1)

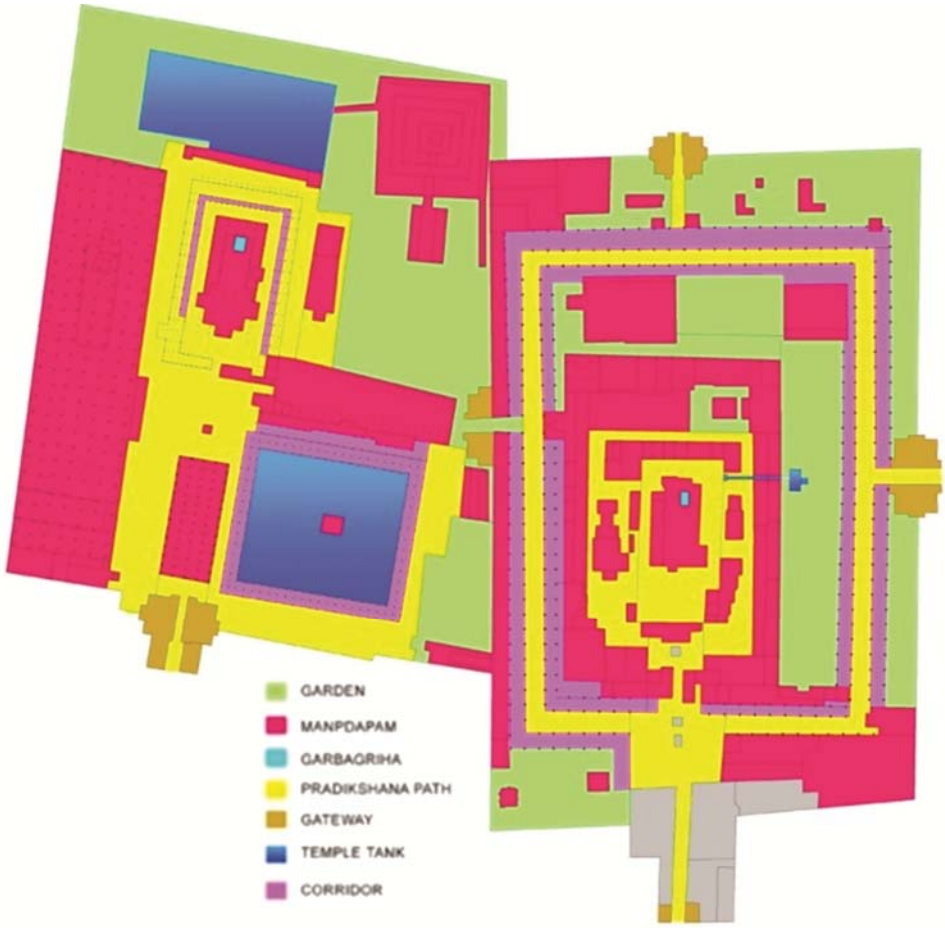

Fig. 1 — Nellaiyappar temple complex layout (Source: Author)

Climate Design Strategies

In this paper, we have discussed a few climatic design strategies which are observed in the Nellaiappar temple. The role of lighting and ventilation across the various shrine precincts of the temple complex is analyzed. The parameters used for ventilation does not affect the rituals and beliefs of the temple. The passive techniques used for cooling space without any mechanical means were reviewed. The clerestory windows, chimneys, open spaces, pradakshina paths, light wells are some of the elements which ventilate the temple complex directly or indirectly.

Clerestory Windows

The clerestory windows are located at different spaces in the temple complex. (Fig. 2). The clerestory openings are provided as a series of slit openings near the roof at the height of 4 m and it includes lighting to the pradakshina path Fig. 3a. The Nellaiyappar temple complex is ventilated using these clerestory windows, chimneys and open corridors.

The inner pradakshina paths of the goddess shrine had open corridors that are accessible to the temple tank. Now the open corridor has been partially closed for various reasons with clerestory opening at the top. These clerestory windows lighten up the corridor spaces aligned to a mandapam called Katchi mandapam. (Fig. 3b).

