

When Machines can be intelligent

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1) Introduction

The question of Can a machine be intelligent dates back to many decades. However, the idea of Intelligent machines is no longer a dream for many countries in the world. It has been a practical reality in most of the developed countries while some of our people are still pessimistic about existence of intelligent machines. According to my understanding, this extreme view can be rectified by answering the question when can machines be intelligent rather than can machines ever be intelligent. The root cause for the extreme view is that people attempt to understand the word intelligence in eternal sense. In this talk, I attempt to explain that there is room for arguing that even machines can be made intelligent if we know enough about natural intelligence. Our over estimation and little understanding of the term intelligence have blocked up avenues for emergence of intelligent machines.

2) Hopes for Machine Intelligence

It is evident that the term intelligence lacks a philosophical definition. Nevertheless, people are aware of some characteristics of humans for which intelligence is assumed to be required. For examples: one's ability to solve mathematical problems requires intelligence. Furthermore, ability to learn, ability to teach, ability to explain how an answer is arrived at for a question, etc. are some intelligent behaviour of humans. Therefore, if a machine can emulate at least some of such characteristics, how can we argue that machines can never be intelligent. This leads to another question that are there any machines on which you can emulate intelligent characteristics of humans. Of course, there is a machine for emulating human intelligence. It's noting else, that is at present the digital computer.

Computer has ability to device an intelligent machine for the following simple reason. That is due to fundamental architecture of a computer. As you all are aware, a simple computer system consists of two layers known as: hardware and software. Basically, hardware is a collection of electronic circuits related devices. In contrast, software is a set of instructions together with necessary information. Computer works on a simple principle that software can run on hardware. This structure allows us to develop intelligent machines with the aid of modern computers. It is simple. Only thing we should do is develop software, which emulate some characteristics of human intelligence. In doing so we can produce an intelligent software. When running such an intelligent software on hardware of a computer, it formulates an intelligent computer, an intelligent machine. In this manner, computer has provided a basis for construction of intelligent machines. We simply can develop intelligent machines by emulating human intelligence as software programs that run on appropriate hardware.

It should also be mentioned that a computer is not essential to develop an intelligent machine. For example, a set of pulleys and strings can be used develop a machine for simple arithmetic calculation. In fact, it gave rise to the birth of analogue computers more than a century ago. Why bother re-inventing the wheel, let us go ahead with the modern digital computer.

While a great collection of evidence is available to justify the existence of intelligent machines, it is important to discuss why some people still tend to think that machine intelligence is a dream. In my view, there is a clear reason for it. That is, people generally consider intelligence as a global phenomenon. They have forgotten the subjectivity and situation dependency of the term intelligence. Put another way, a given person may not be intelligent with regard to every task at every instance. Nobody in the world is intelligent for every thing. Sometimes even machines are more intelligent than some people for a given task. For example, you all know that a child of age 3 cannot multiply two numbers. However, it can be done by a

small calculator. In this event how can we argue that calculator is less intelligent than the child of age three with regard to that particular task. Similarly, a child at age three can recognise his/her father and mother separately, but writing a computer program for doing that is a very difficult task at the moment. Therefore, child at age 3 is more intelligent than a machine for this purpose.

In this sense, it is evident that we can develop intelligent machines for performing some intelligent behaviour of human being. It should be noted that we are not talking of machine intelligence in global terms. That means, at some instance, for performing some tasks machines are also intelligent compared with humans. The number of such occurrences may be very small, however it is not zero. Computer is not intelligent by default. However, it can be programmed to behave as if it is intelligent. If you are unbiased, this nature is true for human being too, that is, nobody is exceptionally intelligent at the time he/she is born. However, they are with the capability to become intelligent if they are made to do so. That is why our children go through a stream of learning. In that sense, people can be made intelligent so do machines!

Since computers are accepting the challenge of making intelligent machines, some are very critical about computers too. One such major criticism is that computers can never produce some thing unknown to the programmer. In other words, computers are not creative or machine cannot emulate the intelligent characteristic of being creative. There is enough evidence that computers can also be creative or find more relations, which were not realised at the time of programming. In fact, there is now an emerging research field in this respect. It is called data mining, which allows retrieving previously unseen relations of entries in very large databases.

