Analysis of The Implementation of Eco-Efficient Solutions Based on Economic Viability Studies. The Case of Civil Construction in The State of Rio de Janeiro

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Abstract

This study aims to examine the implementation of eco-efficient solutions in civil construction processes in three buildings from different social classes (A, B and C) based on economic studies. Buildings are located in Rio de Janeiro - Brazil. It's a descriptive study based on bibliographic research about sustainability in civil construction, including documentation data research and interviews with investors and engineers. Data analysis compares costs among the buildings: costs of traditional solutions versus costs of eco-efficient solutions. As a result, is demonstrates that there are eco-efficient solutions economically viable for the civil construction sector.

Keywords: construction; eco-efficiency; sustainable construction; green technology; engineering sustainability.

1 Introduction

The Civil Construction Industry plays an important role in the transformation of modern society. However, it generates negative environmental impacts through its production processes: both through the large consumption of natural resources, and the generation of waste from the development of new projects and demolitions.

For Fahey, Liam & Randall (1998), the conflict between present and future demands lies at the center of strategic management, making it necessary to learn new processes and forms of operating. The organizational structures, systems and decision making processes inherited from the recent past must be reformulated to adjust to new scenarios that encompass strategic guidelines for sustainability in business.

In the pursuit of more competitive strategic management, it is shown that the inclusion of sustainability concepts in the strategic planning of construction companies is of great importance to initiating changes in management paradigms, enabling the reduction of environmental impacts and construction process costs for new developments. Given the new market reality and the characteristics of the civil construction industry, how should entrepreneurs in this sector move towards implementing eco-efficient solutions in the planning and execution of construction works?

To respond to the problem stated above, we seek to analyze the implementation of eco-efficient practices in construction processes based on economic viability studies.

2 Literary Review

2.1 Sustainability in Civil Construction

The United Nations Environment Programme, UNEP (2010), states that sustainability in civil construction is not just a local challenge, but a worldwide one. For Pinheiro (2006), Agenda 21 of Sustainable Construction enacted in 1999, addresses some challenges that Sustainable Development and Sustainable

Construction must face, among them: promoting energy efficiency, reducing the use and consumption of drinking water, selecting materials based on their environmental performance and contributing to urban sustainable development.

Souza (2007) emphasizes the importance of sustainable construction as a requirement of civil society and an important prerequisite for funding due to the growing need to reduce environmental impacts. The author adds that the large environmental and social impact within the construction chain accentuates this demand and promotes the concept of sustainability.

Over the past few years in Brazil, countless initiatives related to sustainable consumption and production, which impact the Civil Construction Industry, have been created within the government of businesses and civil society. At the level of certification for sustainable construction, it is worth noting LEED (Leadership in Energy and Environmental Design) – a certification for sustainable buildings since 1998, and AQUA (Alta Qualidade Ambiental "High Environmental Quality" – a tool for evaluating sustainability criteria of buildings since 2002), which were not developed in Brazil, but are largely represented in Brazilian construction companies.

2.2 Eco-efficiency

According to the World Business Council for Sustainable Development (WBCSD, 2008), the concept of Eco-efficiency associates economic and environmental progress, necessary for improving economic development with greater efficiency in resource consumption and less impact on the environment. As a result, it helps companies, governments and other organizations become more sustainable. The Brazilian Business Council for Sustainable Development (CEBDS, 2004) defines eco-efficiency as the combination of economic and environmental performance, reducing the environmental impacts, rationally using raw materials and energy, reducing the risk of accidents and improving the organization's relationship with stakeholders. Eco-efficiency focuses on product appreciation and the establishment of long-term goals, as a management philosophy that combines environmental and business excellence with consideration for sustainable production and consumption (SIMONE & POPOFF, 1997).

3 Research Method

According to Vergara (2006), this research is classified, with regard to its purpose, as exploratory and applied:

Exploratory, since it seeks to gather information in order to clarify the research topic and compliance with the general objective. The information gathered on a theoretical basis and in field research is analyzed, in order to define the strategies that benefit the business through eco-efficient solutions for the construction process, in favor of better economic results and less environmental impact.

Applied, as it intends to generate knowledge that translates into important contributions for business practices, with regard to sustainable construction, generating direct benefits for construction companies and the residents (consumers).