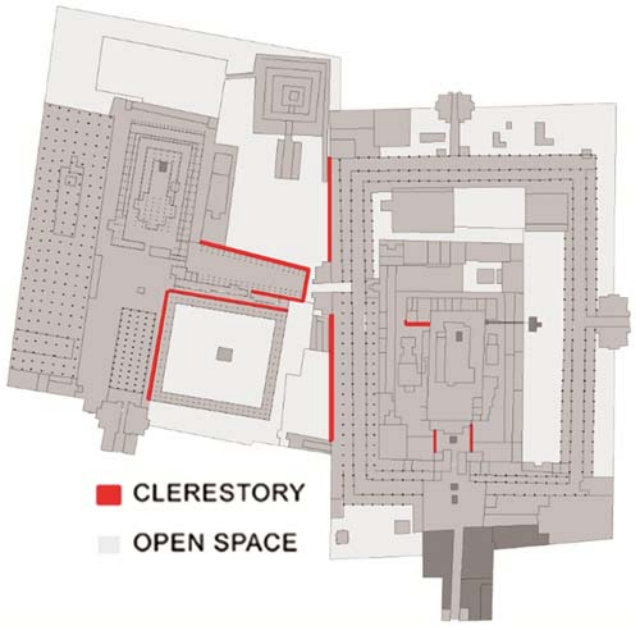

Fig. 2 — The red lines indicates the provision of clerestory window in the building plan of Nellaiyappar Temple complex (Source: Author)

The chain mandapam and the outer pradakshina path of Nellaiyappar shrine are ventilated by the clerestory windows. (Fig. 3c) At the end of the corridor is an open space through which the cold air rushes into space by tunneling effect. (Fig. 4). In consideration of the local climate, the garbhagriha has been moved to the center of the temple with the pradakshina path surrounding it. The garbhagriha is the place where people gather the most. So they are buffered with corridors on all sides from the solar radiation[4]. The hot air inside the chain mandapam between the two shrines rises and gets out through the clerestory windows. The cold air rushes into the mandapam from the garden spaces, open corridors of the temple tank, and enhances evaporative cooling.

Chimney Effect

Chimneys are used for both lighting and ventilation. They are located at various spaces in the pradakshina paths. (Fig. 5) In both god and goddess shrines, it allows diffused light to penetrate and spreads across space and also serves as an outlet for hot air to escape (stalk ventilation). The intensity of the scattered light radiation will be less than the direct radiation. It is provided as slit openings above the roof and covered with grill works. It is observed in (Fig. 6), that the chimneys are located more on the southern side of the Nellaiyappar shrine whereas the northern side of the

Fig. 3 — The figure (a) showcases the provision of clerestory window in Nellaiyappar shrine, figure (b) displays the clerestory windows near “kaatchi mandapam” figure (c) Clerestory Window in Chain mandapam (sangili mandapam)