3) Artificial Intelligence

While some of our people are pessimistic about machine intelligence, people in the developed countries have exploited the power of intelligent machines. In fact, there is a research area called Artificial Intelligence (AI) which was born in 1956, with an aim to develop intelligent artifacts. It should be noted that AI does not talk of an artificial form of intelligence, but the emulation of natural intelligence on suitable artifacts (computers). For this purpose, AI draws from many areas where the theme of knowledge and intelligence has been discussed over many years. Some of these areas include philosophy, psychology, linguistics, epistemology, ethnography, etc. In this attempt to exploit models of intelligence from other disciplines, people realise that we really know very little about human intelligence. Of course, it motivates finding more about the term intelligence in other disciplines as well.

To date there are various intelligent systems including Expert Systems, Genetic algorithms, fuzzy logic, neural networks and robotics. Each of this intelligent software has exhibited a varying degree of intelligent characteristics. For example, neural networks are very good at learning and processing on incomplete information. In contrast, expert systems are exceptionally capable of explaining, how and why an answer is arrived at. In this sense, as human beings, none of them is globally intelligent. Resulting from this, the world is now interested in developing intelligent systems, which attempt to bring increasingly intelligent characteristics into one system. These systems are known as hybrid systems. Hybrid systems have shown a greater potential to solve real world problems, which cannot be solved by classical techniques.

AI techniques now dominate the whole world of software. For example, the recent views such as Agent software can be considered. Agent software emerged as a result of Internet usage. In this vein, the idea of intelligent agent is now emerged as one step ahead from ordinary Agent software. Likewise, the exploitation of some intelligent behaviour of human into software systems has been increasingly popularised. In addition to emulation of human intelligence in the form software, there are also hardware systems that emulate some characteristics of human intelligence. For example, various neural chips to date emulate some neural network programs. This is of course possible, since software can generally be converted into a corresponding piece of hardware.

More we know about natural intelligence, the more AI will be benefited! AI is a multidisciplinary area and has spread out giving many branches to date. Most of the artifacts invented by humans make our physical activities easy. They are products of human intelligence. So what about developing machines for making

intellectual activities easier. Making intelligent machines may therefore be the greatest invention that mankind could ever achieve.

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Finite Element Formulation of the Electromagnetic Fields

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Abstract

The Poisson equation is the governing equation of electromagnetic fields.

$$-\varepsilon \nabla^2 \phi = \rho \quad (1)$$

$$-\mu^{-1} \nabla^2 A = J \quad (2)$$

Equation (1) and (2) describe the electric and the magnetic fields, where ϕ is the electric potential, ε is the permittivity, ρ is the electric charge density, μ is the permeability, A is the magnetic vector potential and J the current density. These equations can be solved by using the Finite Element Method. We have used first order triangular finite elements. A framework to solve the two dimensional Poisson equation problem is provided.

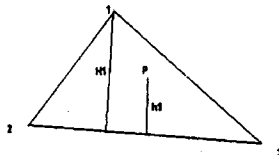
First, we construct functionals, which have minima at the solution of the Poisson equations. These are

$$L(\phi) = \iint \left\{ \frac{1}{2} \varepsilon [\nabla \phi]^2 - \rho \phi \right\} dR \quad (3)$$

and

$$L(A) = \iint \left\{ \frac{1}{2} \mu^{-1} [\nabla A]^2 - JA \right\} dR \quad (4)$$

It is easily shown that the minimum of these functionals are satisfied by the Poisson equations. The above functional integrals in the domain is equal to the sum of the functional integrals in the sub-domains. Now, let us see the triangular formulation.



