DRYNESS INDEX STUDY IN HIGH MOUNTAIN CATCHMENT AT LANGTANG VALLEY, NEPAL HIMALAYA

A DISSERTATION SUBMITTED FOR THE PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE MASTER'S DEGREE OF SCIENCE IN HYDROLOGY AND METEOROLOGY.

BY

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February, 2008

Letter of Recommendation

This is to certify that **Mr. Rajan Babu Kafle** has completed his dissertation work entitled "**Dryness Index Study in high Mountain Catchment at Langtang Valley, Nepal Himalaya.**" as a partial fulfillment of Master's of Science Degree in Meteorology and Hydrology under my guidance and supervision.

This study contains useful result for recent Meteorological and Hydrological research aspects. To my knowledge this work has not been submitted for any other Degree. Therefore, I recommend this Thesis for final approval and acceptance for the partial fulfillment of the requirements for the Degree of Masters of Science in Hydrology and Meteorology under Tribhuvan University.

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Letter of Approval

On the recommendation of Mr Tek Bahadur Chhetri, Asst. Professor, this dissertation work of **Mr. Rajan Babu Kafle** entitled "**Dryness Index study in high Mountain Catchment at Langtang Valley, Nepal Himalaya.**" has been approved for the examination and is submitted to the Tribhuvan University in partial fulfillment of the requirements for MSc. Degree in Meteorology and Hydrology.

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Certificate of Acceptance

The dissertation paper submitted by **Mr. Rajan Babu Kafle** entitled "**Dryness Index Study in High mountain Catchment at Langtang Valley.**" towards partial fulfillment of Degree of Master of Science in Meteorology and Hydrology is hereby accepted. It is based on the original research under the guidance of Mr. Tek Bahadur Chhetri. The Thesis in part or full is the property of the **Central Department of Hydrology and Meteorology (TU),** and therefore should not be used for the purpose of awarding same academic degree in other institution under TU.

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Acknowledgements

I would like to express my sincere gratitude to my supervisor, asst. Professor Mr. Tek Bahadur Chhetri for his expert guidance and Supervision that led me to the accomplishment of this research work. He has been a source of inspiration and guiding spirit throughout this work.

I want to express my heartfelt gratitude and feeling of indebtness to my respected superior, Mr. Chhetri for his valuable guidance and supervision during my work in different situation for collecting data etc.

I am highly grateful to Professor Khadga Bahadur Thapa, Head of the Department, Central Department of Hydrology and Meteorology TU for his kind help and valuable suggestions.

Similarly, I'm grateful to all other Professor, Associate Professor, Assistance Professors and all the Staff members of the same Department who have greatly contributed to this outcome

In addition, I want to express my deepest Gratitude to my family and friends for their wholehearted support and encouragement into my task.

Abstract:

A simple test of SVAT Model and it's components is performed to find the dryness index of soil in a High Mountain Catchment, in Langtang Valley, Nepal Himalaya. The details description and application of SVAT model is found in MA *et. al*. 1999., and was carried out in Kamitani Basin (5km^2) which is source area of Yura River in the central Japan in 1993 to 1994 and proved that the SVAT model can be used to find the soil condition, the dryness index or wet index of a high mountain basins covered by snow and natural vegetative cover under Humid Climate.

Although the geographical position of Langtang Valley is different comparing to Kamitani Basin, but considering other components (high mountain location, snow cover area in winter, Hydrometeorological conditions, monsoon Climate (Rainy summer season) nearly same, I carry out this study to calculate the radiative dryness index using simple formula described as in the SVAT model and its component part to find out the soil index of Langtang Valley by using available Meteoeological (Precipiatation P and Net radiation Q_N) Data of 1996. Because of the importance of dryness index to the soil parametric information and for the crop production rate over the High Mountain Basins or Valleys of Nepalese Himalaya, the part of equation of the SVAT model is used and compared with our investigated results and found similarities in quantitative values. Therefore, it is applicable in High Mountain Basins in Nepal Himalaya, in order to find out soil dryness index under Monsoon Climatic Condition.

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1.GENERAL INTRODUCTION

1.1 Physiobackground of Nepal

Nepal is a landlocked country, which lies between China to the North and India to the South, East and West. It is roughly rectangular in shape having mean width of 193 km of North to South and length from East to West is 885 km and the total area is 147,181 sq km. It lies between 26^0 22’ N to 30^0 27’ N. latitude and 80^0 4’ E to 88^0 12’ E longitude. Eight of the ten highest mountains in the world are located in Nepal, which includes Mount Everest (8,848 m), Kanchenjunga (8,481 m) Dhaulagiri (8,172 m) and Annapurna (8,091 m).

The country has a very great variety of topographical features where altitudes vary from 60 m in the Terai Plane to over 8,848 m on the top of highest Peak Mount Everest. The country experiences tropical, mesothermal, microthermal, taiga and tundra types of climate. The existing topographical features altitude wise climate variation to the north is the main reasons for the diversity of lifves, property and economy of Nepal, Kaystha D. ‘*MSc Thesis’* 2006.

The land area of Nepal is divided into five major physiographic regions- Terai, Siwaliks, Middle Mountains, High Mountains and High Himalaya. Distributions of the land area by physiographic regions are given below.

Physiogra Regions	High Himalaya	High Mounta	Middle Mountai	Siwalik	Terai	Total
Area in ‘000 ha	3349.2 (22.7%)	2959.3 (20.1%)	4443.6 (30.1%)	1885.7 (12.8%)	2110.4 (14.3%	14748.2 (100%)

Table 1. Sourse: CBS (2004); MSc Thesis, Dinkar Kayastha

Looking above, table 1. the mountain region includes the about 85 % in Nepal out of which about 45 % is covered by High Himalayas Mountains, containing many small and big catchments within this percentage area. The plain land occupies only 15%, which is comparable for mountain region.

1.2 Meteorology and Hydrology of Nepal

Because of existing uneven topographical features, geological position and altitude wise distribution of natural resource in our country the hydrological, meteorological and micro-meteorological studies are very important from the point of view of agriculture production, biodiversity conservation, water resource, land surface features and vegetative covers and soil conditions and many more. Hydro-meteorological studies are not important only from these points of view but it also plays role for the keeping balance of hydro-meteorological cycle in the atmosphere, which is very necessary to us for our economy and over all development of the nation.

Excluding the geological studies of the planet-earth structure, we can study all other its parts and its component from the detail studies of Hydrology and Meteorology which include simply the gaseous atmosphere, water Hydrosphere in liquid form or Cryosphere while frozen ice in and on the surface covered by the atmosphere, Nakawo *et al*., 1999.

Scientist have predicted that there will be a rise in temperature of about 1.4 to 5.8^0 C (Kayastha D. 'MSc Thesis', 2006) and this temperature rise will continue further which is expected to melt polar ice sheets and glaciers including Himalayan snow/glaciers located particularly in the high mountain catchments in Nepal.

The global warming of the planet is affecting to the every nations directly, partly or indirectly to their life forms in the Biosphere. Melting of ice and snow is challenging to all by increasing oceanic surface, flooding agricultural land and forest, (Chhetri, T.B.,2005). It is modifying many natural atmospheric cycles within the blanket of gases, which is known as atmosphere. Atmosphere, which is mobile, compressible and expansible is now changing its regular phenomena place to place. It is transparent to many form of radiation can reflect or divert some and can absorb parts so that it keeps safe the living world.

It acts as a great canopy to protect the earth's surface from the full range of solar effects by day and prevent excessive loss of heat by night. It protects earth from cosmic radiation and meteorites. Without the atmosphere life would be impossible, there would be no clouds, winds or storms. If not the weather would have been great extremes of temperature between day and night. The atmosphere is rarely at rest and transfers heat, water and others from point to point.

Atmospheric motions are characterized by a variety of scales ranging from the order of a millimeter to as large as City size. These scales of motion are classified into three broad categories, the motion as large as a continent as macroscale, the size of a few thunderstorms as mesoscale and those smaller than a city as microscale. The branch of meteorology, which deals with the microscale motion at the lowest part of the atmosphere, is the Micrometeorology. Its scope can't be rejected when we make studies related to Meteorological phenomena over the earth (Chhetri, T.B., 2004).

Nepal has a lot of High Mountain Catchments containing natural vegetation, agricultural land and snow cover areas in the high Himalaya region. The most available Natural Resource of our country is the land, forest, water and atmosphere. The water is found in the form of rivers, snow and glaciers, lakes and underground water in these high mountain catchments. These show importance of studies related to Hydrology in Nepal. Hydrology deals with the all form of water such as river, snow/glaciers including underground water (Chhetri, 2002 and Rana, *et.al*., 1997).