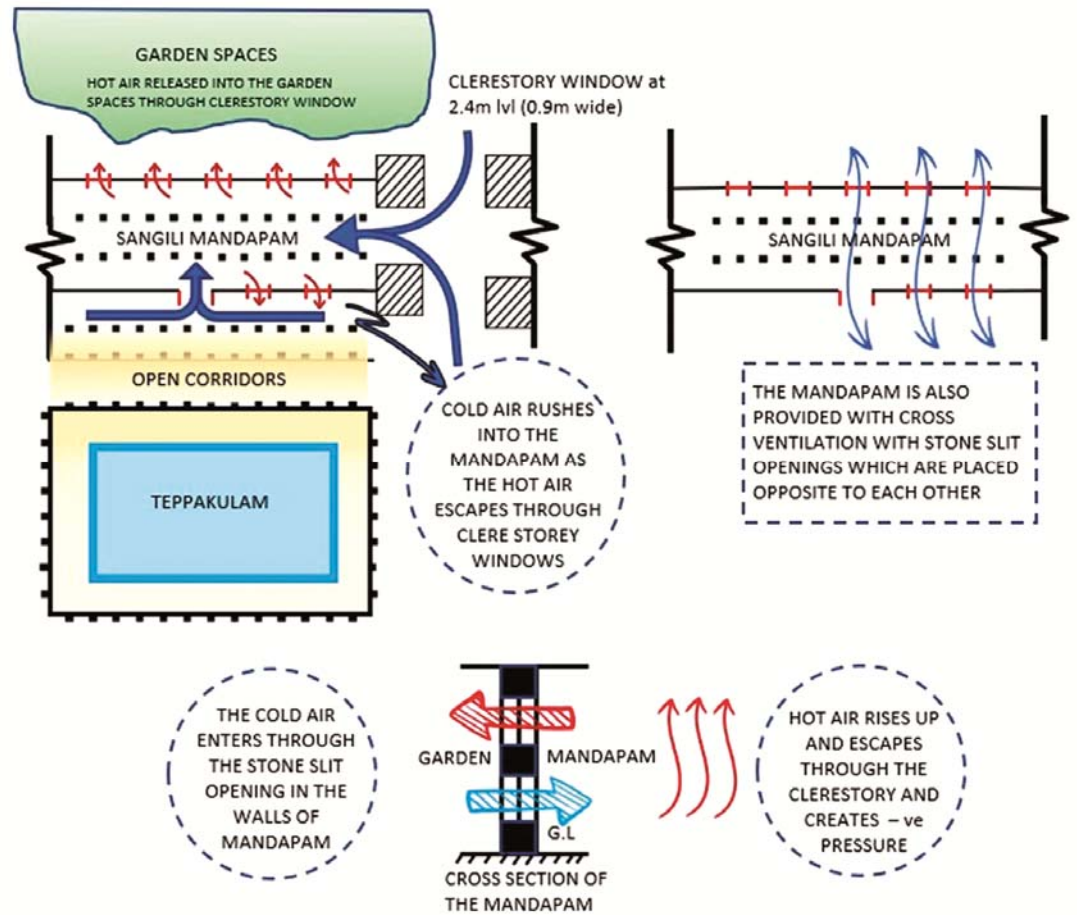

Fig. 4 — The illustration depicts the optimum airflow using clerestory windows in Nellaiyappar temple (Source: Author)

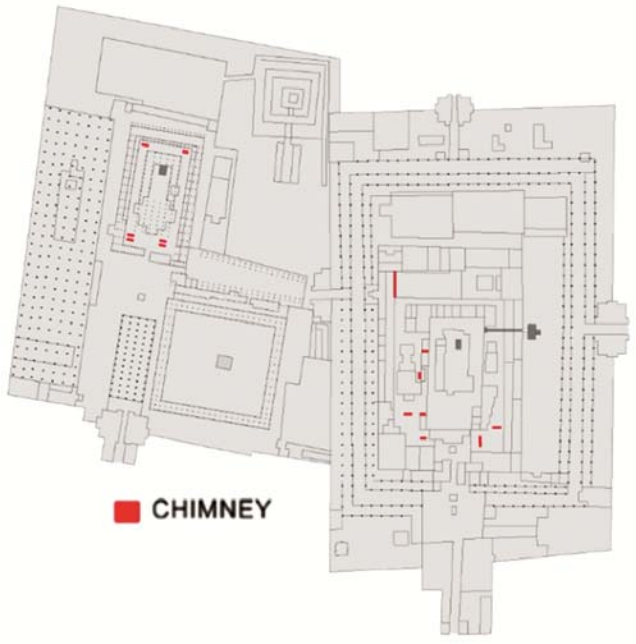

Fig. 5 — The red dots in the plan represent the chimneys in Nellaiyappar temple complex (Source: Author)

Fig. 6 — Images of different chimneys portraying the ventilation mechanism in Nellaiyappar shrine (Source: Author)

temple complex is ventilated using open corridors and garden spaces. (Fig. 7)

Open spaces and Evaporative Cooling

The Nellaiyappar shrine precincts comprise of 72% built spaces and 28% open spaces and the Kanthimathi goddess shrine precincts consist of

