Sea Sand as an Alternative to River Sand

A solution for booming construction cost

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Shelter in Sri Lanka

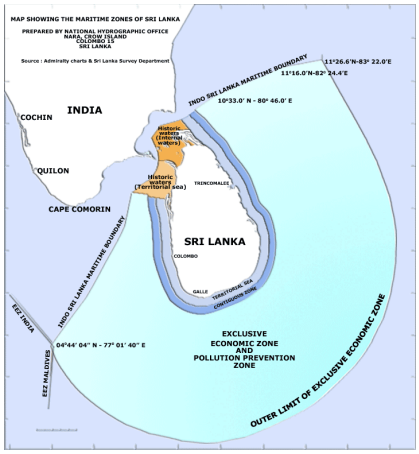
Geography and Administration

Democratic Socialist Republic of Sri Lanka is a petite green Island (65,610 sq km) in the Indian Ocean just south of India and about 800 km North of Equator.

South-central hilly region surrounded by low land and Indian ocean has created a unique ecology. The highest point is Pidurutalagala 2,524 m high from mean sea level. The average temperature in central hills drops down to 10 ^{o}C while around 27 ^{o}C in low land areas. The climate is tropical with two monsoons. South-West monsoon brings rain to south west and central hills, while North-East monsoon feeds mainly North and Eastern low lands.

The administrative capital is Sri Jayawardenapura while the commercial capital is Colombo. It is divided in to 09 provinces and further sub divided in to 25 Districts for the administrative purpose. The legislative powers are exercised by the unicameral parliament with 225 seats and the executive powers by the President elected by popular vote.

Sri Lanka claims for 12nm territorial sea, 24nm Contiguous zone and 200nm exclusive economic zone around its continental shelf. Which is approximately 230,000 sq.km.



Sea territory of Sri Lanka

Demography

The total Population of the country is about 21 Millions with an average population density of 300 persons per sqkm.

Life expectancy at birth is 72 years for male & 77 years for female.

According to the department of census, the official poverty line at national level for July 2008 is Rs. 2937 (28 US$) and the population under the national poverty line is 22%.

Sinhala & Tamil are official national languages and English is the compulsory link language.

Economy

In 1977, more market-oriented, export-oriented free trade economic policies were introduced against static economic policy which was practiced for decades. Major contributions changed from Agriculture (Tea, Rubber, Coconuts) to Tourism and industrial sector.

GNP was Rs.103, 679 (Billion) in 2004.

Shelter Related Facts and Figures

Access to Shelter

Housing stock:

In 2001, Total housing stock of 18 districts was 3.969,027 out of which,

Permanent	- 2,771,860 (69.8%)
Semi permanent	- 1,123,003 (28.3%)
Improvised	- 33,799 (0.9%)

Yearly percentage increase in number of dwelling units

Annual percentage increase in housing units is 1.5%

Housing deficit (quantitative and qualitative)

According to 2001 census, the housing deficit is 20,258.

Yearly percentage increase in number of dwelling units

During the period from 1981 to 2001, the population has increased by 10.1% while the number of housing units has grown up by 35.5%, gradually closing up the gap.

Occupancy

Table 1: Occupancy distribution.

Number of Occupants	**Housing Units %**
Total	100
1-4 persons/unit	47.4
5-9 persons/unit	45.2
More than 10 persons/unit	7.4

Source: census 2001

Tenure of households

82.1% of total owned by a member of the household, 7.0% are on rent free, 5.8% on rent/lease and 1.4% are encroached.