This work has adopted qualitative and quantitative research methods. Qualitative, since it is a bibliographic research on sustainability in civil construction proposed to adapt the construction process of a residential development to the new market reality; and quantitative when the quantitative surveys of the construction processes related to eco-efficient solutions are used for the economic study of comparing traditional and eco-efficient solutions and data processing.

It is worth noting that we sought to develop this research based on a construction company with common characteristics in the market, without certification, but motivated by senior management to remain competitive and gain market share. This research sample was defined, taking into consideration three residential developments with distinct public audiences. For confidentiality, the projects will be identified as Project C (Low/Average Standard), B (Medium Standard) and A (High Standard).

The research was developed based on the planning of data and information collection stages, according to Table 1:

Table 1: Stages and Instruments of Data Collection

STAGES	DATA COLLECTION INSTRUMENTS	DESCRIPTION
1) Selection and Research of the areas related to the Theme	Bibliographic Research	Analysis of the articles published in periodicals, events, theses and dissertations
2) Selection of the Projects for Field Research	Documentary Research	Analysis of the characteristics of the construction company's projects
3) Analysis of the Projects' Budgets	Documentary Research	Analysis of the budgets of the construction company's projects
4) Selection of the construction process stages	Documentary and Field Research	Analysis of the budget, design, specification documents and construction techniques
5) Selection of Eco-efficient Solutions	Bibliographic and Field Research	Analysis of the eco-efficient solutions available in the market and the characteristics of the projects.
6) Economic and financial study	Bibliographic, Documentary and Field Research	Technical and economic viability study, of the quantity of inputs for construction and the construction techniques.

For the Data Interpretation Phase, the viability techniques allow the project manager to evaluate if it is viable or not to invest in a particular project, since the capital used must be remunerated in order to maintain the business' economic flow.

Under this concept, we use indicators such as the NPV (Net Present Value), IRR (Internal Rate of Return), ROI (Return on Investment), MAR (Minimum Attractive Rate) and Discounted Payback, which are the primary methods analyzing the economic viability of a project. According to Gitman (2004), NPV (Net Present Value) is considered a sophisticated technique due to its ability to clarify the time value of money compared to the Minimum Attractive Rate (MAR), which in turn is considered a rate with a low degree of risk, where the company's financial resources are applied. The MAR is usually a low-risk interest rate practiced in the market, which is used to calculate the NPV.

Another indicator used in project evaluation is the Payback, which consists of evaluating the payback period. This indicator can be analyzed in two ways: one, known as Simple Payback, which does not account for the discount rate; and the other, known as Discounted Payback, which accounts for discount rate (KASSAI et al, 2000).

The Profitability Index (PI) is another method used in determining the economic viability of projects, and it is calculated using the results of the NPV and the Initial Investment. The indicator aids in decision-making when there is a restriction of capital in choosing between dependent projects. To analyze the PI, follow the rules for analyzing the NPV decision, or rather, if the Profitability Index is greater than 1 the project should be accepted. On the other hand, if the Profitability Index is less than 1 the project should be rejected (ROSS, WESTERFILD AND JAFFE 1995).

According to Ross, Westerfild and Jaffe (1995), indicators such as NPV, IRR, MIRR, Payback and the PI have distinct characteristics that aid the manager in making decisions regarding the best project from an economic standpoint. In view of this statement, mutually exclusive projects should be evaluated by incremental cash flows, where accepting a project rejects the other. In this case, the authors claim that the manager should note if the higher incremental NPV of the project is positive and if the incremental IRR is greater than the Minimum Attractive Rate of the investment. Another example mentioned is related to dependent projects, in which the Profitability Index is an appropriate indicator for analysis.

4 Strategies for Incorporating Eco-efficient Solutions

4.1 Project Descriptions

Project C, intended for members of Class C (low standard), is characterized by 12 floors, with 8 apartments per floor and penthouses with balconies for units on the 12th floor.

Project B, intended for members of Class B (medium standard), is characterized by 9 floors, with 4 apartments per floor and penthouses for 2 apartments.

Project A, intended for members of Class A (high standard), is characterized by 11 floors, with 2 apartments per floor and penthouses for 2 apartments.

4.2 Criteria for Selection of Construction Processes

First, we analyzed the budgets of the three projects mentioned earlier and surveyed the percentage of holdings (%) of the construction processes. Next, we developed table 2 below to facilitate identification of the productive processes with the greatest holdings in the budget.

