Mediating fragile ecologies through digital technologies for sustainable tourism

R. Ab. Rahman, S. S. Zubir & F. R. Razali
Department of Architecture, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia

Abstract

Natural environments such as the rainforest, mangrove and marine ecologies are part of Malaysia's natural resources. Other than being useful for their physical contents, the contexts too are highly valuable. These ecologies are priceless in the tourism industry. However, mass tourism affects these fragile ecologies in negative ways. Unchecked tourists' behaviors are known to destroy marine life such as the corals. Whilst totally stopping visitors into the fragile environments might not be practicable in the nearest future, there has to be an alternative mechanism whereby foreign intrusions into the sensitive ecologies could be toned down. This paper highlights an architectural experiment where digital technologies are utilised to mediate the highly sensitive natural environments. First, architectural design schemes are proposed within the context of the rainforest, mangrove and marine ecologies. Next the experiment looks at the tourists' receptivity towards experiencing the proposed designs within the fragile ecologies via 3D digital simulation. The results from this experiment will provide the insights into using this approach as an alternative mechanism for designing towards sustainable tourism.

Keywords: fragile, ecologies, digital design, sustainable tourism.

1 Introduction

Natural environments such as the rainforest, mangrove and marine ecologies are part of Malaysia's natural resources. Their physical contents and contexts are highly valuable. These ecologies are priceless in the tourism industry. The paradox is that tourism may function as an international agent of social and ecological change with both desirable and undesirable consequences [1–3].

WIT Transactions on Ecology and The Environment, Vol 148, © 2011 WIT Press
www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/RAV110501

Unchecked tourists' behaviors are known to destroy marine life such as the corals. Too many boats plying the rivers along mangrove forests are causing bank erosions through their wake-currents. Too many visitors trampling the jungles are scaring the animals away besides bringing in unnatural leftovers such as plastic containers. Preserving the sensitive ecology becomes an imperative. Whilst totally stopping visitors into the fragile environments might not be practicable in the nearest future, there has to be an alternative mechanism to tone down foreign intrusions into the sensitive ecologies. This includes new development of tourism-associated facilities within such ecologies [4]. Whilst there have been studies on engaging nature such as biomimicry, biophilia and environmental morphology, the discussion neglects the social implications [5]. This paper highlights an architectural experiment where digital technologies are utilized to mediate the highly sensitive natural environments with sustainable tourism in mind.

2 Fragile ecologies and development concerns

Habitat fragmentation and habitat loss contribute to the locality's species extinction [6]. Although fragile, embedded within ecology is the aspect of integrated and dynamic environment, energy and resources that may reveal the approach towards sustainability [7]. Ecological concepts and ecosystem strategies need not be related only to natural phenomena. Planners widely agree that the creation of cities could also be more ecologically sensitive [8]. Developing a project within a sensitive ecology naturally demands integration into the existing eco-system. Typically, clients go to an architect with a project and site well-decided. The function of the building is predetermined, placing it critically under the client's control [9]. The development of buildings will only take place once the profit-seeking criteria of the numerous elements of capital involved in the creation of the built environment are met [10]. Development within sensitive natural surroundings needs to address the best interest of the capital investors, the natural environment and the communities there. It is communities that should be sustained to support tourism, rather than "sustainable tourism" [1]. The architect has to steer on the best recourse in spatial programming and impact of the proposal to the ecology.

Many experiments have been done to test environmental best-fit including measures to gauge landscape preference in its natural setting or with newly introduced object [11]. There is distinction between visual quality assessment and visual impact analysis. In the later the indicators of preference have mainly to do with visibility. Introduced element not visible in the natural setting means there is no impact. The colour and lightness contrast of that element with its natural surrounding, perceived size and atmospheric scattering effect due to haze, are measures of impact [12]. Verbal questionnaire, base map, and street map with a diary have been used to elicit environmental perception and to evaluate 'place value' [13, 14].

Other means to elicit landscape preference include 3D visualization [15], map representation and panoramic scenes [16]. Laing *et al*. [17] used realistic 3D

computer visualisations to analyse public preference of urban green-space with environmental economics. The external environment of a location indicates its quality-of-place, in turn, contributing to the feeling of well-being, fulfillment, or satisfaction of the residents and visitors to the place [18]. Visibility analysis is also pertinent, particularly to assess 'the visual ecological process between occupant and space that leads to "a journey from visibility to visual inhabitation" [19]. This encompasses the experience of actually walking at the location or simply enjoying a representation of it. Thus, the external 3D visualisation of a locality could be appropriate to use as an assessment of environmental-fit. In environmental impact assessment (EIA) and urban planning, the visualisation facilitates viewing and better appreciation of human impacts on the environment [20]. Whilst EIA covers many environmental factors, this experiment will examine specifically on the external visual impact of a new structure into the fragile ecology.