Different changes are taking place in those catchments over the high mountain regions of Nepal. Global warming is the most important for the climate change of the world. Scientists from their investigations have shown for possibility of further rising trend of warming globally. According to the previous studies, the temperature rise is showing high rate of melt of snow-ice and glaciers in Nepal. All of these affect the climate, life and property/economy of a particular place (Moon, R.E., 1966).

Investigations of meteorological parameters are found changing from the beginning to the end of Monsoon season in Nepal year to year (Chhetri, T.B., MS Thesis', 2000). From all those studies, it is obtained that unchangeable fact is, Nepal is chiefly dominated by the monsoon system in South Asian region.

1.3 Introduction of Study

Nepal has a lot of High mountain-Catchments containing natural vegetation, agricultural land and snow cover areas in the high Himalaya region. The most available Natural Resource of our country are the land, forest, water and atmosphere. The water is found in the form of rivers, snow and glaciers, lakes and underground water in these high mountain catchments (Ohno *et.al*, 1998).

Different changes are taking place in those catchments over the high mountain regions of Nepal. Raising temperature is the most important climatic factor for the climate change of the world. Scientists have shown investigation for further rising trend of warming. According to the previous studies, the temperature rise is showing high melt of snow-ice and glaciers in Nepal. All of these affect the weather/climate, life and property of a particular place (Takeuchi *et al*, 2000).

Many studies related to Hydrology and Meteorology were carried out before in Langtang Valley, Nepal Himalaya since about 1970. Most of those studies are discharge calculation, Glacier melting (Chhetri,T.B.2000, 'MS Thesis'), hydrometeorology and climatology. Therefore, the main purpose of my work is to estimate and study the radiative Dryness Index at high Mountain Catchments in Himalaya Region of Nepal, which is very important for us to know the use of land for cultivation, agriculture, forest and vegetation coverage. The study of conservation of the natural resource and distribution of our vegetative cover for the future is also essential for developing programs and plans.

Ma *et al*. 1998, proposed a simple Soil-Vegetation-Atmosphere transfer (SVAT) model to present the land surface heat flux in one dimension. In the SVAT model, the land surface is described by a big-leaf and a soil layer with 6 m deep. The radiative Dryness Index and minimum resistance which are the parts of the SVAT model are calculated for our purpose. The discussion of components of SVAT model are also important in this study, it is because to know the soil condition with respect vegetative-climatic point of view, particularly at Langtang Valley in high mountain regions in the Nepal Himalaya. To study its seasonal change and different characteristic features of meteorological parameters are also part of this study mainly in the Monsoon season.

1.4 Study Area:

The Langtang Catchment

Langtang Basin in Langtang Himalaya, which is the high mountain catchment is selected to carry out the all objectives for my study, because of data availability. Langtang Valley lies in the north of Rasuwa district of Nepal just 60 km. directly northward from Kathmandu Valley. The specific location of the spot is 28^0 13’ N latitude and 85^0 34’ E longitudes, where all the meteorological data were recorded (Fujita, *et.al*., 1997). The exact altitude of this study area is 3880 m (Fujita, *et.al*., 1998) above the sea level covering with snow and glacial area to the north and east above the station site in this Himalayan Catchment.

It is situated at an average altitude about 4000 m above sea level where as the lower part stands down as the valley with having cultivable land and bush type of Tundra Vegetative cover (mixed type of forest) to the south of the basin. The Langtang river flows through the narrow passage of the valley having its outlet at Syabrubesi in the west side of the basin (Chhetri T.B. MS Thesis’ 2000) .

Langtang Valley is one of those high mountainous basin where many research investigation with respect to Hydrology and meteorology have been done representing almost all such Basins in the Himalaya region of the country (Higuchi, *et*. *al*. 1984). The location of the study area and its land coverage features can be seen in the figure (1.).

The Langtang Basin in Rasuwa with Langtang Valley, Nepal Himalaya

Figure 1. Map of Nepal showing study area with different land features in it.

1.5 Data source

Different meteorological data were recorded out by the scientists involved from Japan and Nepal as the Glaciological Expedition Nepal-1996, group of members for the period from 7th May to 25th in October 1996. The data were recorded by using automatic instruments as well as manually in the interval of 1 hour. The station was established at Kyanjin Base House at altitude 3820 m (Fujita *et al*.1998) from the sea level.

Meteorological data such as net radiation (Q_N), surface temperature (T_s), air temperature (Ta), Relative Humidity (RH) wind speed data (U), precipitation data (P) including observed data of evaporation were recorded. Axcept Net Radiation and Precipitation all the above meteorological data were recorded at two different heights of the atmosphere, which is explained in detail in (Fujita *et al*.1996)

The specific location (Kyangjin) of the meteorological data recording station is shown in Fig 1.1. The detailed description and analysis of meteorological data is given by (Fujita *et al*.1996).

2. SURFACE METEOROLOGY

2.1 Concept of land surfaces

The simple definition of land surface is stated as the surface of earth, but it is not sufficient to understand its structures and types to explain in detail.

Form the hydro-meteorological point of view, it can be said as the surface where the hydrometeors first touches the surface on its falling from the atmosphere. Form the Micro-meteorological point of view it can be said as the surface is that where the friction velocity of the wind in lower atmosphere tends to be zero, Liston *et al* (1995). Similarly, farmers can tell easily, surface is that where we grow different types of crops in it.

Again a Meteorologist will define the surface in terms of the principle of conservation of energy, and will be stated as the place where the sum of all energy terms coming to it is equal to sum of energy outgoing from that. In other words the sum of all the components of energy will be the same over a surface. Actually, the energy balance is used to determine the thermal state (phase change) of an object or substance (air, water) at the surface at different conditions. Therefore, energy-balance study is very important for such studies in meteorology, micrometeorology, climates and glaciers.

The temperature of he substances which are found at the surfaces plays the vital role for interaction and exchange process of the energy from substances to substance or surface to surface. The flow of air and water are the active means of transportation of the heat and mass from the point to the point of different surface depending on their temperature in them, Schmugge (1991).

Actually, there are different types surfaces in the nature. They are land surface, water surface, snow surface, ice surface etc. Each surface has its own characteristic features for transformation of energy and mass to different points of land to atmosphere about which we deal in hydro-meteorology.

2.2 Introduction of Net radiation Q_N and Precipitation P

The principle of conservation of heat is stated, as the sum of all terms of heat coming to a surface is equal to the sum of heat outgoing from that surface regarding to the hydro-meteorological research point of view. In other words heat flows from higher- temperature body to lower temperature body i.e. heat flux from the hotter matters to cooler objects. For a natural surface, heat balance equation states that the sum of all components of heat fluxes to a surface is zero, Kayastha *et al* (1999). In general heat fluxes towards the earth surface is assumed positive and loss of the heat fluxes from that surface is assumed to be as negative.

An approximate annual heat budget of the Eart-Atmosphere system is explained here to understand the exchanging process of heat between surface and atmosphere, Critchfield (2002). The average solar flux for a entire is presented as 100 Units. We know that the solar constant value is 1365 W/m^2 and on the top of the atmosphere it is only 341 W/m^2. Out of this 100 units incoming solar flux 26 % are absorbed by the atmosphere (22% by cloud free air and 4% by cloud). Next 30% part are reflected back to space (7% from cloudless atmosphere, 17% from cloudy atmosphere and 6% from the earth's surface). The remaining 44% are absorbed by the earth's surface. This amount of energy is used for different purposes at the surfaces of earth. Part of it is radiated as the long wave radiation from the earth, part of it is used for life activities (animals+ Plants) and part of it is used to melt snow/ice and for other different purposes at the earth surface, Paterson WSB (1994). In this all activities, in general the sum of energy fluxes incoming at the earth's surface and outgoing from it should be equal and but recent researches shows a warming trend globally which is dangerous to all, Nakawo & Rana, (1999).

Similarly in terms of mass balance, the surface can be defined as, from the principle of conservation of mass it is stated, as the sum of all masses of the substances coming to a surface is equal to the sum of masses outgoing from that. This is also called continuity of mass at a surface.

2.2.1 Net radiation (Q_N)

Actually, all wave net radiation Q_N on land surface can be defined by the sum of the net differences of the short wave and long wave radiation incoming and outgoing by using the relation given below (Ageta, *et al* 1984; Chhetri, T. B. 'MSc-thesis', 1993).