Table 2: Holdings of the Costs of the Construction Processes in the Total Budget

Processes for Project Construction	**Project C**	**Project B**	**Project A**
GENERAL SERVICES	33.28%	23.00%	31.48%
SUPERSTRUCTURE	12.85%	17.26%	13.26%
INSTALLATIONS	13.29%	9.55%	11.34%
FRAMES AND HARDWARE	6.59%	7.56%	10.24%
INTERNAL COATING	7.54%	5.16%	3.91%
EXTERNAL COATING	6.08%	3.92%	4.50%
INFRASTRUCTURE	2.57%	7.57%	3.58%
PAVING	3.98%	3.64%	5.20%
CERAMICS AND METALS	2.34%	2.66%	2.25%
PAINTING	2.58%	2.27%	2.25%
WALLS AND PANELS	2.82%	2.22%	2.03%
PRELIMINARY SERVICES	1.07%	2.93%	3.02%
COVERINGS AND TREATMENTS	1.44%	2.89%	1.93%
TRIMS	1.96%	1.23%	2.00%
GROUND WORKS	0.21%	4.05%	0.15%
ASSESSMENT OF CONDOMINIUMS	0.06%	2.36%	1.46%
INITIAL SERVICES	1.09%	1.38%	1.31%
COMPLETION OF WORK	0.26%	0.35%	0.08%

The criteria used were to select the processes that account for the most significant portions of the project budgets. Based on these criteria, the following processes were pre-selected: GENERAL SERVICES, SUPERSTRUCTURE AND INSTALLATIONS.

Knowing that the superstructure process is very similar to the infrastructure process, we chose to include the analysis of infrastructure activities in the scope of this project.

Based on the analysis of the descriptions of pre-selected processes, it can be seen that the process General Services is directly related to the projects' administrative expenses (payroll taxes, work administration, protective equipment, etc), and it does not represent a large environmental impact when compared to the other construction processes. Therefore, the construction processes selected for the development of this research are the following: Superstructure and Infrastructure Processes and the Installation Process.

4.3 Criteria and Selection of the Guidelines for Eco-efficient Residential Construction

The construction and production processes selected were broken down into activities and analyzed based on the concept of sustainable construction presented in the theoretical basis chapter of this research, in order to define the eco-efficient solutions most appropriate for the realities of the projects studied, according to the table below.

Table 3: Identification of Eco-efficient Solutions

Selected Construction Processes	Activities	Eco-efficient solutions
SUPERSTRUCTURE AND INFRASTRUCTURE	Concreting	Comparison between ready-mix concrete and concrete produced on site
	Molding	The use of struts, beams, guides and locking of metallic molds
INSTALLATIONS	Rainwater harvesting	Construction of a water tank for rainwater harvesting
	Energy efficiency	Solar Energy Catchment for water heating
	Lighting	Comparison between incandescent bulbs and electronic bulbs

5 Study of the Economic Viability of Projects

5.1 Initial Considerations

In this section, the studies of economic viability are presented, in order to analyze the situation of the constructor and the consumer (resident or investor) with regard to eco-efficient solutions. In this sense, it was necessary to determine the MAR (Minimum Attractive Rate) to calculate the economic viability. The MAR was designed based on the parameters of investments reported by the constructor. All of the projects were budgeted with their own resources. The MAR used was 11.75% (Central Bank; March of 2011) a year, minus taxes. That rate applied in the calculations had the same value as the SELIC rate for the month of March, 2011, because its compensation is regarded as safe with immediate liquidity on the applied capital. Table 4 provides the gross annual rate, net annual rate and the net monthly rate, which were used in all of the calculations in this study.

Table 4: Minimum Attractive Rate

GROSS MAR CALCULATION (a.a)	11.75%
MAR = NET (a.a)	6.96%
MAR = MONTHLY NET (a.m)	0.58%

Source: Central Bank (2011)

Based on the aforementioned data, we present the constructor analysis. To this end, we surveyed the information made available by the department of Construction Planning, in order to define the timetable for construction works and the duration of the stages studied. Next, there was the consumer analysis, or rather, a study of the impacts on the residents when implementing eco-efficient solutions.