3 Methodology

The experiment has been carried out in the BSc. (Arch) (Hons) Third Year/Semester 06 Studio at UiTM. The project site is on Langkawi Island, still fairly underdeveloped. It is also diverse in natural ecologies. It is timely that a new paradigm to devising new developments is explored. In this experiment, the focus has been on the rainforest, marine, and mangrove environments. First, the ecological and environmental aspects of a particular site were studied and analysed. These formed the project parameters that will have a direct influence on the design generation. The strengths, weaknesses, opportunities and constraints (SWOC) of each site were also recorded. From the eco-environmental and SWOC analysis, a specific design issue was identified for each site. The next step was developing proposed programmes and activities for the area for targeted local community that will alleviate specific problems or enhance positive conditions. Finally, architectural design schemes were proposed within the context of the natural ecosystems.

3D computer models were used to envision and visualise the proposed schemes. The 'natural' context of each project is merged with the proposed scheme in a simulated mixed reality using the software Rhino and Lumion. This was then transformed into 3D animation to be used in the survey. The choice of using 3D computer model and animation is best reflected by [21]. 'Our view of the world is inherently 3D…' Altogether, the studio produced 42 viable proposed schemes. Due to survey time-constraint six schemes were chosen to be deployed. The first three were selected from the high-achievers (A-, A) in the studio, as assessed by professional practitioners. Each had a specific programme and design characteristic particularly in the choice of form. The second set of three schemes tried to match this criterion. Professional assessment of the spatial programs in the second set placed them in the slightly lower grade (B-, B).

Tourist-arrival at Langkawi for 2010 has been recorded at 2.45 million visitors [22]. In a worst-case scenario of 50%, with confidence level at 95%, the sample size of 150 is required [23]. Using this as guideline, 200 questionnaires

were distributed among tourists at Langkawi. 85 questionnaires were returned. 3 had too many questions unanswered, thus N=82; Confidence Level 95%; Confidence Interval 10.8. Survey locations covered venues of tourists' interests including the Langkawi Airport, Kuah Jetty, Eagle Square, Gunung Mat Chinchang and Pantai Chenang.

The first part of the questionnaire introduced the research objectives. The demographic information was in part three. The second part outlines the main enquiries to evaluate environmental best-fit. These consist of closed questions requiring a Yes/No response or ticking a particular selection from a given list; rating-based questions on a scale of 1 to 5; and open questions requiring one word response to longer comments. As the animation only showed the external features of each scheme, a question probed the tourists' interest to explore the internal spaces. The main questions were geared towards the tourists' favourite scheme. Only one question was asked on the least favourite to limit the questionnaire pages. The final segments enquired the level of enjoyment of viewing the animation and time allocation.

4 Findings and discussion

First, this experiment looks at how the existing ecologies would inform the design parameters of proposed projects within the natural context. Rather than a project title defining the building function, the natural factors will determine the project title and activities. This is evaluated as a more responsive and responsible approach to creating a sustainable environment. A development is not forced onto nature. A potential client might have another building category in mind. However, it becomes the designer's responsibility to convince that an alternative programme would be prudent. Tourism has never been set as the main agenda. Foremost, activities and spaces have been programmed to optimise the resources within each natural environment for the purpose of enhancing the locals' economy. The six schemes had to respond to its site-specificity. It is encouraging to note the diversity of building typology being created (Table 1). Thereby, not only resorts are worthy of scenic natural settings.

Second, the experiment looked at the tourists' receptivity to the proposed schemes (Figure 1). They viewed the 3D animations on a laptop/notebook/i-phone and then had to fill in the questionnaires. For a more standardized viewing, similar sized screens would have been recommended. The tourists comprised 39% Female and 61% Male. The majority were 20-30 yrs (48.8%), followed by 31-40 yrs (18.3%), <20 yrs (17.1%), >50 yrs (8.5%) and 41-50 yrs (7.3%).