Point P (x, y) = (ξ₁, ξ₂, ξ₃), where ξ₁ = h₁/H₁, ξ₂ = h₂/H₂, ξ₃ = h₃/H₃

The potential within the triangle is determined by first order interpolation.

$$\varphi(x, y) = \xi_1 \varphi_1 + \xi_2 \varphi_2 + \xi_3 \varphi_3 = \alpha \phi \quad (5)$$

where

$$\begin{aligned} \alpha &= [\xi_1, \xi_2, \xi_3] \\ \phi &= [\varphi_1, \varphi_2, \varphi_3] \end{aligned} \quad (6)$$

In the triangle, ϕ₁ is given by vertex 1, ϕ₂ is given by vertex 2, ϕ₃ give from vertex 3. In triangular co-ordinates, the charge density vector is

$$\rho = \xi_1 \rho_1 + \xi_2 \rho_2 + \xi_3 \rho_3 = \alpha \rho \quad (7)$$

Substituting for ϕ and ρ in the above functional equation we have

$$L(\varphi) = \sum_{\Delta} \iint_{\Delta} \left\{ \frac{1}{2} \varepsilon [\nabla \alpha \phi]^2 - [\alpha \rho][\alpha \phi] \right\} dR \quad (8)$$

We can represent equation (8) in Cartesian coordinates as

$$L(\varphi) = \sum_{\Delta} \iint_{\Delta} \left\{ \frac{1}{2} \varepsilon \left[\left(\frac{\partial}{\partial x} \alpha \phi \right)^2 + \left(\frac{\partial}{\partial y} \alpha \phi \right)^2 \right] - [\alpha \rho][\alpha \phi] \right\} dR \quad (9)$$

Let

$$\frac{\partial}{\partial x} \alpha = b \quad (10)$$

$$\frac{\partial}{\partial y} \alpha = c \quad (11)$$

$$\iint_{\Delta} [\alpha \rho] [\alpha \phi] dR = \iint_{\Delta} (\phi' \alpha') (\alpha \phi) dR \quad (12)$$

$$\iint_{\Delta} [\alpha \rho] [\alpha \phi] dR = \phi' AT^{11} \rho \quad (13)$$

$$\iint_{\Delta} [\alpha \rho] [\alpha \phi] dR = \phi' \left\{ \iint_{\Delta} \alpha' \alpha dR \right\} \rho \quad (14)$$

where

$$T^{11} = \frac{1}{12} \begin{bmatrix} 2,1,1 \\ 1,2,1 \\ 1,1,2 \end{bmatrix} \quad (15)$$

Then

$$L(\varphi) = \sum_{\Delta} \frac{1}{2} \varepsilon \iint_{\Delta} [(b\phi)(b\phi) + (c\phi)(c\phi)] dR - \sum_{\Delta} \phi' \iint_{\Delta} \alpha' \alpha dR \cdot \rho \quad (16)$$

$$L(\varphi) = \sum \left\{ \frac{1}{2} \varepsilon A [\phi' b' b \phi + \phi' c' c \phi] - A \phi' T^{11} \rho \right\} \quad (17)$$

Generally this can be written as

$$L(\varphi) = \sum_{\Delta} \left\{ \frac{1}{2} \phi' P \phi - \phi' Q \right\} \quad (18)$$

The sum of the contribution of all elements is

$$L(\varphi) = \frac{1}{2} \phi' P^g \phi - \phi' Q^g \quad (19)$$

By differentiation with respect to ϕ , we have

$$\frac{\partial}{\partial \phi} L = [P^s + (P^s)' - Q^s] \quad (20)$$

For the minimum of the functional L

$$\frac{\partial}{\partial \phi} L = P^s \phi - Q^s = 0 \quad (21)$$

$$P^s \phi = Q^s \quad (22)$$

Solving this linear equation for the vector ϕ , we obtain all unknowns ϕ_i . Thus we can find potentials of all the discrete points on the domain.

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An Overview of Surface Water Modelling Applications in Sri Lanka

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Abstract

Numerical models have been used in civil engineering hydraulics from the 1960s. This work was done mainly in conjunction with university research. However, the widespread practical application of these models did not take place until the 1980s. In the 1990s, the use of mathematical modelling has become a standard tool in many investigations and planning exercises in hydraulics and water resources engineering. Such models were introduced to Sri Lanka in the late 1980s and have now become an often-used tool, particularly at Lanka Hydraulic Institute (LHI). This paper provides an overview what has been done, mainly in Sri Lanka, at LHI.

The paper describes two types of models, one-dimensional river network models used in flood simulations and forecasting and two-dimensional modelling used mainly in shallow coastal reaches and estuaries. This paper does not deal with hydrological modelling or ground water modelling. Neither does it deal with longshore sediment transport modelling which is a widely used and very important tool in Sri Lanka.