Building materials

About 80% of housing units are constructed with permanent materials. They are mainly Bricks/Cement blocks with cement sand plastering, and cement rendering. The demand increases day by day increasing prices of materials

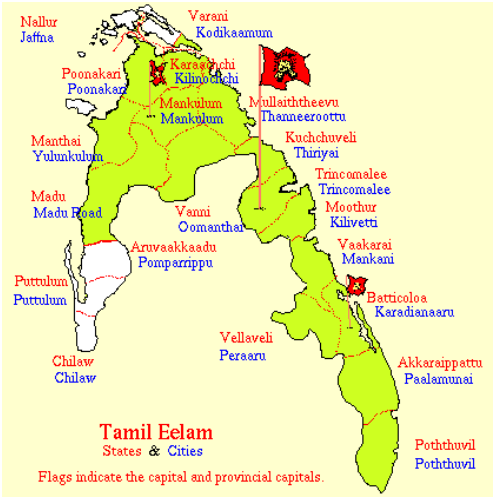
Boom in Construction Industry:

This incremental rate was propagated tremendously due to demand created after tsunami in 1994. The following chart illustrates the price variation in past few years.

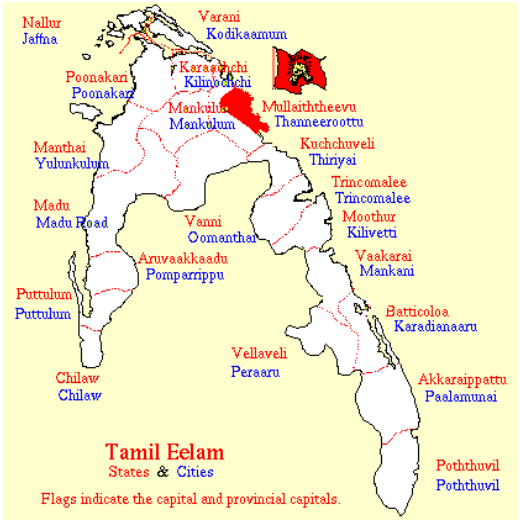
It shows that cost of a house with fine finishes of 100 sq.m will costs about SL Rs. 3800000[1]. That would be around SL Rs. 2000000 for a house with basic finishes.

It is expected a further increase in demand on housing materials after liberation of areas held by LTTE terrorists in Northern region. (See Annex 5 – map)

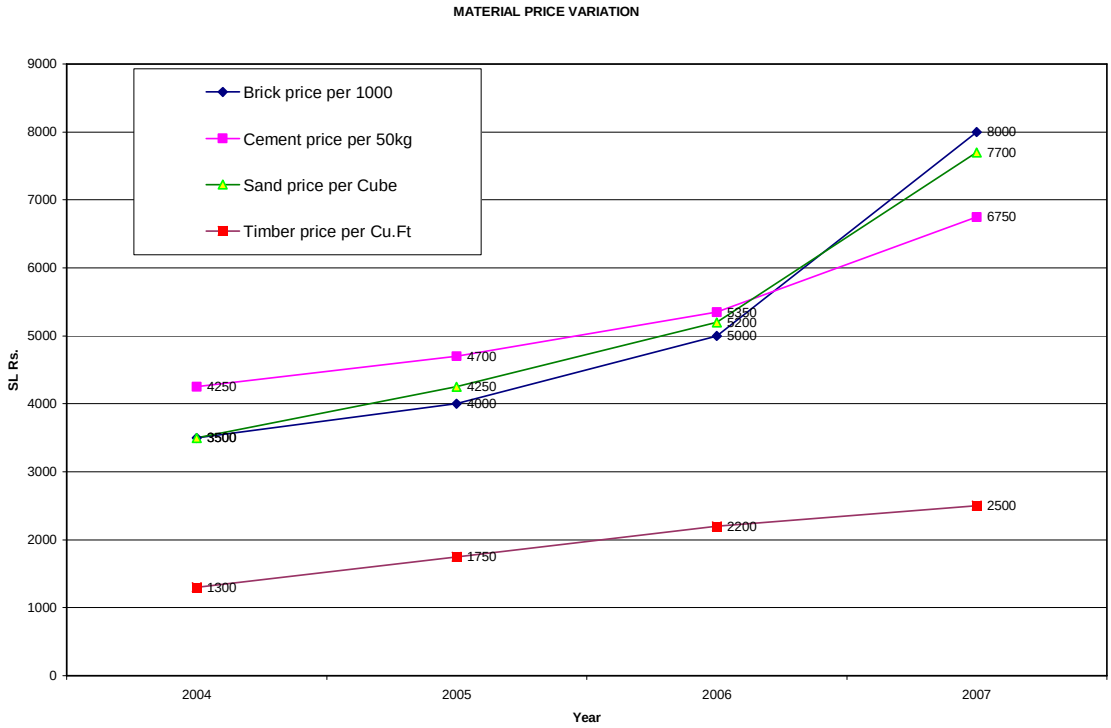
[1] 1US $ = SL Rs. 102 (in Dec 2008)