Their nationalities were Malaysians (50%), European (23.2%), Middle-East/Asian (13.4%), African (6.1%), Australasia (6.1%) and North American (1.2%). 51.2% were first-time visitors to Langkawi, 41.5% have visited between 2-5 times and the rest have visited >5 times. Their occupations were students (30.9%), commercial sector (27.2%), professionals (21.0%), government sector (12.3%), and retired (4.9%) to non-professional (3.7%).

Table 1: Schemes summary.

Schemes	Ecology	Issues	Program
S1	Rainforest	Repopulating a rare species cycad plant with medicinal potential	1. Research Lab 2. Seedling garden 3. Demonstration (pollination, growth capsule, extraction chamber, processing) 4. Exhibition 5. Ancillary facilities 6. Administration.
S2	Rainforest	Archiving and breeding the seedlings of xylocarpus rumphii plants for medicinal benefits.	1. Outdoor Botany 2. DNA Archive 3. Research Botany (Modular Plantation) 4. Exhibition 5. Research Lab 6. Administration.
S3	Mangrove	Buffering and repopulating the mangrove banks from erosion-depletion due to wake currents	1. Monitoring Station 2. Seedling farm 3. Test Lab and Research 4. Exhibition 5. Administration 6. Ancillary facilities
S4	Mangrove	Tannin extraction from mangrove leaves for medicinal benefits	1. Mangrove Rehabilitation 2. Test Lab+ Medicinal Lab 3. Harvesting 4. Extractor 5. Distribution Zone 6. Administration
S5	Marine	Wave barrier to manage Miracle Border erosion at Dayang Bunting Island	1. Wave energy generation 2. Monitoring 3. Wave pool 4. Wave slider 5. Wave inspiration 6. Jetty and ancillary facilities.
S6	Marine	Managing coral depletion around Beras Basah Island	1. Labs (research, monitoring, sampling, spawning). 2. Hatchery/sanctuary (breeding, harvesting, release, monitoring) 3. Diving training 4. Maintenance 5. Ancillary Facilities 6. Jetty

The primary attraction for the tourists in Langkawi was the beaches/sea (49%); nature (18.3%); cable car (13.4%), atmosphere and variety (7.3%). 70.7% indicated familiarity with the term eco-tourism. Nature came first to their mind when thinking about eco-tourism (mentioned 16 times). After viewing the 3D animation, 81.7% agreed that the designs are related to eco-tourism (although the key design objectives were not about tourism). The tourists' favourite is Scheme 5 (Table 2, Figure 2). Set in marine ecology, this seems to correspond with the overall tourists' main interest in sea-related activities, a befitting supply and

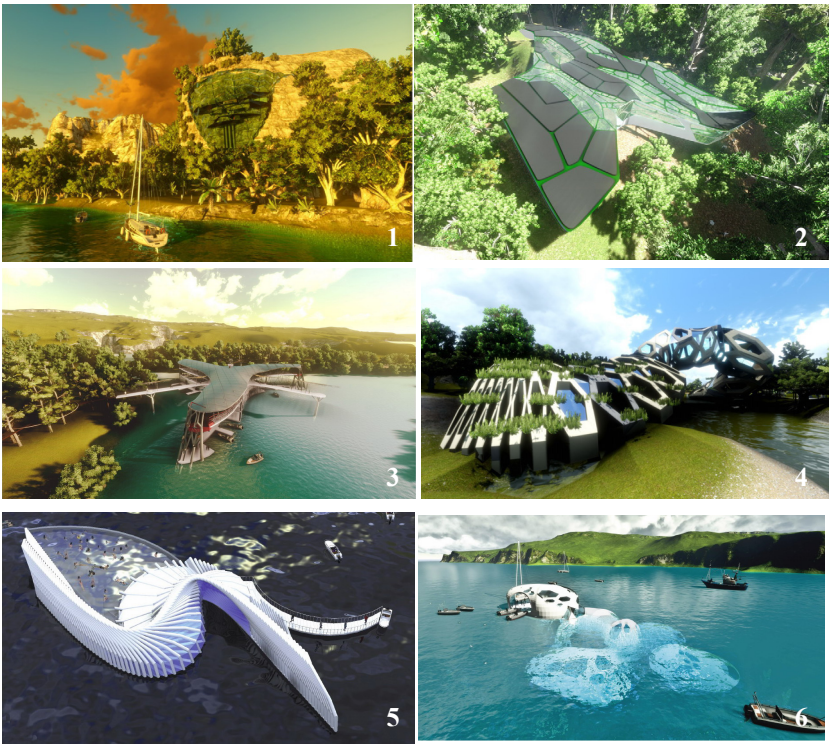

Figure 1: Six schemes in context.

demand. The key issue was to reduce the impact of the waves that have contributed to the shore erosion of the Miracle Border. It separates the fresh water of Lake Dayang Bunting from the sea. The structure was envisioned primarily as contraptions to slow down the waves before reaching shore and generating energy simultaneously. Facilities for a wave-park take advantage of a calmer sea, functioning as a 'pool' and water-slider in the ocean.