The Net radiation Q_N can be calculated as,

$$Q_N = (K_i - K_o) + (L_i - L_o) \qquad \ldots\ldots\ldots\ldots\ldots\ldots(2.1)$$

Where, K_i and K_o is incoming and out going short wave radiation, L_i is incoming and L_o is the out going long wave radiation from the surface.

$$(L_i - L_o) = \varepsilon\sigma\,(Ta^4 - Ts^4) \quad \text{and} \quad (K_i - K_o) = (1-\alpha)\, Q_o\, (1-0.52C)$$

Where, Ta and Ts = air temperature and surface temperature whereas ε is the surface emissivity, with a value of 0.96 to 0.98, and σ is the Boltzmann constant ($5.78 * 10^{-8}$). The parameter α is the albedo of the surface. C is the fraction of cloud varying from (0-1). The Value of Global solar radiation Q_o in clear sky condition, Zillman (1972), is given as

$$Q_o = S\, Cos^2Z / \{(CosZ + 2.7)\, e \times 10^{-3} + 1.085\, CosZ + 0.10\}$$

This equation was experimentally found by Zillman, (1972) and used in modeling in worldwide. In 1984, Shine modified the same formula and he introduced new coefficient in the same equation.

$$Q_o = S\, Cos^2Z / \{(CosZ + 1.0)\, e \times 10^{-3} + 1.2\, CosZ + 0.\, 0455\}$$

Where, S is the solar constant $1365W/m^2$,Ohno and Nakawo, (1998) Z is the solar zenith angle and *e* is vapor pressure (mb) at the surface. The zenith angle is determined by geometric formula as given here,

$$\text{Cos } Z = \text{Sin}\Phi \text{ Sin}\delta + \text{Cos}\Phi \text{ Cos}\delta \text{ Cos } H$$

In which Φ is latitude, δ is the declination angle and it can be estimated from relation

$\delta = 23.44^o \text{ Cos } \delta \, [(172\text{-}J)\pi/180]$; J is Julian day and the Hour angle H is estimated using 15(12-h) where, h is the local solar time. The above equation involves the atmospheric optical air mass effect and that of astronomical attenuation factor due to zenith angle variation with respect to position and time of the day and year. In practice a cloudiness factor, (Parkinson and Washington, 1979) used $1\text{-}0.6\ C^3$ and Bennett (1982) used 1-0.52C for their Arctic sea-ice modelling studies. We can estimate the value of incoming solar radiation (K_i) for the clear sky condition by the following Empirical relations directly, derived by the different scientists as listed below, source: LecturesNotes,Chhetri T.B.

a) Kuzmin (1961): $K_i = (0.62 + 0.05\sqrt{e})\ \sigma\ T_a^4$

b) Efimova (1961): $K_i = (0.746 + 0.0066e)\ \sigma\ T_a^4$

c) Swinbank (1963): $K_i = (9.2 \times 10^{-6} \times T_a^2)\ \sigma\ T_a^4$

d) Idso and Jackson (1969): $K_i = \{1 + 0.261\exp\ (-7.77\times 10^{-4}\ (273\text{-}\ T_a)^2\}\sigma\ T_a^4$

e) Maykut and Church (1973): $K_i = 0.7855\sigma\ T_a^4$

f) Brustaert (11975): $K_i = (1.24\ (e/\ Ta)^{1/7})\ \sigma\ T_a^4$

g) Satterlund (1979): $K_i = 1.08\ (1\text{-}\exp\ (\text{-}e^{\ Ta/2016})\ \sigma\ T_a^4$

h) Ohmura (1981): $K_i = (8..733 \times 10^{-3} \times T_a^{0.788})\ \sigma\ T_a^4$

i) Idso (1981): $K_i = (0\ .70+5.95\times 10^{-5} \times e^{\ 1500/Ta})\ \sigma\ T_a^4$

j) Andreas and Ackley (1982): $K_i = (0.601+5.95\times e^{\ Ta/2016})\ \sigma\ T_a^4$

k) Prata (1996): $K_i = (1\text{-}(1+\eta)\ \exp\{-(1.2+3.0\ \eta\ )^{0.5}\})\sigma\ T_a^4$ where $\eta=46.5(e/\ T_a)$

l) Guest (1997): $K_i = \sigma\ T_a^4 - 85.6$

in which σ is the Boltzmann constant and T_a the air temperature (k). *e* is the vapour pressure (mb) in the surface layer. We can also directly measure the values of Q_N by using Net Radiometer, Flux meter and py-rhanometer etc, Arya, SPS, (1988).

If we have data of other components of energy balance on the land surface such as Ground heat flux (Q_G), Sensible Heat Flux (Q_H), Latent Heat Flux (Q_L) and Precipitation Heat Flux (Q_P) then from Energy balance equation the net radiation according to remaining method,
we can determine the value of all wave net radiation

$$(Q_N) = -(Q_H + Q_L + Q_G + Q_P)$$

There are essentially four types of energy fluxes at an ideal surface and when we assume the surface to be a very thin interface the principle of the conservation of energy at the surface on a normal day can be expressed as: Arya, SPS, (1988) and Chhetri TB (2006).

$$Q_N = Q_H + Q_L + Q_G$$

Where,

Q_N = Net all wave radiation

Q_S = Turbulent transfer of Sensible Heat

Q_L= Contribution of Latent Heat of Evaporation and Evapotranspiration

Q_G = Transfer of heat into or out of the sub medium (soil or water)

Q_P = Heat Flux due to Precipitation

The equations of all components of heat balance over the land surface are not mentioned here, which are not necessary for this study.

2.2.2 Precipitation (P)

The precipitation term denotes all forms of water that reach the earth from the atmosphere. The usual forms are rainfall, snowfall, hail frost and dew of all these. Rainfall being the predominant form of precipitation causing stream flow, especially the flood flow in a majority of rivers in Nepal. The magnitude of precipitation varies with time and space. Differences in the magnitude of rainfall in various parts of Nepal at a given time and variations of rainfall at a place in various seasons of the year are found. The study of precipitation forms a major portion of the subject of Hydrometeorology.

The precipitation to form the atmosphere must have moisture, these must be sufficient nuclei present to aid condensation. The weather conditions must be good for condensation of water vapor. The product of condensation must reach the earth under proper weather conditions. The water vapor condenses over nuclei to form tiny water droplets of sizes lesser than 0.1 mm in diameter. The nuclei are usually salt particles or products of combustion and are normally available in plenty. Wind speed facilities the movement of clouds while its turbulence retains the water droplets in suspension. Precipitation results when water droplets come together and coalesce to form layer drops that can drop down. A considerable part of this precipitation gets evaporated back to the atmosphere. The net precipitation of a place and its form depend upon number of meteorological factors, such as the weather elements like wind, temperature humidity and pressure in the volume region enclosing the clouds and the ground surface at a given place.

During summer months, tropical cyclones originate in the open ocean at around 5-10^{o} Latitudes and move at speeds of about 10-30 Kmph to higher latitudes in a irregular path. They derive their energy the form of latent heat of condensation of ocean vapour and increase in size as they move on oceans. When they are on land the source of energy is cutoff and the cyclone dissipets its energy very fast. Tropical cyclones gives moderate to excessive precipitation over very large areas, of the order of 10^3 km^2, for several days. Tropical cyclone cause heavy damage to life and property on their land path and intense rainfall and heavy floods in streams are its usual consequences, Yamada et al (1992). Climate of our region can be considered to have two major seasons and two transition periods as.

South-west- monsoon (June-Sept)

Transition Period 1, Post-Monsoon (Oct-Nov)

Winter Season (Dec- Feb)

Transition Period 2,Summer (March- May)

The investigation and estimation of precipitation heat flux is difficult work and sensitive because the measurement of temperature of raindrops or snow crystals is very difficult during precipitation. The temperature of precipitation is considered as the same value of temperature of air during the precipitation.

The precipitation heat flux Q_P for liquid phase can be determine using relation (Ohno and Nakawo, 1998) by

$$Q_P = c_w P_P T_P$$

where, c_w is the specific heat of water at 0^oC (4.22×10^3 $Jkg^{-1}K^{-1}$, P_P is the precipitation intensity in kg/m^2s and T_P is the temperature of precipitation. The precipitation flux is found of very low values so its contribution to the heat budget Equation is generally can be neglected. Because of precipitation being a very important parameter, therefore to achieve our goal, for the determining the conditions of the soil at the land surface and precipitation heat flux is explained to understand the theoretical approach only.

2.3 Importance of vegetative resources

From the point of view of meteorology, in the recent days, farm-land, forest or any type of vegetative cover on the land surface are known as active meteorological regions. The vegetative coverage of the land surface plays a vital role to exchange the energy flux as well as mass flux to the atmosphere from the surface and toward the surface. The canopy is not considered the barrier to transformation of water vapour and heat Arya SPS (1988). Although the quantities may differ because of their dependency upon many features of the land such as slops, structure of the soil etc. In short, the vegetative coverage land surface contains strong sources of sinks of heat and moisture, which might differ in amount place to place.