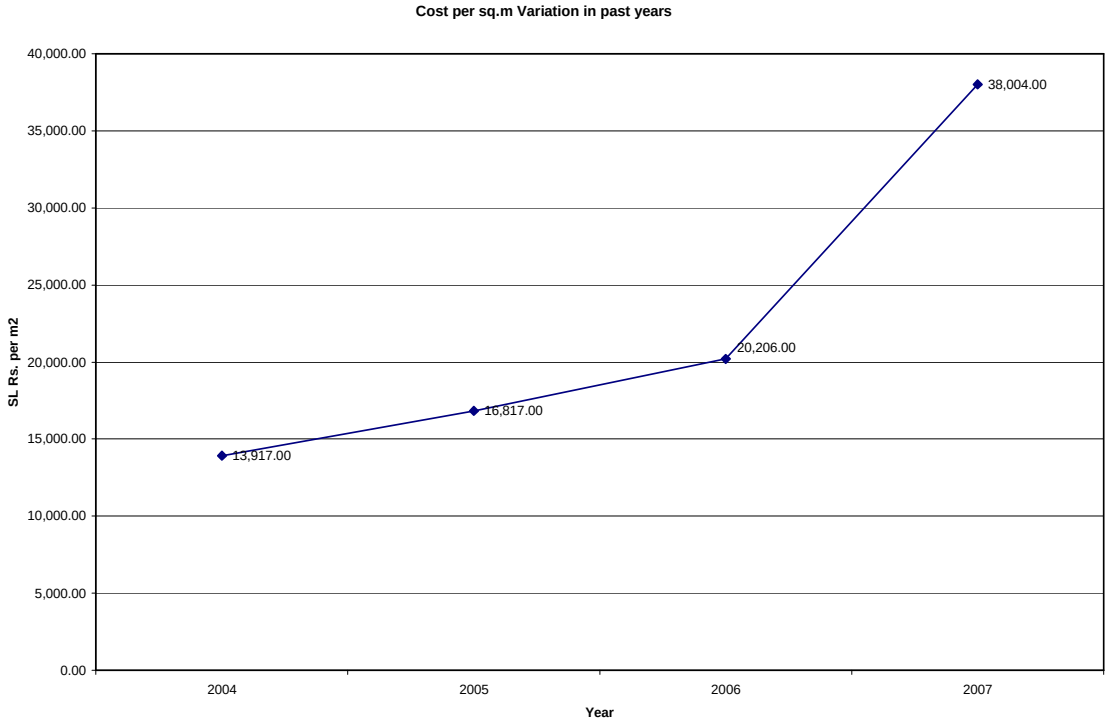
LTTE held area before 2006



Present LTTE held (Feb 2009)



House price to floor area ratio



The cost of housing variation from 2006 to 2007 is more than 150%.

Access to and cost of Basic Services/Infrastructure

Water Supply:

The country has 103 distinct natural river basins covering 90% of the island. Highly productive aquifers are found in Jafna peninsula, Mullaitive and Puttalam, in northern dry zone areas. Out of 4,054,186 housing units, only 1,089,879 (26.9%) have pipe born water facility and 3,316,815 (81.8%) have access to safe dinking water source.