Table 2: Favourite scheme.

S1	S2	S3	S4	S5	S6	Total
12.5%	11.4%	12.5%	5.7%	30.7%	27.3%	100%

Tourists Ts5 were attracted to its design, location and function. They also related eco-tourism with nature, preserving for the future, and greenery. Other words they related to eco-tourism such as 'money, travel and adventure' describe what [24] said about natural features having an economic effect on sustainability. 100% of tourists Ts5 thought that this scheme has destination potential.

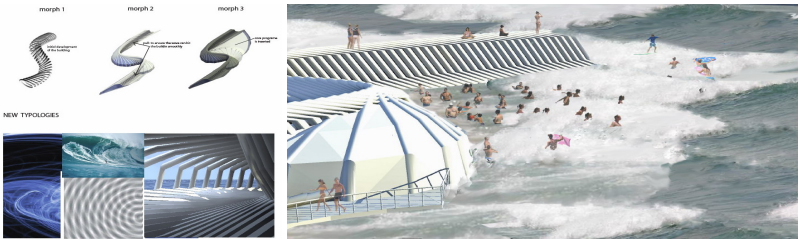

Figure 2: Scheme 5 in detail.

Introducing man-made element into a scenic natural setting is a concern [12]. The visual impact of the six schemes in their natural ecologies is similarly contentious. Table 3 summarises the key results and interrelated factors. The level of dominance may reflect the level of contrast between the building shape or form, colour, and size perception against its natural setting. Despite this, the majority of tourists Ts5 felt that the building size is appropriate (77.8%; overall 80.5%). 92.6% of tourists Ts5 felt that Scheme 5 is in context with its natural surrounding (overall 90.6%). They also preferred this proposed building design (66.7%) over its natural setting (29.6%) whilst 3.7% like both elements together (overall preference: 50% natural setting, 42.7% proposed schemes and 7.3% both elements together). Scheme 1 (35.1%) was the least favourite due to the design, function and contextual resolution.

Table 3: Summary of results.

Factors	Scheme 5		Overall		Scale
	Mean	Sd	Mean	Sd	
1. Knowledge of eco-tourism	2.56	1.13	2.77	1.20	1 Very poor, 5 Very Good
2. Potential to Visit	4.44	0.56	4.26	0.83	1 Very Little, 5 Very High
3. Level of Connectedness between building and ecology	3.93	0.78	3.82	0.72	1 Very Little, 5 Very High
4. Level of Contrast between building shape or form and natural setting	3.48	0.88	3.56	1.03	1 Very Little, 5 Very High Contrast
5. Level of Contrast between building colour and natural setting	3.56	1.01	3.59	1.03	1 Very Little, 5 Very High Contrast
6. Dominance of building design against natural setting	3.65	0.85	3.63	0.99	1 Not Dominant, 5 Highly Dominant
7. Perception of building size against natural setting	3.19	1.04	3.46	0.94	1 Too Small , 5 Too Big
8. Architect's sensitivity to nature	3.74	0.90	3.52	0.93	1 Not Sensitive, 5 Highly Sensitive
9. Disturbance to nature	2.70	0.91	3.02	1.11	1 Very Little, 5 Very High Disturbance
10. Enjoyment of Viewing Animation	4.15	0.79	4.21	0.78	1 Not Enjoyable, 5 Highly Enjoyable
11. Time to Appreciate Design	3.11	0.82	3.18	0.97	1 Too Little Time, 5 Too Much Time

Overall, the 3D animation has been well received. The enthusiasm about wanting to venture inside the most favourite scheme (95.1% overall; 96.3% Ts5) could also attest to the receptivity of using this as a tool in garnering tourists' perception on ecological-fit. It concurs that virtual environments have been recommended as a potential approach to enhance decision support system for sustainable tourism in fragile environments [25]. Bearing in mind the possibility of the 3D-rendered model and animation competing with the true reality [26], more studies have to be made on the effect of the animations and the variations that may be evident in each portrayal of a scheme upon the tourists' perception. Nonetheless, the response to this experiment has been positive (Table 4). In the spirit of 'cognitive connectivity', the connectivity of a place and its natural ecology has to go beyond aesthetics and long term restoration to also teach about the place's cultural and ecological dynamics [27].