Over the region containing vegetation all the meteorological parameters are seen in balanced through a long time period. This is very important to know before urbanization and developing of an area. Large Valleys and basins have been studied from the point of view healthy life of the people, and found that there is an economic importance of such land containing vegetative resources, Sharma CK (1976).

From the following facts the importance of vegetative resources can be understood easily.

1. The evaporation and transpiration that is evapo-transpiration is being one of the important parts of the Hydrological cycle, and hence, we can take it into account for importance of vegetative resource.
2. The energy that drives the meteorological mass from point to point on the land and in the atmosphere.

Evaporation is a process in which a liquid changes to the gaseous state at the free surface. Transpiration is the process by which water leaves the body of a living plant and reaches the atmosphere as water vapor. The water is taken up by the plant-root system (Vegetative source) and escapes through the leaves. The component evapotranspiration deals with the characteristics of the movement of water mass and energy from the plants cover at the earth surface. Thus for a given set of atmospheric conditions, evapotranspiration depends upon the availability of water in the surface of earth or in vegetative resource, Chhetri TB (2000).

3. LITERATURE REVIEWS

3.1 Research-developments in high mountain areas in Nepal.

Nepal is a mountaneous country, where mountains and hills occupy more than 80% of the area. The mountains are vulnerable to various aspects such as hazards associated with landslides and river erosion due to fragile geological condition at great elevation having different slope and terrain form of land. About 3 % of the area above 5000 meters above sea level is mostly covered by snow and ice throughout the year forming the glaciers and glacier-lakes. These parts of the country have very low temperature and very high wind speed prevails over the whole year therefore it is really very difficult to observe and record the Hydro-meteorological data for the research developments in Nepal, Chhetri TB (2000).

Pre history of the research in high Himalaya can be seen in the trans Himalaya section in the regions of Machhapuchhre-Annapurna, Langtang region, Khumbu region and in eastern Sorong Himalaya region. Studies related to Hydrology and Meteorology were carried out in Langtang Valley, Nepal Himalaya since about 1970, Higuchi *et al* (1982). Most of those studies are analysis of discharge estimation, Glacier melting and glacier climatic condition. Recently Studies are going on to continue in those region such as in Khumbu, Kshorolpa glacier Lake and Langtang Valley even today. Different scientists, organizations and scientific Committee from Nepal, Japan and other different SAARC countries are involving in investigations and research developments concerning to the high Himalayan region of the country, Chhetri TB (2004).

3.2 Hydrometeorological Researches in Langtang Valley

In the past, many scientist and researchers from different organizations of Nepal and foreign countries have carried out different studies about glacier melting, hydrological related measurements and glacio-climatic conditions in Langtang region, in Nepal Himalaya since last 30 years, Yamada 1998 and Wecs 1987. Most of those studies are concerned with the estimation of discharge and snow/glacier melting. Basically, any kind of researches and investigation with respect to snow and glacier melt over the high mountain region is difficult because of the snow fed rivers originating from the glaciers or glaciers lakes in the high Himalaya areas in Nepal.

Eventhough, there are many studies done by the various scientists in the past, from the agriculture point of view considering vegetative coverage of the Langtang Basin there is no any such detail studies found, therefore, the main purpose of my attempt is to study about the Dryness Index Study in high Mountain Catchments in Himalaya Region of Nepal**,** which is very important for us to know the use of land for cultivation, conservation of the natural resource and reservation of our vegetative cover for the future. The minor part of this study is to know the application of the component part of SVAT model to determine simply the soil condition particularly at high mountain Catchments in the Himalayan region considering the Monsoon season as humid condition in Nepal.

4. OBJECTIVES AND SCOPE OF THE STUDY

4.1 General Objectives

The main purpose or objective of this study is to know the condition of the soil with respect to meteorological parameters the Net radiation and Precipitation. That is water mass fluxes present in the soil to categorize the dry/wet condition of the prevailing soil in the land surface. Dryness Index of the soil separates the region of having either wet soil condition or dry soil condition with respect to the cultivation point of view and can be found by only using the Net radiation and Precipitation data. Kamitami *et al* (1998).

Actually, the overall objective of this work is to investigate the resolution of dry and wet condition of soil on a particular year, that means it separates the region for the vegetative cover and production rate forecasting, in terms of dryness Index and minimum surface resistance in Langtang Valley in Monsoon season. Another objective of this study is to investigate the seasonal variation of the Net radiation and precipitation. It is supposed that the effect of these components to the crop rate production and vegetative cover must be high.

Contribution of radiative dryness index is also supposed to be important for the mass balance process or energy balance in Langtang valley of Nepal Himalaya. Except these, seasonal variations and characteristic features of different meteorological parameters in Langtang valley of Nepal Himalaya are investigated (Chhetri T.B.2004) to see the general trend in the monsoon season.

4.2 Specific Objectives

The specific objective of this study can be summarized as follows.

* To estimate total and average monthly net radiation.
* To estimate the range of minimum surface resistance for various vegetation.
* To study seasonal variation of net radiation and its characteristics features.
* To know the contribution of net radiation to other process.
* To know the distribution of vegetation in Langtang Basin.
* To know the application of simple SVAT in high basins in Nepal Himalaya.

4.3 Scope and Limitation

This thesis tries to find out the soil condition for distribution of vegetation using only two major meteorological parameters, which are discussed previously. Considering Langtang basin as the high mountain catchments in Nepal Himalaya and also considering this resembling as of same condition of Kamitami Basin in Japan, has been selected for my investigation work.

The observation, calculation and conclusion of this thesis can be utilized for further investigation on the similar basins in Nepal. As this thesis is based on actual daily and monthly average data which are being recorded by the professional team of Professors from Nepal and Japan as most reliable. This dissertation will try to clear the trend of meteorological parameters, Net radiation, Precipitation, Soil index components and other general features of the Langtang Catchment.

As almost everyone is saying about Global Warming and Glaciers retreat, it will try to find out practically with the data and to explain the cause and reason behind every results and conclusions, Kayastha D (2006). Is the net radiation (fluxes) increasing its effect at the surface on mountain basins? Does the impact of climate change is seen on the vegetative cover over the mountainous regions or not? These are example of some questions that should be answered through the different investigations.

This thesis has also certain limitations and among those some are outlined here as follows.

Major limitation is the failure of field visit and collection of recent data and year to year. The present context of our country is the main reason behind it along with the

-Lack of fund and sponsors for the field visit programs.

-Past data of 1996, might be its limitations and drawbacks

Eventhough, this work is of kind of first, being So, I hope that the outputs of this Dessertation will be appreciated by all because of its important obkectives as mentioned before. Certainly this types of Hydrometeorological study is difficult being the high altitude basin in the Himalayan range in Nepal.

5 PROCEDURE AND METHODOLOGY

To obtain the stated objectives of the study, the primary and secondary data and parametric values were collected from the various published and unpublished papers, documents, thesis, literatures, books, journal and electronic media with kind cooperation of my Supervisor and were investigated.

I have carried out necessary discussions with my colliques and concerned with the Internet facilities for collecting additional information to this study. The major primary data source is taken from Fujita *et* a*l*.1996. According to this paper, the data were recorded from 7th May to 25th October 1996.

The temperature and relative humidity the upper level height is fixed at the height 1.23m from the ground and the lower level height is fixed at 0.23m from the ground making the difference in height of 1m. Similarly for Wind Speed the upper level height is fixed at the height 1.44m from the ground and the lower level height is fixed at 0.47m from the ground making the difference in height of 0.97m. The air temperature at two levels is given in ^{0}C, relative humidity in percentage and wind speed in m/s. The station height is 3,880m from the mean sea level where the atmospheric pressure is found 621h.pa Chhetri TB (2000), the air density is estimated as 0.73kg/m^3. The specific heat capacity as 1005J/kg^{0}C, the Latent heat of fusion as 2.5 X 10^{6}J/kg and the von Korman constant as 0.41 are used in our equations.

As all the data are given in hourly basis, first of all the hourly data are converted to average daily data and then into monthly averages. Then by using stated equation the radiative dryness index of the soil for each months are estimated.

6 DESCRIPTION OF METEOROLOGICAL DATA AND THEIR VARIATION

6.1 Air Temperature

Daily averages of surface temperature T_s, air temperatures, at height 1.23 m (T_U) and 0.23 (T_L) m, are shown in Fig. 2 (c). The patterns of seasonal change of air and surface temperatures are same but only difference is found in their magnitudes. This shows increase of air temperature (T_a) at about 1.0m height is roughly proportional with the increasing surface temperature (T_s). The average surface temperature is found about 15.0 ^{o} C and at 1.0 m above the surface is about 8.5 ^{o} C during the period from 7 May to 25 October. The trend shows a greater deviation from May to July with a gradual increasing values, then a constant trend up to September, and eventually a decreasing trend in post-monsoon season in (October). The average daily minimum temperature lies above 5^{o}C, and remains positive throughout the summer. This fact was considered to conclude that there was neither frost nor any ice cover on the land surface permanently at Kyangjing Chhetri TB 'MS Thesis' (2000).