One dimensional river network modelling was introduced as a practical application in the Kelani Ganga Flood Study where the flood conveyance/storage properties of the Kelani Ganga Basin was modelled in its present deepened (after excessive sand mining) form and in the original state it was in during the 1947 flood. The flood risk was reassessed in today's context of developing infrastructure in the flood plain. This model, in its two-layer form is later used to estimate salinity intrusion.

Two-dimensional models have been used widely in the computation of wave propagation inshore from the deep sea and later how they penetrate into harbours. The hydrodynamic and sediment transport models

have been used to estimate the impacts of wind and wave driven currents superimposed on tidal currents. Recently, the impacts of cyclone driven currents and waves in the presence of sea surface elevation has been studied in connection with Oluvil Harbour have been studied.

The applicability of various types of models and the overwhelming need for good field data have been emphasised.

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Modelling Orographic Rainfall in Sri Lanka

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Rainfall in Sri Lanka has been analyzed in terms of various statistical measures and useful conclusions have been drawn. Agro-ecological zones have been identified as shown in figure 1. Spatial and temporal statistics have been identified and the rainfall has been broken into two monsoonal regimes and its intervening periods.

Yet, statistical analysis alone does not reveal the physical mechanisms or gives us a predictive capacity. Indeed, since there are many variables affecting rainfall, it is difficult to disentangle meaningfully, the impact of each factor. To understand rainfall in our island, we need quantitative models of climate based on the laws of nature

Rainfall Mechanisms

The principal mechanisms of rainfall for this island are

- Convective – particularly when the rising limb of the Hadley cell crosses Sri Lanka in March-April and October-November, warm moist air is convected up forming clouds. The topography does not affect convective rain much. It is more or less uniform through the island. It is common to call this period the inter-monsoonal period – although the cause of the rainfall is really the monsoon cell.
- Orographic – orographic rain occurs only on the windward side of mountains as moist air is forced up by winds blowing into mountains. Strong orographic patterns are seen from June to September on the Western slopes and from December to February on the Eastern slopes.
- Cyclonic or Depressional rain – atmospheric pressure is depressed by either geostrophic vorticity or local cyclonic circulation. In the North, cyclonic circulation is brought about by the abrupt presence of the Western Ghats mountains of India. Cyclonic and orographic rain accounts for the higher rainfall in Jaffna as opposed to that in Mannar.

A Model for Orographic Rain

If one considers the topography of our hills as shown in figure 2, one sees that from Kirigalpotta to Hantana, the mountain massifs form a ridge going from South to North. If one considers the wind flow during the South-West monsoon, it is approximately perpendicular to this ridge. Indeed a cross section of this mountain taken on an axis starting from a point North of Galle on the West Coast passing Sita Eliya at the crest and ending just South of Batticaloa in the East Coast is shown in figure 3.

To estimate orographic rainfall, one must first estimate the vertical air velocity as the geostrophic pressure gradients forces winds across the mountain ridge. The hypothetical case of a mountain whose cross-section extends uniformly perpendicular to the wind flow can be tackled in a revealing manner.

The equations that have to be satisfied for the atmospheric circulation are the

- Conservation of Mass
- Conservation of Momentum
- Conservation of Energy

From these equations, one may estimate the vertical transport of air, under the assumptions, that

- the flow is steady and laminar at the non-viscous limit and two-dimensional.
- the geostrophic flow is unaffected by the orographic perturbations
- the typical variation of wind velocity, temperature, density and relative humidity over Colombo in July can be used for the entire cross-section and
- adiabatic equilibrium thermodynamics holds.

The boundary conditions that have to be satisfied are

- At the lower boundary, the flow has to be tangential to the topography (we use a Lorentzian approximation of the topography for our calculations)
- At the upper boundary, the atmospheric circulation above a certain height, say 5 kilometers, does not affect the dynamics.

Based on these simplifications, based on estimates for temperature, relative humidity, wind speeds at various heights obtained from the Colombo meteorological station and from a finite difference formulation of the laws and boundary conditions, one may derive the vertical velocity $w(x,z)$ at different heights and at different distances from the crest. For our calculations, these velocity profiles appear as shown in figure 4.