Table 4: Tourists' comments.

Virtual to Real	I would love that if it's built; Hope to see 1 of the design[s] will be 'real' 1 day. TQ. ; *Jadikan impian anda suatu kenyataan utk memperkenalkan kecantikan alam semulajadi di M'sia.*; *Nak tengok benda tu jadi…Teruskan usaha agar jadi kenyataan…;* Hopefully, the project can [be] done successfully. Becoz, can attract tourists to our country & we can [be] proud with [our] building; Hopefully, the project can [be] done [realized]; U can do it; Something new. This idea must continue because it can increase image of Malaysia. It can help attract more tourists to come to Langkawi.
Encouragement	Amazing video; Good animation; Great job; Great animation though!!! Good Luck!; Video is great; Great video; Good work guys!! Good luck; Make more practical e.g. with wcam of proposed building; Make video short but informative; try to make it short and understanding [easier to understand] Good job!; Well done, great animation, great work; *Terbaik* [The Best]; Good idea! Good people! Good goals! Good Luck!; Video is enjoyable.

5 Conclusion

Place branding a destination with a particular eco-tourism at the highest stage must incorporate the ethical, social, economic and political determinants. Inevitably, place branding will have a profound impact on the locality [28]. In this experiment the initiative has to begin from the social-economic and ideological generation for the place. The approach taken is based on three principles from the understanding of ecological system: fluctuations, stratification and interdependence [29]. The designs have been envisioned as places of interaction for 'cultural' and natural processes of that particular site. Much more than trying to be a representation of those processes, each scheme attempts to move the potential users to 'digitally experience' those processes in order to connect them to the actual contents of the surrounding. It thus implies a re-thinking of what is 'cultural' in the context of sustainable tourism. In this experiment, 'cultural' must go beyond the performance of rituals, dancing and singing for the tourists [30]. The actual daily activities of the locals and locality, including work-routine based on local resources are instantaneously the 'cultural' and natural processes. Both have to be incorporated into the definition. Only then would it reflect the reality of the destination. So in this experiment, the community's activities are what inform the parameters of the design programme of which the tourists may also be involved. The results from

this experiment will provide the insights into using this approach as an alternative mechanism for designing towards sustainable tourism.

Acknowledgements

Appreciation is extended to Studio BSc. 06 Jan-May 2011 especially Amir Izzat, Shuieb and Shamim; Askaree, Amir Ezwan, Huari, Fadzlan, Syamil and Anwar; tutors and invited jurors from CODA, Dwell Design, GDP, UKM; Al-Farabie & Shahidatul of PTAR; ATSA, RushdanMohdSalleh & Ahmad Pauzi Architects.

References

[1] Potts, T. D. & Harrill, R., Enhancing Communities for Sustainability: A Travel Ecology Approach, Tourism Analysis, Vol. 3, pp. 133-142, 1998.
[2] Yasue, M. & Dearden, P., The potential impact of tourism development on habitat availability and productivity of Malaysian plovers Charadrius peronii, Journal of Applied Ecology, 43, pp.978–989, 2006.
[3] Neto, F., Sustainable Tourism, Environmental Protection and Natural Resource Management: Paradise on Earth?, International Colloquium on Regional Governance and Sustainable Development in Tourism-driven Economies, Cancun, Mexico, 20-22 February 2002.
[4] Bulleri, F. & Chapman, M. G., The introduction of coastal infrastructure as a driver of change in marine environments, Journal of Applied Ecology, 47 (1), pp.26-35, February 2010.
[5] Olgyay, V. & Chan, C., Embracing Forces of Nature: Environmental Morphology As An Influence On Ecological Architecture, American Solar Energy Society (SOLAR 2010 Conference Proceedings), 2010.
[6] Loonen, W., Heuberger, P. S. C., Bakema, A. H. & Schot, P., Improving the spatial coherence of nature areas using genetic algorithms, EPB: Planning and Design, 34 (2), pp.369-378, 2007.
[7] Stremke, S. & Koh, J., Ecological concepts and strategies with relevance to energy-conscious spatial planning and design, EPB: Planning and Design, volume 37, pp.518-532, 2010.
[8] Crewe, K. & Forsyth, A., Compactness and connection in environmental design: insights from ecoburbs and ecocities for design with nature, EPB: Planning and Design, 38 (2), pp.267-288, 2011.
[9] Cuff, D., MIT Press: Cambridge, Architecture: The story of practice, 1991.
[10] McLaran, A., Edward Arnold (Publishers) Limited: London, Making Space - Property Development and Urban Planning, 2003.
[11] Bishop, I. D., Assessment of visual qualities, impacts, and behaviours, in the landscape, by using measures of visibility, EPB: Planning and Design, 30, pp. 677-688, 2003.
[12] Bishop, I. D., Determination of thresholds of visual impact: the case of wind turbines, EPB: Planning and Design, volume 29, pp. 707-718, 2002.
[13] Linden, M. & Sheehy, N., Comparison of a Verbal Questionnaire and Map in Eliciting Environmental Perceptions, Environment and Behavior, vol.36, no.1, pp.32-40, January 2004.