6.2 Wind Speed

Seasonal trends of daily average wind speeds at two heights 1.44 (U_U) and 0.47m (U_L) above the surface, are shown in Fig.2 (d) which show wind speeds vary from about 0.5 m/s to 3 m/s. The average value is found 1.5 m/s in the period from May to October. Wind speeds are found lower in rainy season from July to September and higher in pre-monsoon season.

6.3 Relative Humidity

The measured daily average values of relative humidity at two heights 1.23m (RH_U) and 0.23 m (RH_L) and daily precipitation are shown in Figs. 2 (a) and (b). Fig.2 (a) shows the seasonal variation of relative humidity in Langtang. This trend shows constant relative humidity more than 95 % from mid-June to September. Higher fluctuations of (RH) are seen in the beginning of rainy season before June and in October. Gradual increasing trend in pre-monsoon and decreasing in October is directly related due to the fact of monsoon onset and retreat, respectively, over this high mountain region in Nepal.

6.4 Precipitation

As shown in Fig.2 (b), daily precipitation shows 4.0 mm of average rainfall in the whole observation period from May to October with two maximum peak rainfall events in 13th August (42 mm) and 4 to 5th October (30 mm). These extraordinary precipitation events are considered being caused by monsoon due to cyclonic depression-systems, which form over the Bay of Bengal or Arabian Sea and shift northward (Takahasi *et al*., 1987). Heavy rainfall occurs when the trough positions are found to the south of foot Himal in Nepal in the monsoon season.

