

スリランカ全土の陸水を可視化する

Water Flow in Sri Lanka Estimated by Preliminary Numerical Simulation

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Geosphere Environmental Technology Corp.

第12回地圏と環境セミナー Application of GETFLOWS for Sri Lankan Terrestrial Water Circulation

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<u>General Introduction to Sri Lanka – スリランカの概要</u>

- Introduction Sri Lanka
 - Location South of Indian subcontinent (longitude $79^0 82^0$, Latitude $5^0 10^0$)
 - Population 200 万 (20 million) [日本 127 million]
 - Commercial Capital Colombo
 - Total land area 65610 km²
 (北海土>スリランカ>九州)
 - Population density 265 / km²
 - Maximum Length and width 417 km and 225 km
 - Annual average rainfall 2000 mm (max 5300 mm, min 935 mm), [九州]
 - Average temperature 27 °C (low country), 15 °C (up country)
 - Climate Tropical [~ Okinawa]
 - Number of river basins 103
 - Economy Agriculture and minor industries
 - Currency Rupee ($1 \bowtie = 1.35$ rupee)
 - GDP US\$ 41 billion
 - Races Sinhalese (74%), Tamils (18%), Muslims and others (8%)
 - Religions Buddhism, Hindus, Catholics and Muslims





<u>Geology of Sri Lanka</u> — 地質構造



Ref. Panabokke and Perera, 2005, Groundwater Resources of Sri Lanka

Sri Lanka

• Generally shows a considerable diversity in geology and land forms.

of Sri Lanka

- Geologically, 90% of the country's landmass is underlain by Precambrian basement rocks and the remaining 10% by sedimentary rocks of Miocene age.
- These two geological units along the coast have been modified by the Pleistocene and Holocene sea level fluctuations and climatic changes causing deposition of sand, clay, gravel and peat deposits along low-lying coastal areas.



Ref. Climate data, Trends and Scenarios in Sri Lanka, Senaka Basnayake, (CCCS), Department of Meteorology, Sri Lanka

<u>Sri Lanka's water resources situation</u> —水資源の現況

i, Surface water

River Basins of Sri Lanka

Sri Lanka's radial network of rivers begins in the central highlands. There are about 103 distinct river basins covering 90 percent of the island.

Mahaweli river – Longest river (335 km) basin area 10,448 km²

6 River basins – basin area $3500 - 2000 \text{ km}^2$ 10 River basins – basin area $2000 - 1000 \text{ km}^2$ 11 River basins – basin area $1000 - 500 \text{ km}^2$ 32 River basins – basin area $100 - 500 \text{ km}^2$ 43 River basins – Small coastal basins with basin area is less than 100 km^2

The total runoff in Sri Lanka is estimated at 49.2 (km³/year).



Ref. P.P.G. Dias, Hydrometric Network & Flood Mitigation.pdf Irrigation Department of Sri Lanka

Sri Lanka's water resources situation ... cont

ii, Ground water

- 1, Groundwater resources have been extensively used since ancient times for domestic purposes using shallow open wells in almost all parts of the country.
- 2, Sri Lanka's largest aquifer extends over 200 km in the northwestern and northern coastal areas.
- Northern and northwestern coastal areas excessive concentrations of iron and nitrates (due to agrochemicals and fertilizers) have been reported.
- 4, Due to uncontrolled abstraction of groundwater for domestic and agricultural uses, brackish water intrusion has occurred in the coastal areas.
- 5, Total groundwater demand in 2000 was 10.92 km³ (90% agriculture, 7% domestic, 3% industries)



Ref. Panabokke and Perera, 2005, Groundwater Resources of Sri Lanka



Ref. P.W. Senevirathna, PROMOTION OF PUBLIC AWARENESS OF WATER CONSERVATION SRI LANKA EXPERIENCE

Main Water Related Issues in Sri Lanka — 水問題 1. Improper planning for water management 適切な水管理の不足

- i, Minor attention for water resources protection and catchment management
- ii, Poor flood and drought management
- iii, Unreliable/non availability of Data and information
- iv, Poor coordination
- 2. Growing demand 需要の増大
- 3. Unplanned exploitation of groundwater
- 4. Groundwater contamination by fertilizer and pesticides (Agriculture) 農薬汚染
- 5. High concentrations of Florid/Iron present in groundwater in north central part of Sri Lanka
- 6. Saltwater intrusion in coastal areas
- 7. Contamination of river and groundwater due to industrial/domestic waste 排水

Why do we need to model whole country for the water resources of Sri Lanka?

- 1, No detail scientific assessment of terrestrial water environment.
- 2, Very limited researches and numerical simulations for water environment
- 3, There is no reliable country map for ground/surface water resources
- 4, Encourage SL government and researches to pay more attention of water resources and their development

- 1, This is the **First Time** to develop a numerical model for Sri Lanka for country scale.
- 2, Mesh size 1.0 km x 1.0 km (Total No of grids ~ 5.5 million)
- 3, Numerical Model 3D 2 phase (air/water) 3 components (air/water/salt)

Data Collection and availability

- 1, Rainfall/Temperature <u>www.weatherbase.com</u>
- 2, Land use ISCGRM http://www.iscgm.org/cgi-bin/fswiki/wiki.cgi
- 3, DEM <u>NASA/NSA Shuttle Radar Topography Mission (SRTM) dataset & GTOPO30</u> <u>data</u>
- 4, Geology Geological map of Ceylon, Soil map of Sri Lanka, Soils and Agro-Ecological environments of Sri Lanka by *C.R. Panabokke*
- 5, River flow Reliable data could not find yet
- 6, Groundwater levels Reliable data could not find yet
- 7, Salinity levels of subsurface water in coastal areas Reliable data could not find yet