Starting with these velocity profiles, the condensation may be estimated, by applying laws of conservation of both air and moisture for small cells. For realistic estimates, the horizontal transport of the raindrops by the wind as it falls has to be accounted for. Based on these calculations, the rainfall variation with respect to the topography as shown in figure 5.

The peak in rainfall occurs at a point that is around 20 kilometers on the windward side of the mountain crest. Indeed, if one extrapolates qualitatively from this finding for the Sri Lankan topography, the rainfall pattern expected is similar to that prevalent in July (figure 6). During July, there is a strong westerly wind across the mountain ridge. Indeed, as one would expect, the rainfall peaks around 10-20 kilometers to the windward side of the Adams peak, Pidurutalagala and Knuckles mountain ranges.

Implications of the Orographic Model

While this analysis has been based on a simplified flow model and restricted to orographic rains, one may still make significant observations. Spatial variation in rainfall is principally from orographic rain. Indeed, it is clear that the so-called Wet Zone is the windward side of the mountains in the stronger monsoon and that the regions with peak rainfall are regions approximately 10-20 kilometers from the crest. A similar rainfall pattern conforming to orographic predictions is found in the Eastern slopes during the North East monsoon. Regions that are not affected by orography are Hambantota and Mannar and these are arid.

More precise estimates of rainfall will follow, after a better three-dimensional wind model for Sri Lanka, based on the work of Ajith Gunaratne which is also reported here, is obtained. These models have to be calibrated against precise hourly rainfall measurements in stations in the South-West.

One immediate implication based on the clear significance of Orographic rainfall is the consequences of particulate/SOX/NOX transport from stack emissions from a coal power plant from the three sites that are considered – Mawella, Puttalam and Trincomalee. It would be unwise to locate a coal plant in the South-West coast, as the SOX/NOX will be transported into our hills during most of the year and precipitate in the hill country and the resulting acid rain will contaminate our rivers. Puttalam seems safe on grounds, of contaminant transport. Trincomalee, too is not all that bad as the North East wind patterns prevail only for three months and the wind trajectory above it does not cross the hills. The Mawella site would be the worst option.

Figure 1 – Agro-Ecological Zones – after Domroes

Figure 2 – Topography of Sri Lanka

Figure 3 - Mountain profile through Galle-Sita Eliya-Batticaloa

Figure 4 – Vertical Velocity Variation with height at different distances from the crest

Figure 5 – Rainfall estimate based on these velocity profiles

Figure 6 – Actual July Rainfall

- A - 1904 mm isohyer of the mean annual rainfall.
- B - 508 mm isohyer of the mean south west monsoonal rainfall.
- C - Boundary line of the effective dry period.
- D - Area with less than 1270 mm annual rainfall.