[14] Borst, H. C., Miedema, H. M. E., de Vries, S. I., Graham, J. M. A. & van Dongen, J. E. F., Relationships between street characteristics and perceived attractiveness for walking reported by elderly people, Journal of Environmental Psychology, 28, pp.353-361, 2008.
[15] Sang, N., Ode, A. & Miller, D., Landscape metrics and visual topology in the analysis of landscape preference, EPB: Planning and Design, 35(3), pp.504-520, 2008.
[16] Ode, A. & Miller, D., Analysing the relationship between indicators of landscape complexity and preference, EPB: Planning and Design, 38(1), pp.24-40, 2011.
[17] Laing, R., Davies, A-M, Miller, D., Conniff, A., Scott, S. & Morrice, J., The application of visual environmental economics in the study of public preference and urban greenspace, EPB: Planning and Design, 36(2), pp.355-375, 2009.
[18] Andrews, C. J., Analyzing quality-of-place, EPB: Planning and Design, volume 28, pages 201-217, 2001.
[19] Turner, A., Analysing the visual dynamics of spatial morphology, EPB: Planning and Design, 30, pp. 657-676, 2003.
[20] Lai, P. C., Kwong, K-H & Mak, A. S. H., Assessing the applicability and effectiveness of 3D visualization in environmental impact assessment, EPB: Planning and Design, 37 (2), pp.221-233, 2010.
[21] Bishop, I. D., Using image depth variables as predictors of visual quality, EPB: Planning and Design, 27, pp. 865-875, 2000.
[22] Langkawi Development Agency, http://www.lada.gov.my/v1; 21 July 2011.
[23] Creative Research System, Sample Size Calculator, http://www.surveysystem.com/sscalc.htm; retrieved 21 July 2011.
[24] Bishop, I. D., Lange, E. & Mahbubul, A. M., Estimation of the influence of view components on high-rise apartment pricing using a public survey and GIS modeling, EPB: Planning and Design, 31, pp. 439-452, 2004.
[25] Bishop, I.D. & Gimblett, H. R., Management of recreational areas: GIS, autonomous agents, and virtual reality, EPB: Planning and Design, 27, pp. 423-435, 2000.
[26] Neto, P.L., Evaluation of an urban design project: imagery and realistic computer models, EPB: Planning and Design, 28, pages 671-686, 2001.
[27] May, R., "Connectivity" in urban rivers: Conflict and convergence between ecology and design, Technology in Society, 28, pp.477–488, 2006.
[28] Rajagopal & Rajagopal, A., 'Place branding architecture for eco-tourism', Int. J. Leisure and Tourism Marketing, Vol. 1, No. 1, pp.58–69, 2009.
[29] Dinur, B., Interweaving Architecture and Ecology – A Theoretical Perspective Or: What can architecture learn from ecological systems?, 2005. www.casa.ucl.ac.uk/cupumecid_site/download/Dinur.pdf; 23 July 2011.
[30] Brown, K. G. & Cave, J., Island tourism: marketing culture and heritage – editorial introduction to the special issue, International Journal of Culture, Tourism and Hospitality Research, vol. 4 no. 2 2010, pp. 87-95, 2010.