Rainfall/Temperature - www.weatherbase.com



- 1, High rainfall in West, Central and Southwest region
- 2, Less rainfall in North and East region

-- Thiessen polygon was created for effective rainfall concerning temperature, precipitation, sunshine hours, evaporation .. ---



Fluid Flow & Properties — 流体の物理的性質

Fluid condition	Surface water flow		Manning' s flow	
	Groundwater flow		Generalized Darcy' flow	
	Fluid system		Water – Air, 2 phase 3 component (salt)	
	Water	Density	1.0 [g/cm ³]	
		Viscosity	1.0 × 10 ⁻³ [Pa•s]	
		Compressibility	0.45[GPa ⁻¹]	
	Air	Density	$1.3 \times 10^{-3} [g/cm^{3}]$	
		Viscosity	1.82 × 10 ⁻⁵ [Pa•s]	
		Compressibility	Formation volume factor (Proportional to the inverse of pressure)	
Sea	Density Concentration		1.0184[g/cm ³]	
Water			0.0160[m ³ /m ³]	

Soil properties, land use — 土壤と土地利用

	Density		2.5[Mg/m ³]	
Soil Properties	Compression ratio		10[GPa ⁻¹]	
	Geology		Top soil layer, Alluvium, Coastal sand, Laterite, Deep confine layer, Weathered layer, Bed rock	
	Absolute Permeability Effective porosity	Top soil Alluvium Laterite Coastal Sand Deep confine layer Weathered layer Bed rock Top soil Alluvium Laterite Coastal Sand Deep confine layer Weathered layer Bed rock	$\begin{array}{c} 1.0 \times 10^{-4} [\text{m/s}] \\ 1.0 \times 10^{-5} [\text{m/s}] \\ 1.5 \times 10^{-6} [\text{m/s}] \\ 1.0 \times 10^{-5} [\text{m/s}] \\ 1.3 \times 10^{-6} [\text{m/s}] \\ 1.5 \times 10^{-8} [\text{m/s}] \\ 1.0 \times 10^{-8} [\text{m/s}] \\ 1.0 \times 10^{-8} [\text{m/s}] \\ 0.50 \\ 0.20 \\ 0.04 \\ 0.35 \\ 0.04 \\ 0.08 \\ 0.01 \end{array}$	
Land use	Roughness coefficient		Forest Rice field Bare area Urban area Vegetation Mangrove Water bodies	0.60 2.00 2.00 0.03 0.30 2.00 0.035



土地利用-Land use



水理地質構造-Hydrogeology









<u> 湧出域分布-Distribution of groundwater springs</u>





Groundwater discharge in large quantities can be identified in the highland area. Those areas can be developed for mineral water industry and tourist spots as well.

This area will be developed as a new city in Sri Lanka. Already new international port and an airport are being constructed. High demand of water will be an issue in future. Deep groundwater pumping will be an option. However seawater intrusion can be a problem.

100

km









<u>GETFLOWS to improve Sri Lanka's water environment</u> <u>明日の水環境に向けて</u>

Vision for the FUTURE of Sri Lanka's WATER Environment from GETFLOWS

- 1, How can we use GETFLOWS to improve Sri Lankan *Economy* ??
 - Use available water resources as an economic source
 - (Tourism, Mineral water, Irrigation, Inland fishery)
- 2, Support to establish a *Water POLICY* for Sri Lanka
- 3, How can we use GETFLOWS to improve the sustainability of *Sri Lanka's water environment* ??
- 4, How can we use GETFLOWS results to establish a *Hydrological Database / Information System* for Sri Lanka ??
- 5, Can we see the *hidden side of terrestrial water system* of Sri Lanka from GETFLOWS results ??

General applications as a Numerical simulator

- 1, Flood control and disaster prevent predict river flow rates during raining seasons and extreme weather conditions to protect the residence and property in the down steam area.
- 2, Predict the groundwater levels and effect of pumping in coastal areas and dry zone
- 3, Predict the future affects of surface/groundwater contaminant transport (Industrial waste, domestic waste, agricultural waste etc)
- 4, Reservoir monitoring
- 5, Water distribution for irrigation
- 6, Environmental effect due to large scale constructions (Hambantota harbor/air port, highways..etc)

<u>Potential Business Opportunity in Water Industry</u> in Sri Lanka <u>水のビジネス チャンス</u>

- 1. Water resource monitoring and assessment 水資源の監視
- 2. Drinking water processing 上水の製造
- 3. Water supply and drainage (Surface water, groundwater and rain water) 水の供給と排水
- 4. Waste water and sanitation 廃水と衛生
- 5. Dam management, monitoring and renovation ダム管理とダム機能再生
- 6. Small scale irrigation projects 灌漑計画
- 7. Flood control and management 洪水制御
- 8. Water related infrastructure development (Dams, irrigation, tunnels) 水理工作物(ダム、灌漑施設、導水トンネル)
- 9. Mini hydro-power stations' monitoring and management 小水力発電の管理
- 10. Port and harbor developments 港湾開発
- 11. Nuclear power plants (2020 2030) 原子力発電所

Government institutions - NWSDB (National Water Supply & Drainage Board, WRD (Water Resources Board), The Department of Irrigation, The Mahaweli Authority of Sri Lanka, The Ceylon Electricity Board (CEB), The Meteorological Department of Sri Lanka

Main donor countries and institutions for water resources development – Japan, China, EU, UN, World Bank, ABD, JICA, NORAD, SIDA

The End !!! ----- Thank you very much -----