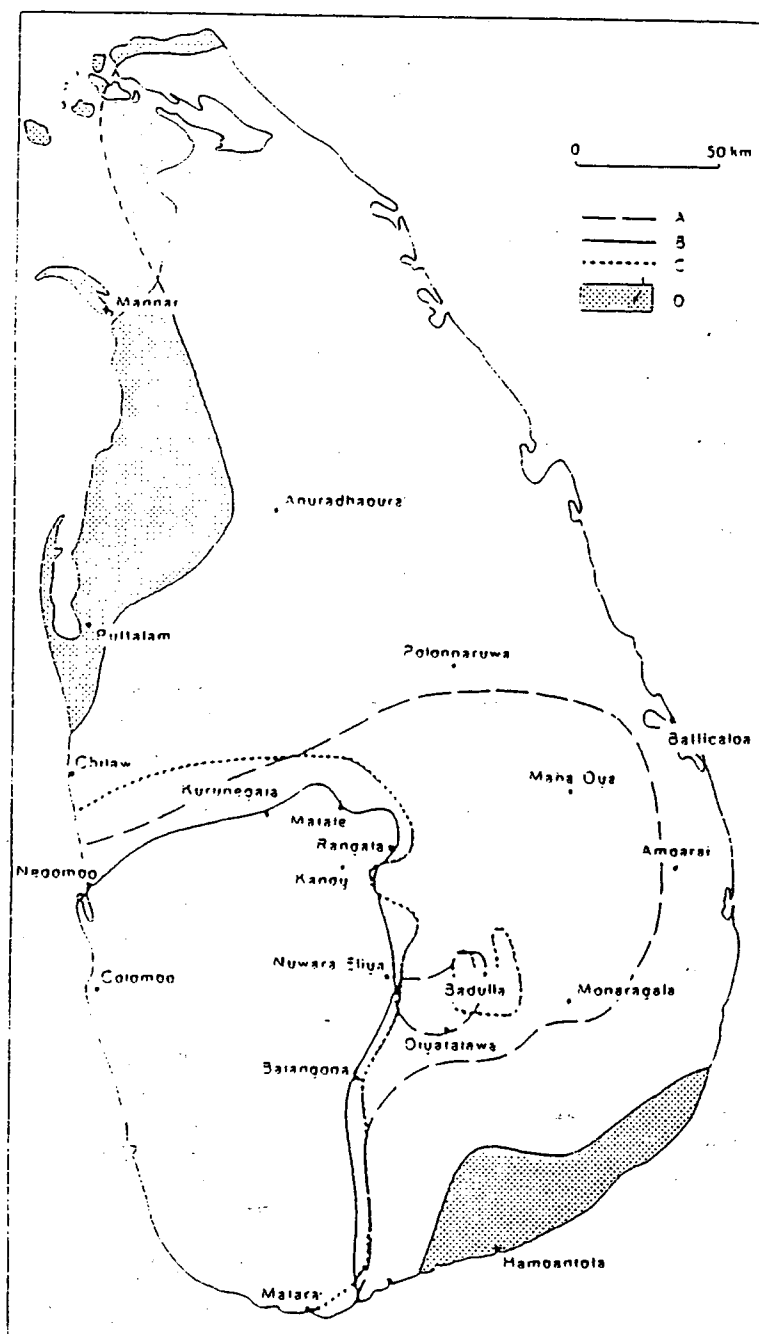


Figure 1: Agro-Ecological Zones - after Domroes

Altitudinal Map

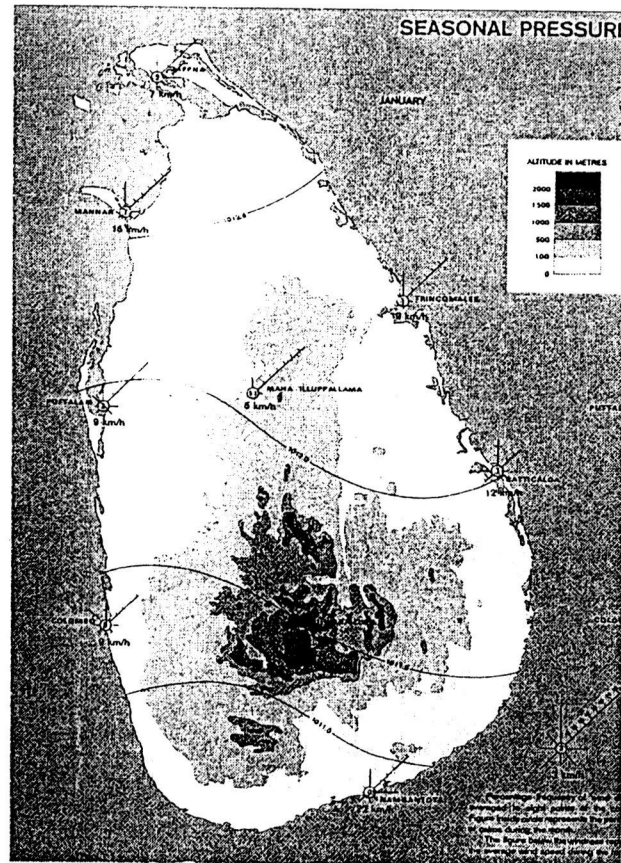


Figure 2: Topography in our Hills - after Wicramagama

Orographic Rain

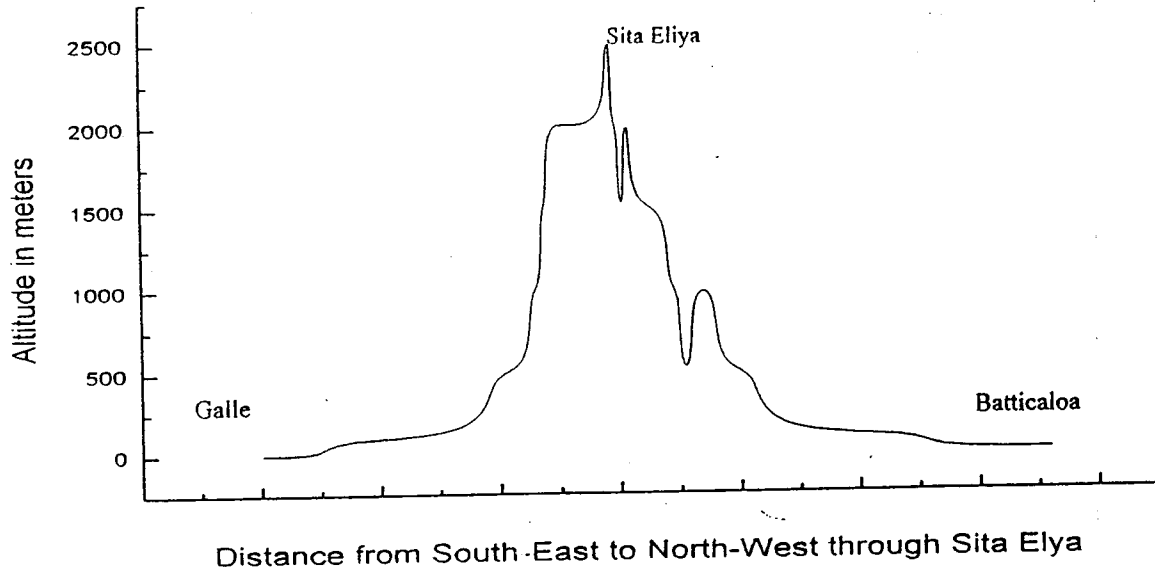