5.2 Economic Viability Study: Emphasis on the Constructor

5.2.1 Study Parameters

The calculations used for the economic analysis were based on the Future Value formula, which consists of surveying the gains or losses in relation to time based on the MAR, from Hirschfeld (2010).

In the economic viability study (emphasis on the constructor), we considered the execution time of activities, from interviews with specialists working in the Construction Planning department, namely:

- Deadline for project implementation (until habitable): 20 months
- Duration of Concreting stage: 06 months
- Duration of Metal Molding stage: 04 months
- Duration of Water catchment for rainwater harvesting stage: 01 month

- Duration of Solar Energy (heating) stage: 01 month
- Duration of Electronic Bulbs stage: 01 month
- MAR (Minimum Attractive Rate): 0.58% a.m.

5.2.2 Period Gain: from start of work until habitable

Each project was assigned a cost and number of months related to the implementation of each of the five eco-efficient solutions. The total costs (Period Gain) for each eco-efficient solution were defined based on the budget presented in the previous topic and the correction was based on a MAR of 0.58%. The Cost of Traditional Construction represents the total value of the project, taking into account the traditional construction, the value and the share of the economic benefit considering the eco-efficient solutions for implementation of the work. Based on the graph analysis, it can be verified that:

- Project C: the Period Gain is BRL$ 187,353.51, considering a MAR of 0.58%. This value represents a holding of 1.64% on the cost of the traditional budget.
- Project B: the Period Gain is BRL$ 129,623.58, considering a MAR of 0.58%. This value represents a holding of 1.03% on the cost of the traditional budget.
- Project A: the Period Gain is BRL$ 56,071.04, considering a MAR of 0.58%. This value represents a holding of 0.43% on the costs of the traditional budget.

All of the calculations were developed based on the Future Value, because in doing so it compensates for the gains and losses of the eco-efficient actions used in the projects. It should be added that these calculations are based on the rate (MAR) that remunerates the values involved. The sum of the projects represents an average holding of 1.01%, or rather, the three projects totaling BRL$ 36,908,105.00, can have an economic benefit of BRL$ 371,777.05, with the implementation of the eco-efficient solutions provided for in this research. It is worth mentioning that the gains presented obey the calculations based on the future value. The holdings and the values related to the implementation of eco-efficient solutions are consolidated in the table below.

Table 5: Project Analysis: Emphasis on the Constructor

	RELATIVE ECONOMY (%)	**ABSOLUTE ECONOMY (BRL$)**
Project C	1.64%	-BRL$ 187,353.51
Project B	1.03%	-BRL$ 129,623.58
Project A	0.43%	-BRL$ 56,071.04

It is noted that Project C stands out when compared with the other two projects. The percentage of the relative economy and the value of the absolute economy of this project (Class C) is more than three time the values of Project A (Class A). It is concluded that use of the eco-efficient solutions selected for this research reduces costs and thereby maximizes the constructor's gain.

5.3 Economic Viability Study: Emphasis on the Consumer

5.3.1 Study Parameters

In this case, three eco-efficient solutions were analyzed: water catchment for water harvesting, electronic bulbs and solar energy. These solutions are executed by the constructor and the residents are impacted, according to the analysis to be presented. The other two solutions, concreting and molding, were not analyzed since they are activities that are executed by the constructor, but they do not impact the residents. In the economic and financial study, with emphasis on the resident, the following parameters reported by the Construction Planning department were considered: Calculation of Gross MAR = 11.75 a.a.; Net MAR = 6.96% a.a.; Net Monthly MAR = 0.58% a.m. The studies presented below represent the gains acquired by the resident during residence, taking into consideration the eco-efficient solutions selected.

5.3.2 Solar Energy: Water Heating (Use of Solar Energy)

The time (t) adopted for the analysis of each of the projects was 04 years (48 months). Consolidated Project Analysis represents a study based on Payback, IRR and ROI for the projects. Table 6 presents the results of this study for the eco-efficient solution of Solar Energy: Water Heating.

Table 6: Consolidated Analysis: Water Heating (Emphasis on the Consumer)

	SOLAR ENERGY FOR HEATING WATER		
	Payback (months)	**IRR (% a.m.)**	**ROI (% in 48 months)**
PROJECT C	29	2.85	60.73
PROJECT B	44	1.00	10.05
PROJECT A	47	0.88	3.09

It can be observed through the table that all of the investments are economically viable, since they obey the basic fundamentals of the parameters of economic viability. It should be noted that Project C is superior with regard to its economic performance, since the relation of its benefits, depending on the investment increments, are greater than the other buildings.