Sanitation:

78.8% uses toilets exclusively and still 4.4% of households are without toilets. Within the Colombo city limits, Main sewer line is available for sewer disposal and in other area isolated septic tanks and soakage pits are used.

Energy:

54.5% of households use LP gas for cooking and 28.8% use kerosene. Only 8% use Electricity for cooking.

Access to and cost of Education

In Sri Lanka every child is assured to have free education by the constitution. It has a very good education structure and the government provide Text book from grade 1 to Advanced level completely free of charge. But only one percent of the population gets university degree level education.

Table 2: Education.

	Year	Latest data
Literacy rate, Adult total	2001	90.7
Pupil-teacher ratio, primary	2005	22
School enrolment, Primary (% gross)	2005	108.3
School enrolment, Primary, female (% gross)	2005	108.3
School enrolment, Primary, male (% gross)	2005	108.4

Source: World Bank report

Housing Policy

The government's policy is to guarantee the right of every family to own or possess a house according to the needs of the family. Activities of the state are constrained by limited recourses. The role of the government should be facilitate, enable & encourage other actors .As a result the role of the government is changing from a direct provider to a facilitator. The private sector has now immerged as a strong force, catering especially to middle & high income households.

Actors in Shelter Delivery and their Roles

- Department of Buildings

  Main adviser to the Government in all building related matters. Mainly provide consultancy services. Involve in large scale housing construction.
- National Housing Development Authority:

  Main actor in housing sector. Responsible for Upgrading and regularization of land, site and services.
- Urban Development Authority

  Responsible for policy making in Housing & Urban development
- Central Engineering Consultancy Buro

  Semi government organisation which handles Design Construction of Houses, Buildings, Roads etc.
- National Water Supply & Drainage Board

  The apex agency responsible for supply of water and sanitation to the population
- Ceylon Electricity Board

Ceylon Electricity Board is responsible for generation and distribution of electricity.

- NGOs

Shelter Design

Land Use

Total extent of land is 65000 sq.km. According to survey department about 0.4% is been utilized for Urban and associated purposes, 56.9% in Agriculture, 27% Forests, 9.1 Range lands, 4.4% wet lands, 1.2% water and 1.2 barren land.

Due to scarcity of suitable land for housing, People tend to encroach Forests and wet lands creating irrevocable environmental & social problems. Wild life is under threat. Floods become more and more often due to unplanned filling of wet lands.The other major problem is unplanned blocking out of large plantations which will leads to economic drawdown.

Population Density

Sri Lanka is the third densely populated country in South Asian region after Bangladesh and Maldives.

Table 3: Population

	2001 data
Total	18797257
Male	9353148
female	9438109
Sex ratio	99.2
Population Density	300/sq.km

Source: census 2001

The Department of Buildings, Sri Lanka

The Department of Buildings is the successor to former Public works department of Sri Lanka. It is the main adviser & Project manager to the Government of Sri Lanka on all building related maters. It provides consultancy services on designs, Construction, Maintenance and restoration of buildings and related services to the Central government; Diplomatic missions abroad, Provincial councils, Local authorities and NGOs. It also assists the state by training technical personals, technical evaluations, feasibility studies etc.

The buildings department contributed in rural housing development in Sri Lanka by successfully completing more than 100 housing schemes under the "Gam Udava" program in 1980s. And more recently involved in design and construction of houses for Tsunami affected people in Western, Southern and Eastern coastal regions with the collaboration of NGOs. Apart from housing projects, the department extends its services towards public by improving infra structure facilities by constructing Hospitals, Post offices, farmer training centres, Police stations, Administrative buildings etc.

After the liberation of eastern province and Northern area of the country from LTTE terrorists, the buildings department has now engaging in construction of 5000 houses as the initial stage.

The Department has been maintaining its own quality management system from the beginning. Documents and systems developed by the buildings department are often followed by other institutions to improve transparency. Building Schedule of Rates, Manuals for Building Maintenance, Building standards etc. are some examples.