Figure 3: Mountain profile through Galle Sita Eliya Batticaloa

Vertical Velocity Variation

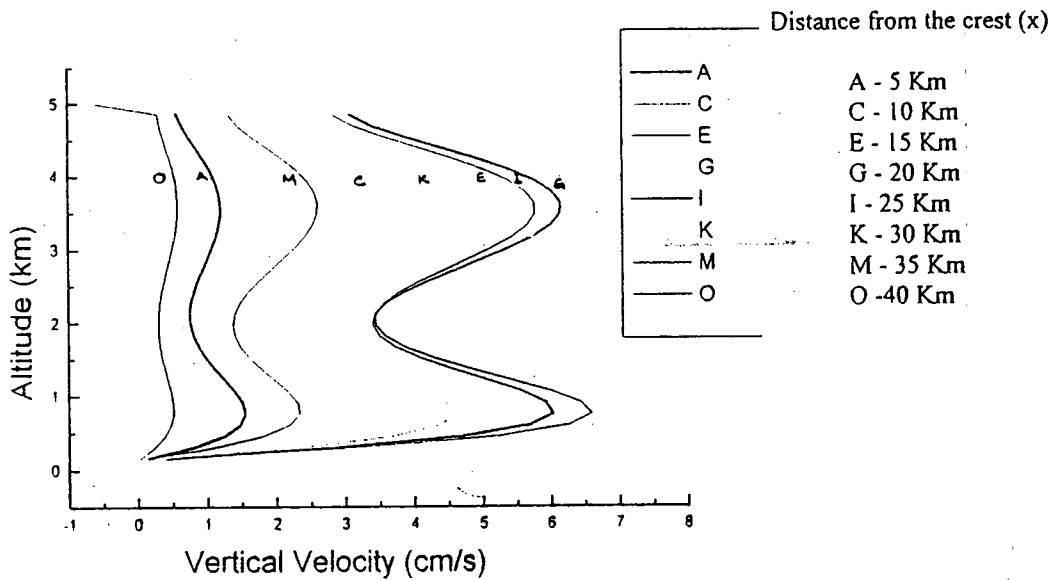


Figure 4: Vertical velocity variation with height at different distances from the crest. Distance from crest where velocity profile is taken is shown in the figure in Km.