58% built spaces and 42% public spaces. In the temple complex, there are semi-open and open garden spaces and temple tanks, which contribute more to the ratio of the open space. The huge open spaces surrounding the temple are treated well with landscaped gardens and water bodies, which reduce the intensity of solar radiation and enhances natural lighting and ventilation inside the corridors. (Fig. 8). The temple complex comprises of two temple tanks and Gardens for creating a micro-climate inside the temple complex. The cool air from the tank enters the open corridors adjacent to the inner chamber and thus enhances evaporative cooling. (Supplementary Fig. S1)

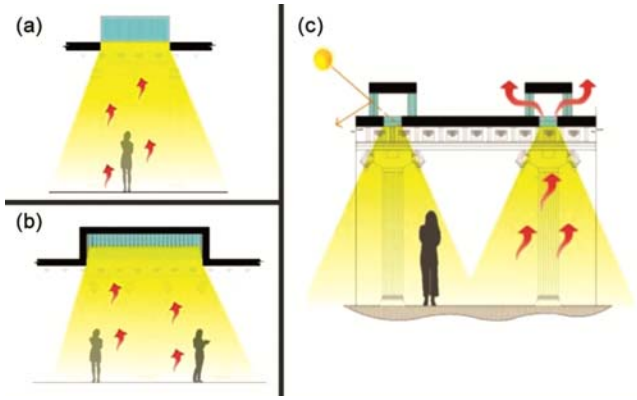

Fig. 7 — The figure (a) and (b) displays the section across the chimneys. The figure (c) shows the section across the chimneys in Kanthimathi goddess shrine (Source: Author)

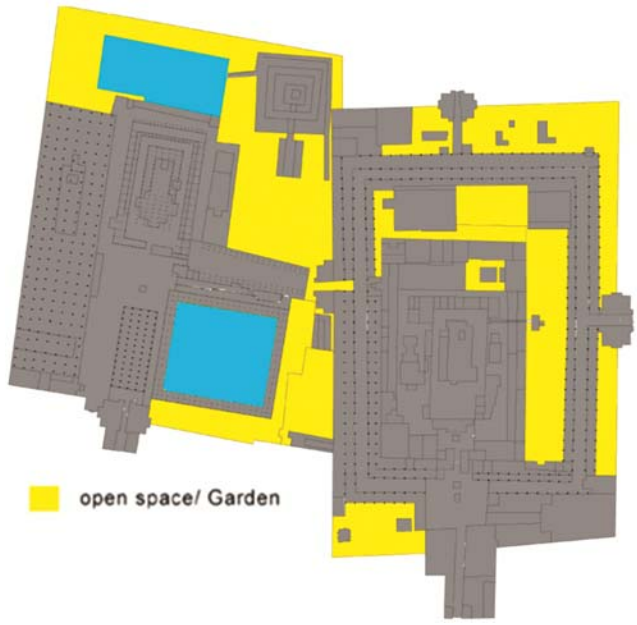

Fig. 8 — Open spaces in yellow available inside Nellaiyappar temple complex (Source: Author)

Pradakshina path and corridors

The Nellaiyappar temple complex has various pradakshina paths and colonnaded semi-open corridors for the circulation of people and other religious activities. The outer pradakshina path has colonnaded open corridors on both sides, allowing the user to circumambulate around the temple, along the longer side of the boundary. (Fig. 9). Whereas, the inner pradakshina path enables the user to circumambulate in the shorter side of the boundary (Fig. 9). Once the user moves around the sanctum, they will also be able to worship the deity in the smaller shrines, which are located along the pradakshina path. It has garden spaces at one end and chimneys at the other side of the pradakshina path for achieving ventilation. (Supplementary Fig. S2).

Dancing Hall (Thamira Sabhai for Lord Shiva):

It is located at the other end of the Kanthimathi goddess shrine of the complex and it is approached by closed colonnaded corridors at either end of the axis and culminates in a closed mandapam, which is called as a dancing space for Lord Shiva (Supplementary Fig. S3). It is surrounded by a raised plinth, and the users experience a visual focus when they enter through the closed colonnaded corridors and moves towards the dancinghall[12]. The users also experience a cool breeze as they move towards the mandapam due to the tunneling caused by closed corridors (Fig. 10). Due to the tunneling effect, the wind rushes into the narrow space (corridors) and moves towards the open space (raised platform) surrounding the mandapam and enhances natural ventilation inside the corridors[4] (Supplementary Fig. S4).