Shelter Problem

Increasing Cost & New trends in building materials

On 26th December 2004 Tsunami waves hit eastern, southern and western coast line killed more than 31,000 people and destroyed over 1.5billion US$ worth property.

Tsunami affected area map,26th December 2006

The subsequent restoration works created huge demand over material as well as labour. The scarcity of materials caused serious socio-economic and environmental problems. For example, the whole demand of Sand was depending on River or fresh water sand extracted from water courses. River beds levels become lower than the sea level for miles inside the country.

Material prices increased dramatically to an out of reach level from poor people. Further increase is expected when reconstruction of houses to be started in Northern and Eastern regions after liberation the area from LTTE terrorists.

Un predictable price hikes cause serious impacts on financing agents in housing.

Effect of price hike on Buildings Department:

Unpredictable Price variations adversely effected on project management and financial management in client organisation as well as implementing agencies. Normally, building contracts contain terms for price variation and escalation methods. But in contrary this is not accepted by clients due to budgetary limitations. This creates huge pressure and impact on the Department.

This situation urged the department to deviate from common construction practices and to consider alternatives in order to provide economical building solutions without compromising the quality.

Proposal for Change

It has become an urgent & timely topic to be addressed in order to cut down building material cost component without compromising the quality of end product. Until 21st century, Material to Labour contribution in rate analysis was 70: 30, but it is observed that this proportion is changing and the Labour component is becoming more significant. In order to face for this new trend it is very important to put more attention on Labour savings. But since the material component is still playing a major role, in this project I will concentrate on materials. In order to controll cost, different materials were brought in to industry by different parties. Sea sand and Cement Stabilised clay blocks are most attractive among others. In this project, it is confined to consider sea sand usage due to time and financial constrains.

Types of Sand and there usability

River Sand:

Normally river sand has very good characteristics for all construction activity. But it is the general practice to test it for impurities and clay content as well as for particle size distribution.

Due to construction engineer's preference on river sands for decades, the whole demand of Sand was depending on River or fresh water sand extracted from water courses. The uncontrolled extraction of sand, gradually river beds become lower than the mean sea level for miles in side the country, created huge Socio economic and Environmental problems. In some rivers salt water reached intake locations for portable water treatment schemes. River banks become unstable.

The government had to act in strict on sand extraction and limitations were introduced.

Sea Sand pumped from deep sea:

Huge quantity of sand particles are being transported around the world by sea currents. When these sea currents travel around the Island, part of it deposits in natural trenches around the Island.

Though this resource could be used for development process, Sea sand was never allowed to use in building sector till recent past. Initially sea sand was collected by pumping for ground improvements suggested for proposed Colombo – Katunayake High way which runs across the "Muthurajawela" marshy land. Subsequently the project was abundant. Hike in sand price urged authorities to try on use of this pumped sea sand stock pile against river sand. This sand pile is now being used for construction activities. But the only source available is Land reclamation board of Sri Lanka. And there is a risk of use of sea sand extraction directly from beach. This needs to be prevented to protect the land from erosion. And is an urgent aspect to find precautions restrict misuse.

Sand dunes:

Naturally formed sand dunes are found in coastal line in North-West and Some southern areas. These sand dunes are formed by sand particles blown by wind

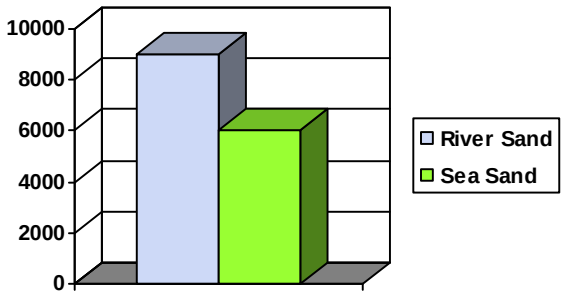
from sea shore. Top most layers of sand dunes contain higher chloride content due to continuous exposure to sea breeze.