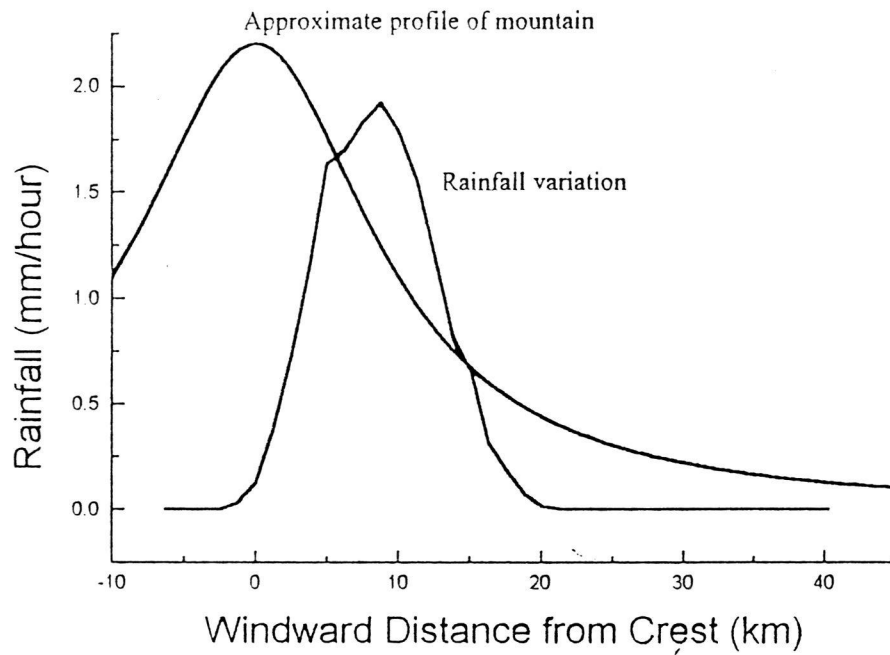


Figure 5: Rainfall estimate based on these velocity profiles

Rainfall in July

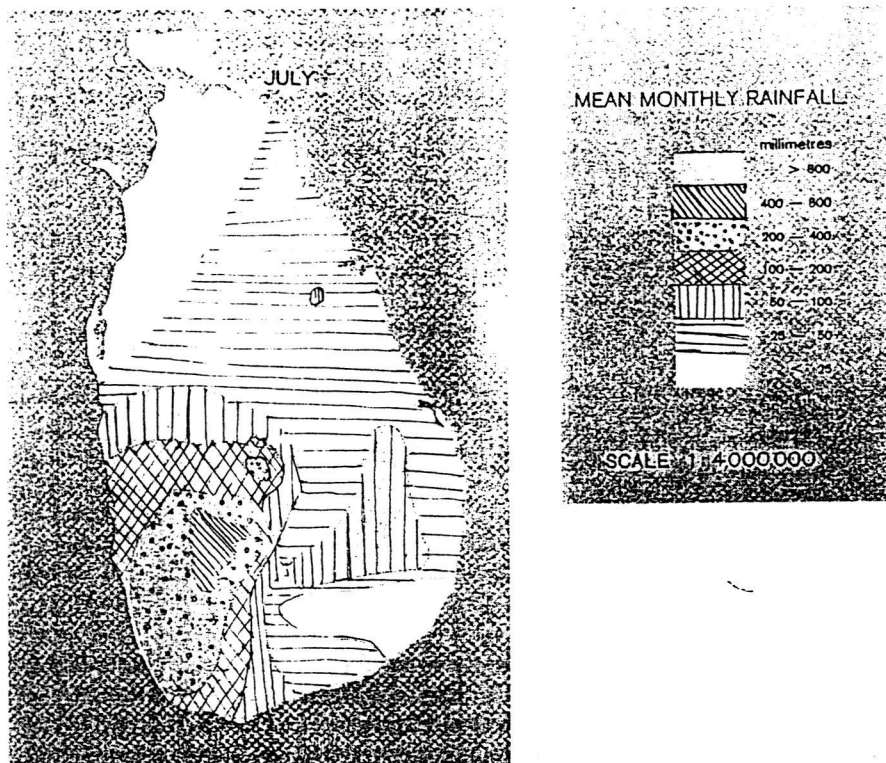


Figure 6: Actual July rainfall.