Light Wells

The light well is an opening in the roof shaft, which allows diffused light and dissipates across space, and Light shafts enhance Stalk ventilation (Supplementary Fig. S5). In this temple, the light wells are provided in the inner pradakshinapath by removing one stone slab in the roof, and filtered light

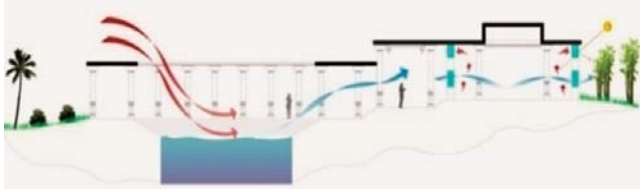

Fig. 9 — Section across temple tank (Source: Author)

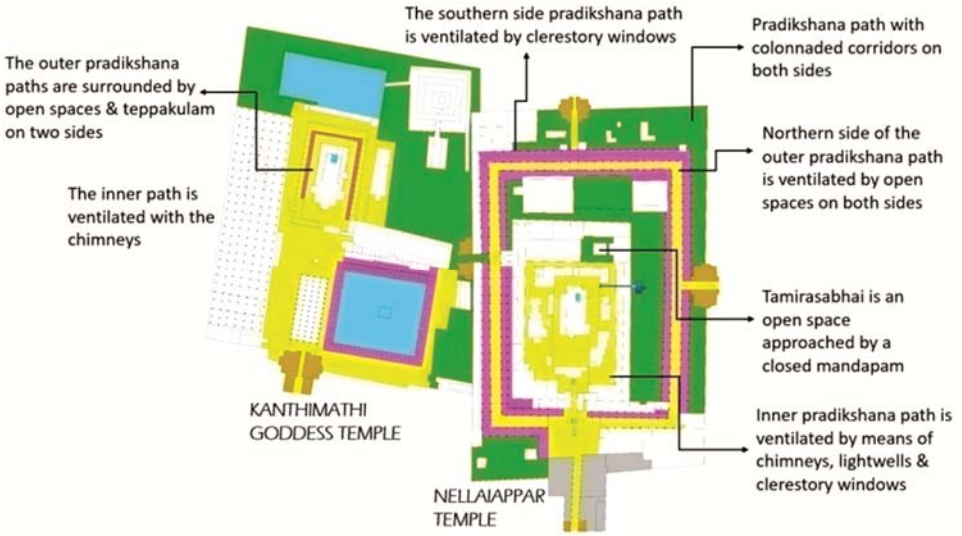

Fig. 4 — The illustration depicts the optimum airflow using clerestory windows in Nellaiyappar temple (Source: Author)

(less radiation) enters into the colonnaded corridors. (Supplementary Fig. S6).

Conclusion

The study analysed the solar passive design principles followed in the Nellaiyappar temple complex in Tirunelveli. The sustainable and climatic design strategies of the Dravidian temples were examined in depth in terms of sustainable planning strategies, orientation, and spatial organization. Additionally, the contribution of the individual design strategies such as the venture effect, evaporative cooling, stalk ventilation and clerestory lighting was thoroughly studied. Furthermore, conclusive evidence was found that responsive climate strategies were evident in the Nellaiyappar temple complex. For future research, it is suggested to carry out a quantitative study to understand the comfort parameters prevailing in the temples. The architects need to understand the climate strategies used in the temple complex for incorporating those ideas in modern temple typologies.

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Conflict of Interests

The authors certify that they do not have any conflict of interest to publish the manuscript in this journal.

Author Contributions

Name of the Author	Contribution of the Author
S Pongomathi	• Conception or Design of the work, • Data collection • Data analysis and Interpretation • Drafting the article • Final approval of the version to be published
Dr R Shanthi Priya	• Structure of the manuscript • Critical Revision of the article • Final approval of the version to be published
M Nallamal Sobana	• Data collection • Data analysis and Interpretation • Final approval of the version to be published

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