5.3.3 Lighting: Electronic Bulbs

The time (t) adopted for the analysis of each of the projects was 06 months. Table 7 presents the results of this study for the eco-efficient solution of Electronic Bulbs.

Table 7: Consolidated Analysis: Electronic Bulbs (Emphasis on the Consumer)

LIGHTING: ELECTRONIC BULBS			
	Payback (months)	**IRR (% a.m.)**	**ROI (% in 06 months)**
PROJECT C	5	13	48
PROJECT B	3	29	119
PROJECT A	3	43	185

It can be observed through the table that all of the investments are economically viable, since they obey the basic fundamentals of the parameters of economic viability. It should be noted that Project A is superior with regard to its economic performance, since the relation of its benefits, depending on the investment increments, are greater than the other buildings.

5.3.4 Rainwater Harvesting: Water Catchment

The time (t) adopted for the analysis of each of the projects was 21 years (252 months). Table 8 presents the study results for the eco-efficient solution of Rainwater Harvesting.

Table 8: Consolidated Analysis: Rainwater Harvesting

WATER CATCHMENT: RAINWATER HARVESTING			
	Payback (months)	**IRR (% a.m.)**	**ROI (% in 252 months)**
PROJECT C	133	0.99	43
PROJECT B	244	0.59	2
PROJECT A	153	0.88	31

It can be observed through the table that all of the investments are economically viable, since they obey the basic fundamentals of the parameters of economic viability. It should be noted that Project C is superior with regard to its economic performance, since the relation of its benefits, depending on the investment increments, are greater than the other buildings.

5.4 Consolidated Results of the Projects

Presented below are the consolidated results of each of the three projects, starting from the analysis of the implementation of eco-efficient solutions.

- Project C

The amounts spent on traditional solutions and eco-efficient solutions were used for calculating the NPV, IRR and ROI.

Table 9: Consolidated Analysis: Project C

	Water Catchment	Solar Energy	Electronic Bulbs	TOTAL
nount Spent	-37,378.91	-125,457.43	- 1,347.50	-164,183.84

In this case, the economic viability study showed the following results:

Table 10: Economic Viability Study: Project C

PayBack (months)	**33**
NPV (R$ in 252 months)	573,266.29
IRR (% a.m.)	3.39
ROI (% in 252 months)	349

Given that the IRR > MAR and the NPV > 0, the project is attractive and viable.

- Project B

The parameters presented above and the amounts spent in traditional and eco-efficient solutions were used for calculating the NPV, IRR and ROI.

Table 11: Consolidated Analysis: Project B

	Water Catchment	Solar Energy	Electronic Bulbs	TOTAL
Amount Spent	-14,248.98	-90,660.90	-2,429.39	-107,330.27

In this case, the economic viability study showed the following results:

Table 11: Economic Viability Study: Project B

PayBack (months)	**35**
NPV (R$ in 252 months)	343,115.54
IRR (% a.m.)	3.18
ROI (% in 252 months)	320

Given that the IRR > MAR and the NPV > o, the project is viable and attractive.

- Project A

The parameters presented above and the amounts spent on the traditional and eco-efficient solutions were used in calculating the NPV, IRR and ROI.

Table 12: Consolidated Analysis: Project A

	Water Catchment	Solar Energy	Electronic Bulbs	TOTAL
Amount Spent	-28,152.24	-56,033.07	-1,817.11	- 86,002.42

In this case, the economic viability study showed the following results:

Table 13: Economic Viability Study: Project A

PayBack (months)	**38**
NPV (R$ in 252 months)	250,442.94
IRR (% a.m.)	2.97
ROI (% in 252 months)	291

Given that the IRR > MAR and the NPV > 0, the project is attractive and viable.

- Consolidated General Analysis of the Projects

Table 14 presents a summary of the economic viability study of the three projects, or rather, the total economic benefits for the consumer. For this study we used the longest time used in the previous analyses, which was 252 months.