METEOROLOGICAL PARAMETRS

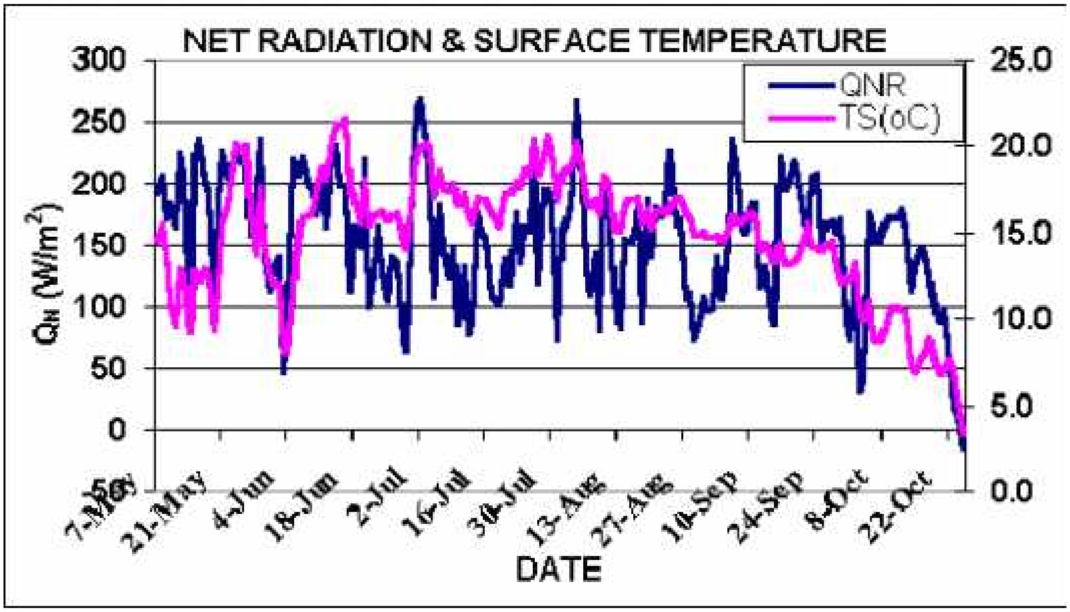


FIG. 2. THE SEASONAL VARIATION OF NET RADIATION AND SURFACE TEMPERATURE

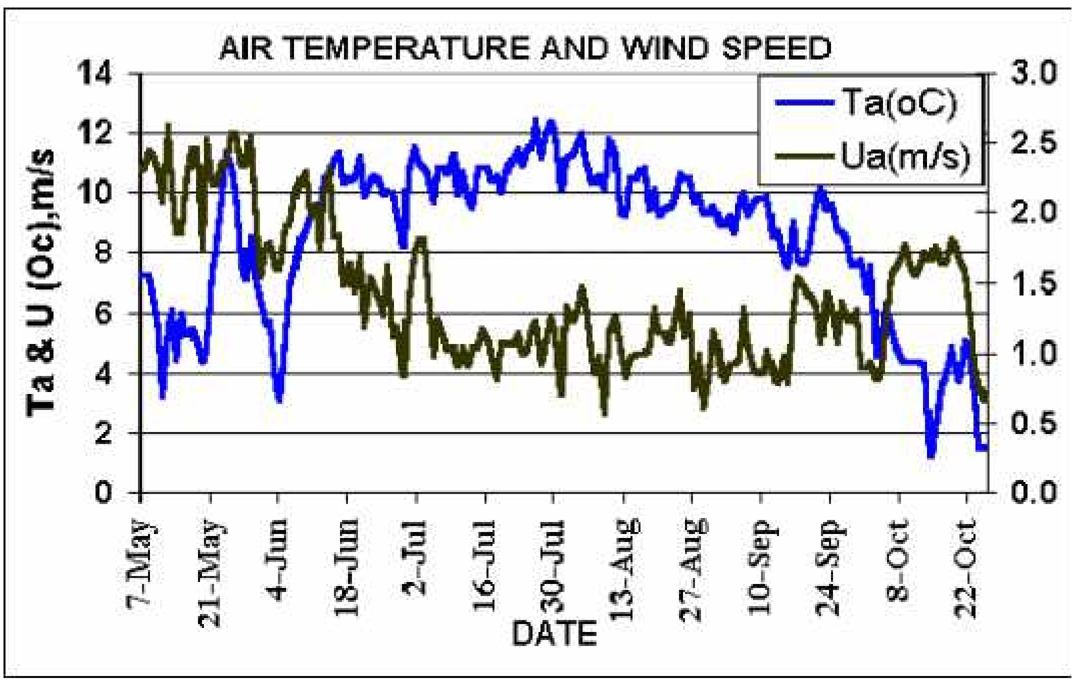


FIG. 3. THE SEASONAL VARIATION OF AIR TEMPERATURE AND WIND SPEED

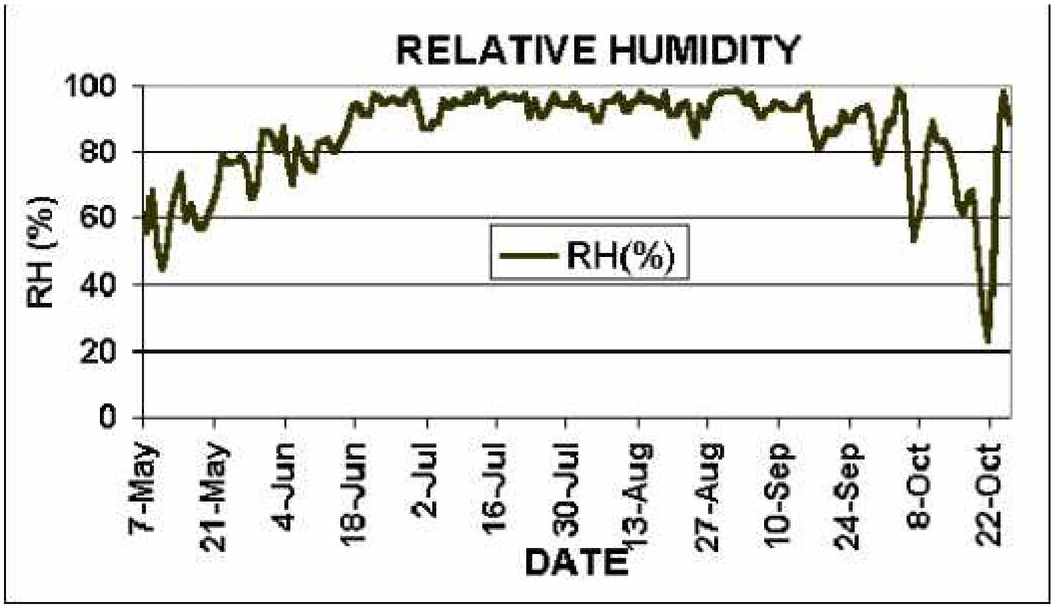


FIG. 4. THE SEASONAL VARIATION OF RELATIVE HUMIDITY

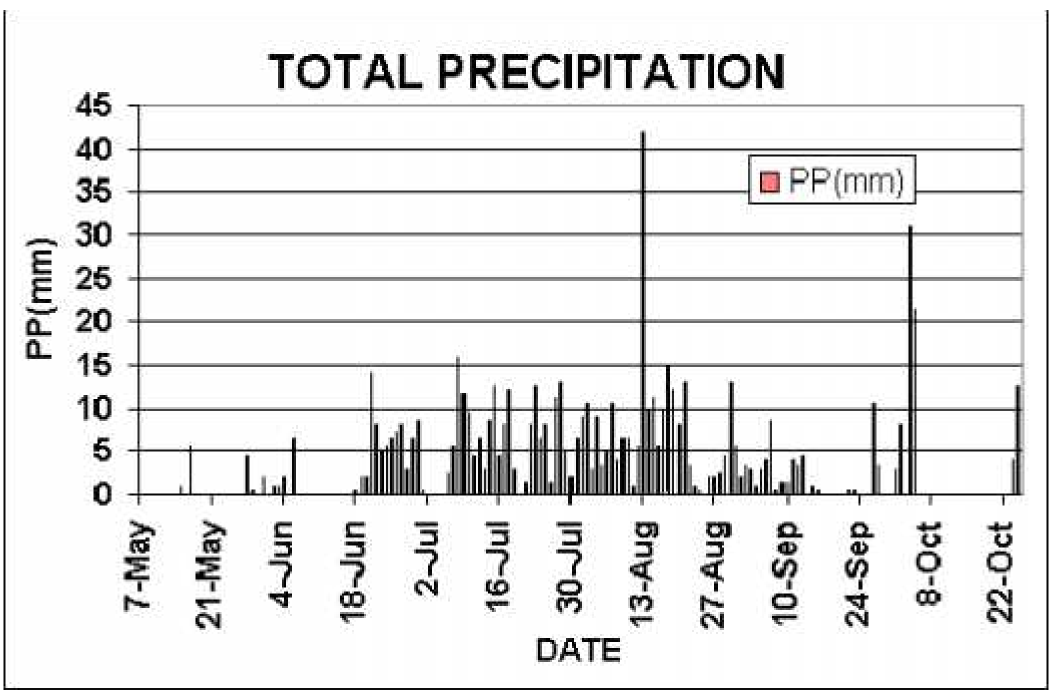


FIG. 5. THE SEASONAL VARIATION OF PRECIPITATION

7 METHOD OF CALCULATION OF DRYNESS INDEX

7.1 Dryness Index of soil

The dryness Index is defined as the Ratio of sum of Net radiation to the total sum of Precipitation in a duration. It deals with the condition of soil moisture with respect to net radiation and precipitation. In other word, RDI indicates the soil moisture factor of an area. The Dryness Index (RDI) of the soil is estimated by using the following equation.

.

$$\text{Dryness Index (RDI)} = \frac{(Q_N)avg}{\sum P}$$

Where,

Q_N = Net Radiation P = Precipitation

RDI = Dryness Index

In Langtang the value of RDI is found with the help of Net radiation and Precipitation from May to October.

The calculated monthly average Data of Meteorological parameters are shown in Table No 2.below

Table No 2. Calculated monthly average Data of Meteorological parameters and Dryness Index.

Month:	**May**	**June**	**July**	**August**	**Sept.**	**October**
Av.Q_N	188.6	159.1	153.1	151.4	162.0	112.0
ΣQ_N	4714.2	4771.7	4745.4	4692.5	4859.6	2800.8
Av. P	0.8	2.9	5.9	7.6	1.9	3.2
Σ P	26	87.5	183.5	235.0	57.0	80.0
RDI:	7.25	1.82	0.83	0.64	2.84	1.40

Table No 3. Mean Minimum resistance in leaf level (LAI-F)

Month:	**100*RDI Rsmin(F)**	**490*RDI Rsmin(G)**	**Mean Minimum resistance in leaf level (LAI-F)**
May	**-**	**-**	**-**
June	**181.8**	**890.7**	**4.9**
July	**83.4**	**64.4**	**4.9**
August	**284.2**	**1392.5**	**4.9**
Sept.	**140.0**	**686.2**	**4.9**
October	**150.8**	**738.8**	**4.9**

For the simulation of calculated data of Minimum resistance between forest line and Grass line are shown in Table No 4.

Table No 4. Range of Resistance for different vegetative coverage profile.

Forest Line	**Grass Line**
64.4	**315.6**
83.4	**408.8**
140.0	**686.2**
-	-
181.8	**890.7**
284.2	**1392.5**

Table No 5. Comparison of investigated results.

Kamitami Basin:

Year	P	m avg rad.	Soil Condn	Min S. Resit.	Results
1993	935.5	95.7	wet	More smaller	Low Production Rate
1994	283	155.4	dry	Smaller	Hot S. Aridness

Langtang Basin: 1996

May	0.8	188.6	dry	More smaller	Hot S & aridness
June:	2.9	159.1	wet	Smaller	Low Production Rate
July:	5.9	153.1	wet	Smaller	Low Production Rate

This indicates that,

Soil Condition	Min Resistance	Results
Wet	More smaller	Low Production
Dry	Smaller	Hot Summer with aridness