Out of above mentioned sand types, sand dunes acts as natural wind breakers and provides protection against tsunami and costal erosion though it is cheep and no additional cost is required on extracting and processing. Hence removal of sand dunes might create various problems including serious environmental issues and therefore, should not be promoted without broad studies.

Though the environmental problems are not very significant in use of Sea Sand, it needs to be studied thoroughly on deposition pattern.

Price difference between river sand and sea sand

The price of $100ft^3$ of sea sand is around SL Rs. 6000 where as river sand is around 9000 SL Rs. Hence it is clear that use of sea sand would significantly reduce construction cost.



Need of standard for sea sand.

Due to huge pressure built up, relevant authorities had to accept use of sea sand in construction sector. There are considerable doubts and fear on misuse and strength characteristics with regards to sea sand.

They are,

1. How to ensure Chloride contents and shell contents are within acceptable limits.
2. How to assure quality sand supply to general public.

The first task can be achieved by developing new standard with proper testing and educating general public with regards to sea sand usage.

In the process of making up a standard, it is important to study how other countries solved the problem. U.K, Netherlands, India, Maldives, Singapore are some of the countries use sea sand in construction industry.

Chloride Content in Sea Sand

The chloride content in sea sand depends on the chloride content in sea water, Moisture content. The sea water contains relatively constant chloride content but more moisture content in sand retains more chloride around particles. In hot climates, though the moisture content is less, due to evaporation of moisture chloride coating will be formed around particles.

BS 5328 Part 1: 1991 specifies total chloride limit to 0.4% by weight. But this guide line is not suitable for countries like Sri Lanka due to difference in climatic condition. It was found in studies carried out in Iraq, that corrosion may increase even with total chloride content of as less as 0.3% (Katwan 2001: 360-366)

Testing for chloride content

Due to time and financial constrains, only Two samples of sea sand were obtained, one from stock pile at Muthurajawela (Offshore) and the other directly from sea shore.

They were tested according to BS 812-117:1988 using Silver Nitrate solution (Which is available even in remote school labs) method. Results obtained were given below

Table 4: chloride content.

Sample	Cl- content (%)
Sample from sea shore	0.16
Sample from stock pile (Off shore)	0.03

Limits on Chloride content

a. For Reinforced concrete: Total chloride content shall be limited to 0.3 %(Katwan 2001) which is lower than BS 5328 limit. Out of which 0.05% should be allowed for chloride content in Cement. Hence, it is suggested

to limit chloride content in sand to 0.075% (conservative approach).This can easily be achieved by allowing sand to be drained under gravity and exposing it to rain for one monsoon period.

b. For Other non structural activities: Though they are not structurally important, the chloride content may cause problems on paints and other fine finishes. So it is suggested hereby to limit chloride content of sand for non structural elements to 0.16% which can be achieved by allowing free drainage of sea water from sand.

Limits on shell content

It is hereby suggested to sieve sand before using for structural concrete. It is not necessary to sieve for plastering mortar and non-structural concert.

Quality Assurance:

It is strongly suggested to issue sand under strict control in order to avoid use of sea sand directly from sea shore.

To achieve this goal, the following method is suggested.

1. Issue sea sand in bags :

   Different colours can be used to indicate whether it is sieved or not and on the recommended usage. Chloride content shall be tested and mentioned in each batch.

2. Issue sea sand in bulk:

   For large quantities sand may be issued in bulk under written certification of chloride content.

3. It should be promoted to test sand for chloride content in site preferably by using strip method given in BS 812 as it is much easier to carry out.

References

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2001 *Corrosion of steel reinforcement in hot countries, an acute case study.* Iraq: materials and Structures, Vol 34, July.

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1988 *Testing aggregates, method for determination of water soluble chloride salts.* London: British Standard Institution

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2001 Colombo: National physical planning Department