Table 14: Economic Viability Study: Consolidated (Emphasis on the Consumer)

INVESTMENT	**-357,516.53**
PayBack (months)	**35**
NPV (R$ in 252 months)	1,166,824.77
IRR (% a.m.)	3.23
ROI (% in 252 months)	326

Given that the IRR > MAR and the NPV > 0, the project is attractive and viable.

5.5 Analysis of the Study of the Economic Viability of the Projects

The eco-efficiency concepts presented in this research are certified by the Economic Viability Study, since the indicators of economic viability are positive for all of the projects. These economic indicators must be used for enterprises management, as well as indicators for social-environmental responsibility must also be defined.

In this sense, it is clear that the behavior of the eco-efficient items is different with regard to the time needed to be viable. The items related to the construction of water catchments for rainwater harvesting require an analysis time that is greater than the items related to energy efficiency. This is justified by the high value of the investment in water catchments in relation to the small benefit presented.

6 Conclusion

As shown in the development of the research, ecoefficient solutions differ from traditional solutions due the reduction of energy and water consumption, as well as reducing the amount of waste concrete and shape. The environmental impact reduction in the enterprise around, reflects positively on local community quality of life, leading this research to be aligned with the goals of the WBCSD.

Although the research was conducted with a limited number of buildings, it can be inferred that the use of eco-efficient concepts applied to civil construction is not common in businesses of this sector. In other words, it has been established that there is a gap between theory and practice.

One of the objectives of this work, in addition to surveying the economic viability of the use of eco-efficient concepts in Brazilian civil construction, is to identify ways to spread the use of eco-efficient concepts in the construction of buildings in Brazil, in order to better structure a set of possible initiatives. To reach this goal, we believe that the introduction of techniques for budgeting, planning, and identification of new technologies in civil construction businesses is the result of three non-exclusive alternatives, which are: i) internal initiatives of professionals in charge of design, planning, budgeting and implementation of buildings; ii) acquisition of specifications recognized by the market: "green" certifications, for example; iii) development and implementation with the participation of external consultants.

References

AGENDA 21 for Sustainable Development in Developing Countries. The International Council for Research and Innovation in Building and Construction and United Nations Environment Program, South Africa, 2002.

CENTRAL BANK. SELIC rate: March of 2011. http://www.bcb.gov.br/textonoticia.asp?codigo=2956&idpai=noticias . Acesso em 20/04/2011.

CONAMA. National Environment Council. CONAMA RESOLUTION N° 307, OF 5 JULY 2002.

BRAZILIAN BUSINESS COUNCIL FOR SUSTAINABLE DEVELOPMENT. Corporate Sustainability Report. Rio de Janeiro: CEBDS, 2004.

DE SIMONI, Livio; POPOFF, Frank. Eco-efficiency, the business link to sustainable development. MIT Press: 1997.

FAHEY, LIAM & RANDALL, Robert M. (1998). Learning from the Future. NY: John Wiley

GITMAN. L. J. Princípios de Administração Financeira, São Paulo: Pearson Addison Wesley, 2004.

KASSAI, J. R; KASSAI, S; SANTOS, A; ASSAF NETO, A. Retorno de Investimento. Abordagem matemática e contábil do lucro empresarial. São Paulo: Atlas, 2000.

PINHEIRO, M. D. (2006). Ambiente e Construção Sustentável. Instituto do Ambiente. Lisboa.

ROSS, S.A; WESTERFIELD R.W; JAFFE J. F. Administração Financeira. Corporate Finance. São Paulo: Atlas,1995.

SOUZA, R. DE; Sustentabilidade nas empresa do setor de construção. Brasil . 2007. Acesso em 15/12/2010. http://www.cbcs.org.br/comitestematicos/avaliacaosustentab/artigos/sustentabilidade_setor_construcao.php

UNEP (b). Buildings and construction as tools for promoting more sustainable patterns of consumption and production, 2010. http://www.un.org/esa/dsd/resources/res_pdfs/publications/ib/no9.pdf accessed on 17/12/2010.

VERGARA, Sylvia Constant. Métodos de pesquisa em administração. 2. ed. São Paulo: Atlas, 2006.

WORLD BUSINESS COUNCIL FOR SUSTAINABLE DEVELOPMENT – WBCSD. Measuring Eco-efficiency: a Guide to Report Company Performance. Available at: <http://www.wbcsd.org>. Accessed on: 12/05/2008.