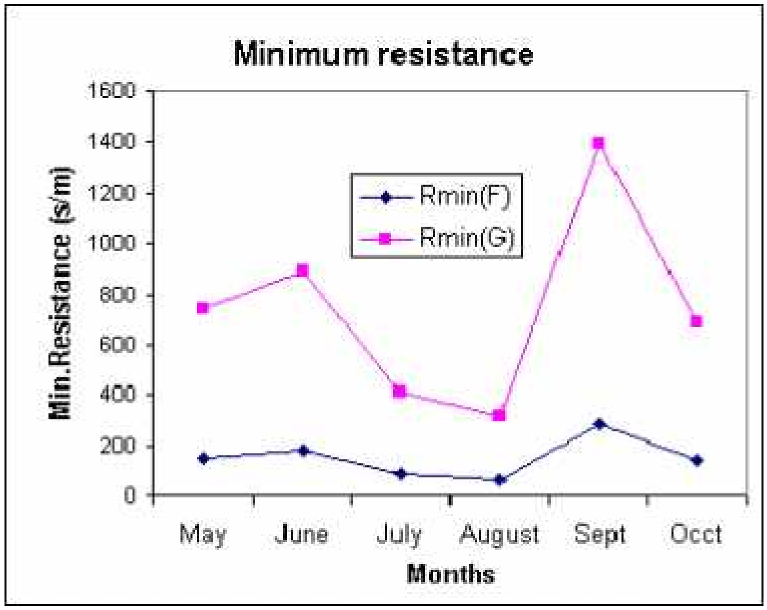


FIG. 6. THE SEASONAL VARIATION OF RESISTANCES FOR FOREST AND GRASS

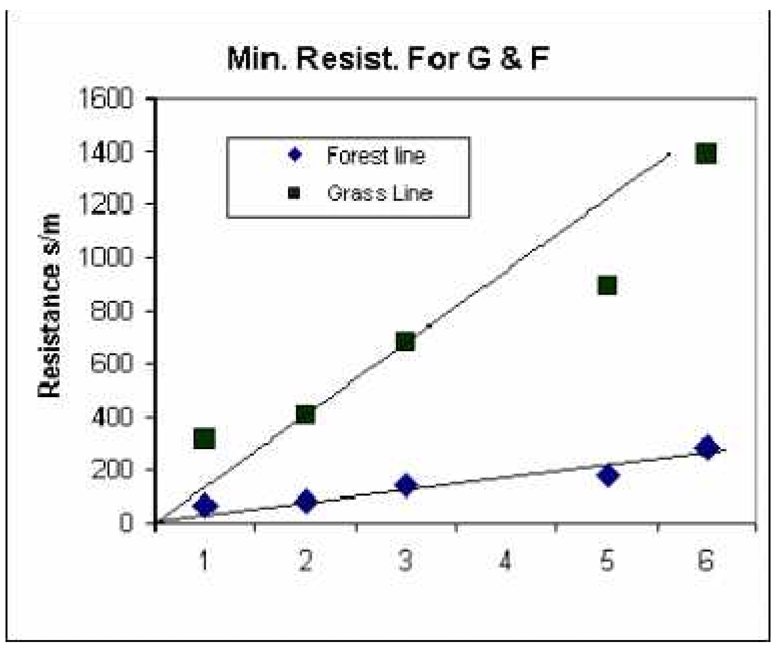


FIG. 7. THE COMPARISON OF MINIMUM RESISTANCES FOR DIFFERENT VEGETATION

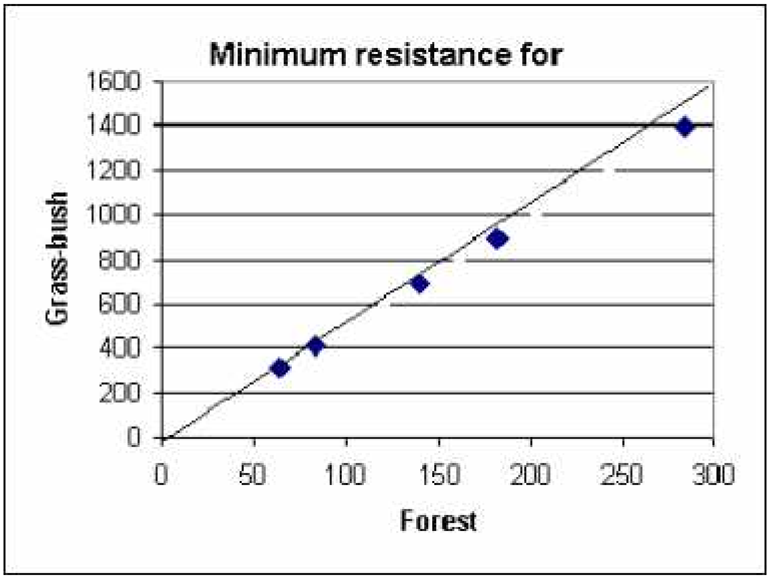
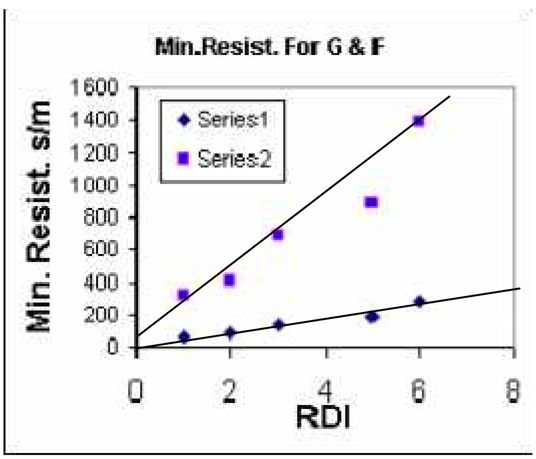


FIG.8. THE CORRELATION BETWEEN THE RESISTANCES OF DIFFERENT VEGETATION



Langtang Basin **Kamitami Basin**

FIG.9. THE RESULT OF KAMITAMI BASIN FOR COMPARISON WITH OUR RESULT

8 RESULT AND DISCUSSION

According to our purpose of study, the meteorological data such as Air temperature, Surface temperature, wind speed Relative Humidity, Net radiation all were plotted in Graphs. The Net radiation and Surface temperature are shown in Fig 2, Air Temperature and wind speed in Fig. 3, Relative humidity and Precipitation in Fig. 4, 5. From all these figures we can see that there is highly variation of the meteorological parameters are found. The trend of changing of these parameters from the beginning of summer season to the end of Monsoon season are time dependent to alter any exchange process from the earth surface in Langtang Basin in Nepal.

The calculated Results of Radiative Dryness Index (RDI) has been shown in Fig. 6, which clearly shows the variation of this parameters in different months from May to October having different values respectively as shown in table No2. The calculated monthly average Data of Meteorological parameters including the Radiative Dryness Index values can be seen in this table. Similarly, The calculated values Mean Minimum resistance in leaf level (LAI-F) are comparised in Table No 3.

For the simulation purpose of calculated data of Minimum resistance profile between forest line and Grass line are tabulated in Table No 4. All the concerning figures are shown respectively in figures 5,6,7,8,9,10.

From the simulated result of two groups and plotting them in the same figure, two linear relationships of the minimum surface resistance versus the RDI are found. This shows that there is similarity to use the component equation of SVAT model to know the minimum resistance and radiative dryness index of the soil surface in high altitude basins in Nepal.

9 COMPARISON OF RESULT

Hiama *et al.*(1999) indicated that Lai of Yakutsk forest during the summer was 3.2. The LAI of Kamitami basin was assumed to be 5 in summer season. Since the value of LAI multiplied by the minimum surface resistance in local scale equal to the minimum surface resistance in leaf level, thereby, we can find the minimum surface resistance of leaves is 300 s/m for deciduous broadleaf trees (60 s/m for minimum surface resistance in local scale), in Kamitami, Japan and 850 s/m for conifer (266s/m as minimum surface resistance from line A, in Yakutsk indicate the range of minimum surface resistance were between 90 and 1460s/m for broadleaf forests and between 120 and 2700s/m for coniferous forest. Our result shows a middle level both for broad leaf trees and for coniferous trees. Table 3. shows a comparison of minimum surface resistance between their results derived in leaf level. Therefore, our estimated values are considered reasonable even in a high altitude catchment in Langtang regardless of geological position in summer season.

The calculated Result has, therefore, shown the agreement for the estimation process and are considered reasonable for the application of Part of SVAT model in high mountain basins in Nepal.

10 CONCLUSION

1. The meteorological parameters are found changing from the beginning of summer season to the end of Monsoon season, which are time dependent to alter any exchange process from the land surface in Langtang Basin in Nepal.
2. Few high records of precipitation were found in summer in Langtang Basin which is considerable for assuming that the basin is Humid and temperate type of climatic nature although the basin is covered by snow and few glaciers on the north part.
3. The value of mean Minimum resistance in leaf level was estimated as 5.
4. From the result, it is found that there is a linear functional relationship between Rmin and RDI value for each group, as described

   Rmin = 100* RDI for forest Group (Line A)

   Rmin = 490* RDI for grass or bush group (line B)

   There is possibility of application of SVAT model completely or partly to use in the Catchments in High altitude mountainous region in our country in the summer monsoon season, regardless the geological position and meteorological condition over the region.

11 RECOMMENDATION

The part of SVAT model and its different formulae/equation is possible to use to determine the dryness index of the soil surfaces and distribution of the vegetative coverage and their existence on the land surface of a high altitude catchment's of Nepal Himalaya in the summer monsoon season.

This investigation is also useful to obtain the information of types of agriculture product that can be grown in summer climatic condition in the similar basin.

For the further investigation, it is required to study comparison results for different years so that we can compare the present result and confidently, can be apply same methodology to analyze estimated results over the high mountain basins in our country.

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Table No 4: Range of Resistance for different vegetative coverage.

Table No 5: Comparison of investigated results between Kamitami basin and Langtang Basin

13. **LIST OF PHOTOS**

1. Sattelite Cloud Pictures before monsoon unset in Nepal
2. Sattelite Cloud Pictures after unset of monsoon in Nepal
3. Photo Picture showing clouds during monsoon season over Bay of Bengal
4. Photo Picture showing clouds as humid condition in summer monsoon over mountains near Bay the Bay of Bengal.

14. **GRAPHS AND FIGURES**

Fig. 1.Map of Langtang Basisn showing its different features.

Fig. 2. Seasonal variation of Net radiation and surface temperature in Langtang Valley, Nepal Himalaya.

Fig. 3. Seasonal variation of Air Temperature and wind speed in Langtang Valley, Nepal Himalaya.

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Fig. 5. High rainfall values on two different dates in summer,1996 in Langtang Valley, Nepal Himalaya.

Fig. 6. Seasonal Variation of Min resistance of Forest and Grass groups in Langtang Valley, Nepal Himalaya.

Fig. 7. Different region of Forest and Grass group vegetation separated by min resistance (line A and Line B).

Fig. 8. The simulation result between calculated Minimum Resistances for Forest and Grass lands in Langtang Valley, Nepal Himalaya.

Fig. 9. The similar results between Langtang and Kamitami basins found for Forest and Grass lands in the analysis.

15 LIST OF ACRONYMS

Appendix

Notations, symbols and physical parameters

(Source: MS thesis,Chhetri, T.B.)

α The albedo of the earth surface.

c_p Specific heat of air at constant pressure (1005 J kg^{-1} K^{-1})

c_w Specific heat of liquid water at 0^oC (4.22×10^3 J kg^{-1} K^{-1})

e Vapor pressure (h pa) at the surface at the surface

e_a Actual vapor pressure (h Pa)

$e_{sat(Ts)}$ Saturation vapor pressure at surface temperature (h Pa)

ε The surface emissivity (0.96 to 0.98).

C The fraction of cloud varying from (0-1).

g Acceleration due to gravity of earth (9.8 ms^{-2})

H The Hour angle

h the local solar time

J The Julian day

k von Karman's constant (0.41)

Ki Incoming solar radiation (Wm^{-2})

Ko Outgoing solar radiation (Wm^{-2})

Li Incoming long wave radiation (Wm^{-2})

Lo Outgoing long waveradiation (Wm^{-2})

L_e Latent heat of evaporation at 0 ^{o} C (2.5×10^6 J kg^{-1})

LAI-F Leaf Area Index for forest

Pa Reference level atmospheric pressure (621 h Pa)

P_o Pressure at mean sea level (1013.25 hPa)

P_P Precipitation in (kg/m^2s)

q_a Specific humidity of atmosphere (kg/kg)

q_s Specific humidity at the ground surface (kg/kg)

$q_{sat\ (Ts)}$ Saturated specific humidity at surface temperature (kg/kg)

Q_G Ground heat flux (Wm^{-2})

Q_H Sensible heat flux (W m^{-2})

Q_L Latent heat flux or evaporation (Wm^{-2})

Q_N Total all wave net radiation (Wm^{-2})

P Precipitation (mm)

Q_P Precipitation heat flux (Wm^{-2})

RH Relative humidity of atmosphere (%)

RDI Radiative dryness index

R_{min} Minimum resistance (s/m)

° Air density (kg m^{-3})

$°_o$ Air density at m. s. l. (1.275 kg m^{-3} at 0^oC; 1013.25 h Pa)

S The solar constant (1365W/m^2)

T_a Air temperature (^oC)

T_U Upper layer air temperature at 1.23 m (^oC)

T_L Lower layer air temperature at 0.23 m (^oC)

T_s Land surface temperature (^oC)

T_P Temperature of precipitation equivalent with air temperature (K)

U Wind speed (ms^{-1})

U_U Wind speed at height 1.44 m (ms^{-1})

U_L Wind speed at height 0.47 m (ms^{-1})

z Vertical distance, measurement height of meteorological data (m)

Z The solar zenith angle

Φ The latitude of the earth

δ The declination angle

π 22/7

σ The Boltzmann constant ($5.78*10^{-8}$). The parameter

Q_o The Value of Global solar radiation in clear sky condition

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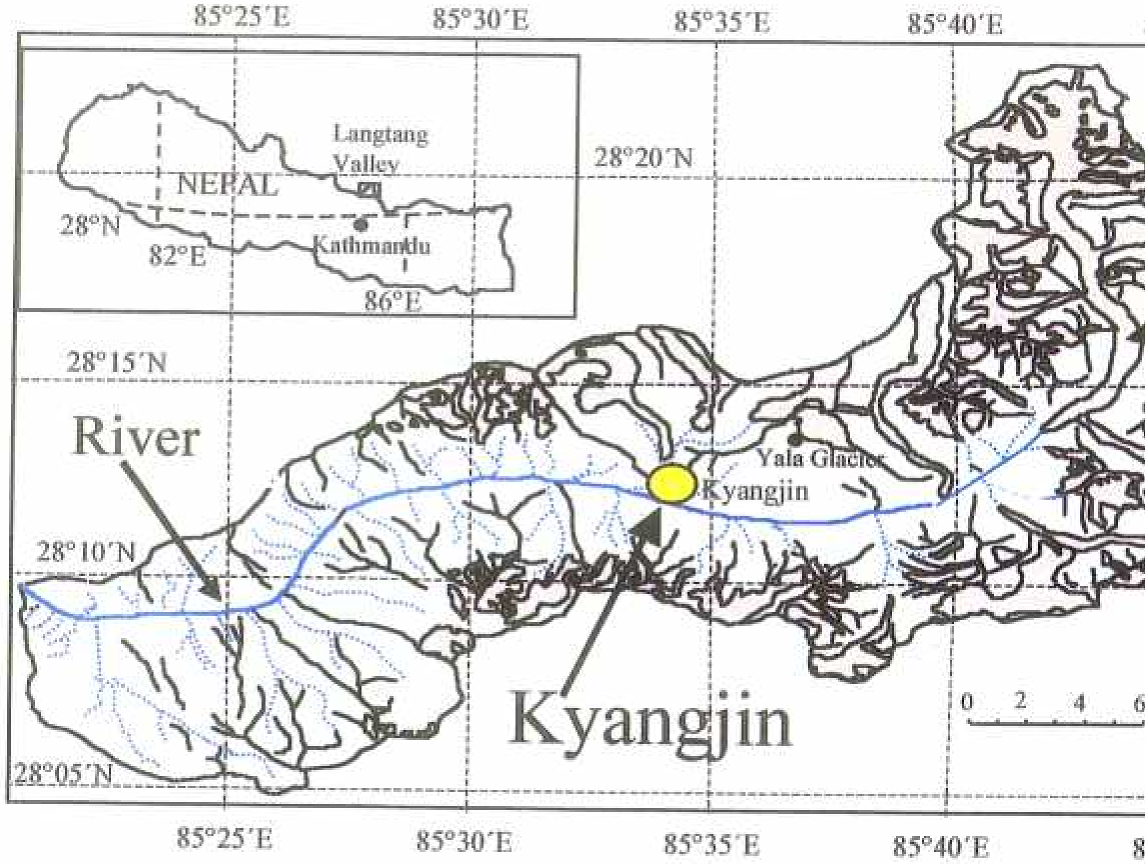
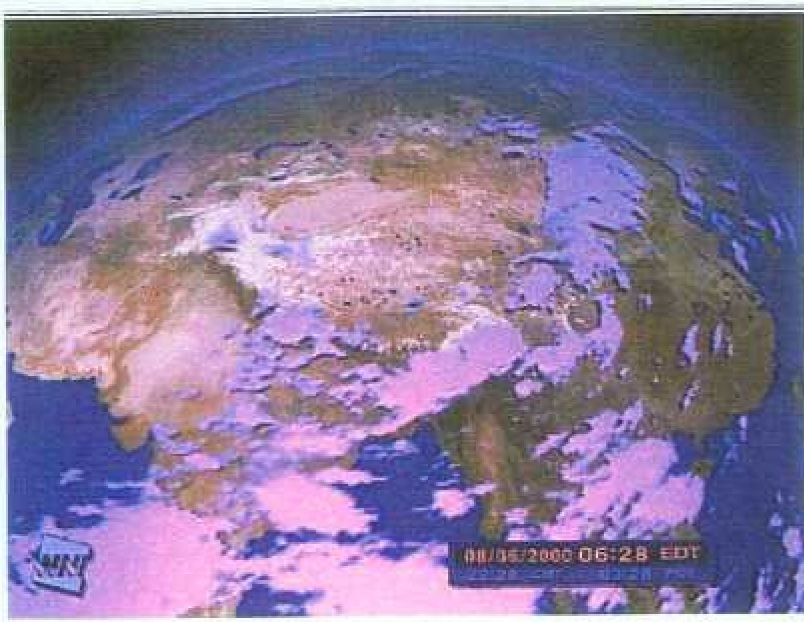


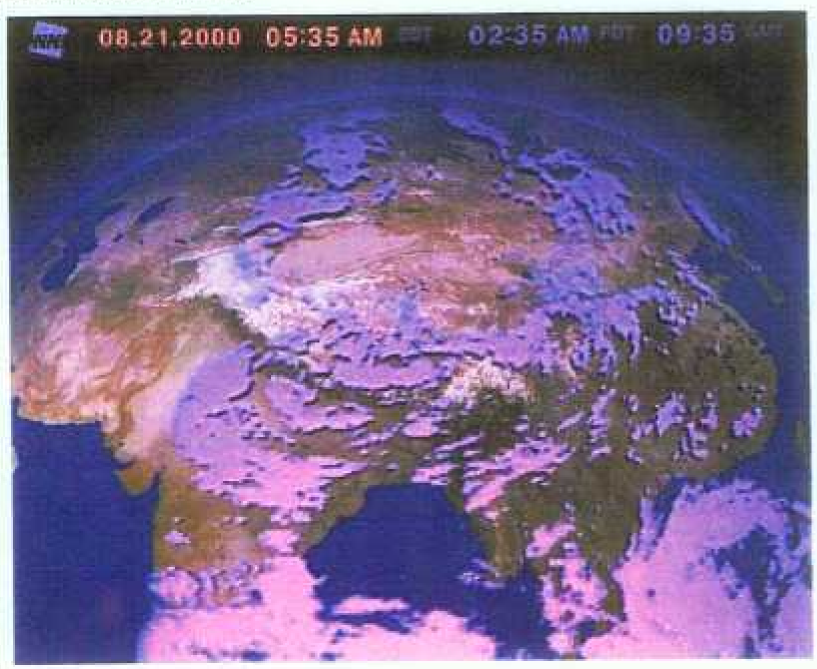
Map of Langtang Valley showing K

Fig. I

Central Asia satellite picture



Central Asia Satellite



Satellite Loop(.gif)