Graduation Year June 2002

Thesis Title: **SEISMIC RISK OF BHAKTAPUR AND ITS MONUMENTAL STRUCTURES**

Submitted by: **Prem Nath Maskey**

Supervisor: **Prof. Dr. T. K. Datta**

ABSTRACT

Bhaktapur is an important city in Kathmandu Valley preserving many monumental and heritage structures. Because of its proximity to eight active earthquake sources the city has a high seismic risk. The damage records of previous earthquakes in the Kathmandu Valley also indicate that the city suffered enormous damages; many dwellings and heritage structures were severely damaged. There has been no systematic study conducted to assess the seismic risk of the city and investigate the vulnerability of the whole heritage structures like temples to future earthquakes. Because of these reasons a systematic study on the seismic risk of Bhaktapur City and its monumental structures becomes important.

The present work deals with a comprehensive study on the subject. It is divided into two parts. In the first part, the seismic risk of the city is evaluated by obtaining an Earthquake Disaster Risk Index (EDRI). Also the hazard curves, risk-consistent response spectra to be used for finding equivalent lateral forces on structures for future earthquake and a probabilistic microzonation of a city with respect to PGA have been obtained. In the second part, nine temples of the city have been selected for analysis keeping in view broad classification of the temples and the microzonation of the city. The material properties of these temples have been determined by collecting samples from different temples and testing them in the laboratory. The temples are analysed for the vertical load and the seismic load calculated as per IS Code using the material properties obtained experimentally. The analysis provided a preliminary estimate of the margin of safety of the temples as per the codal provisions. A simplified procedure for probabilistic risk analysis of these temples is presented. The method of analysis considers uncertainties of ground motion input, materials properties (as exhibited from the coefficients of variation of experimental test results), modeling and analysis procedure, and strength capacity. The uncertainties are included by way of multiplying the mean response by four factors (each factor denoting one kind of

uncertainty). The factors arc assumed to be log normally distributed random variables with specified median and logarithmic standard The mean response is obtained by analyzing the temples under vertical load and equivalent lateral load due to earthquake using eight noded solid modeling. The response analysis is performed using standard software SAP 90.
The equivalent lateral load due to earthquake is obtained by a modified seismic coefficient method, in which risk consistent response spectra are utilized. The equivalent lateral loads are also obtained using free-field response spectra for white noise input at the bedrock level. The probability of failure of the temples for a PGA level is obtained by first order second moment method of reliability. The fragility curves denoting the seismic risk of the temple structures are obtained. The annual frequencies of failure of the structures are determined by combining the fragility curves with the hazard curves of the sites of the temples.

An extensive parametric study is conducted to investigate (i) the PGA amplifications due to different properties of the soil in different locations of the city; (ii) the effect of non-linearity of soil on the seismic inputs to the structures; (iii) the nature of ground motion on the probability of failure of the structures; (iv) the effect of the distribution of magnitudes of earthquake on the hazard curves; and (v) the effect of the uncertainty factors on the probability of failure of structures.

The results of the study indicate that the above factors have considerable effect on the probability of failure of the temple structures. Further, it is observed that some of the temple structures have high probability of failure at PGA level of 0.4g and above.

Graduation Year October 2007

Thesis Title: **IMPROVEMENT OF ALGORITHM IN THE PARTICLE TRACKING VELOCIMETRY**

Submitted by: **Shashidhar Ram Joshi**

Supervisor: **Prof. Dr. Dinesh Kumar Sharma**

Prof. Dr. Kazuo Ohmi

Prof. Dr. Tor Ytrehus

ABSTRACT

Keywords: Particle Image Velocimetry(PIV), Particle Tracking Velocimetry(PTV), self organizing Map(SOM), Labonte's SOM, Ohmi's SOM, Modified Algorithm, Delta Bar Delta, IIVD Algorithm, Single Threshold Binarization, Dynamic Threshold (Binarization)

The neural network techniques are becoming a useful tool for the particle tracking algorithm of the PIV system software and among others, the self-organizing maps (SOM) model seems to have turned out particularly effective for this purpose. This is mainly because of the performance of the particle tracking itself, capacity of dealing with unpaired particles between two frames and no necessity for a priori knowledge on the How field (e.g. maximum flow rate) to be measured. Initially, Labonte applied concept of SOM to PIV. Ohmi modified it and further modified algorithm is developed using the concept of Delta-Bar-Delta rule. It is a heuristic algorithm for modifying the learning rate GIS training progresses. Earlier, the treatment of unpaired particles, a specific problem to any type of PIV, is not fully considered and thereby, the tracking goes unsuccessfully for Home particles. The present research is to bring about further improvement and practicability in this promising particle tracking algorithm. The computational complexity can be reduced employing modified algorithm compared to other algorithms. The modified algorithm is tested in the light of the synthetic PIV standard image as well as in particle images obtained from visualization experiments.

Graduation Year October 2007

Thesis Title: **PARELLED OPERATION OF INDUCTION GENERATION AND SYNCHRONOUS GENERATOR IN MICRO HYDRO SCHEME**

Submitted by: **Indra Man Tamrakar**

Supervisor: **Dr. Shilpa Bhakta Silpakar**

ABSTRACTS

Electrification of rural and remote areas is a challenge for the underdeveloped country in order to achieve the balanced development of the country. Electrification of such areas through the national grid extension is not financially feasible due to high cost investment in the construction of transmission line and increased power loss in the line. Generation of electricity from the locally available renewable energy sources is the suitable option for the electrification of rural settlements. Global environmental concerns and the fast depletion of fossil fuels also have drawn the attention toward the use of renewable energy sources. Micro Hydro Power (MHP) plant is one of the popular options of renewable energy source for rural electrification as it is cheaper than the other renewable energy sources such as wind power, solar power, biomass etc. The hydro power plants of capacity 3 kW to 100 kW are classified as MHP plant in Nepal. Since the people of the rural settlements cannot afford the higher cost of electrical energy, one of the prime requirements of MHP plant is that the generation cost should be low. In order to make the cost of MHP plants affordable to rural people, the MHP plant designers have made their efforts to reduce the construction cost by using the local materials and labor for the construction of plant, using locally manufactured turbine, using comparatively cheaper Electronic Load Controller (ELC) to replace conventional governor, allowing larger variation of voltage and frequency to reduce the cost of control component and using induction generator instead of synchronous generator. Use of induction generator is increasingly becoming more popular in MHP application due to its simpler excitation system, lower capital cost and less maintenance requirement. Most of the early stages MHP plants are equipped with the synchronous generator. Whereas, most of the new MHP plants up to capacity of 50 kW are equipped with induction generator. Many of the existing MHP plants with synchronous generator may require add-on plant, which operate in parallel connection to fulfill the increasing load demand. In such a situation, the plant cost can be reduced further if induction generator is used as the add-on plant to the MHP equipped with synchronous

generator. Analysis of isolated operation of induction generator, grid connected induction generator are reported in the many literatures. However, the detail analysis of parallel operation of induction generator with the synchronous generator in isolated mode is not reported so far. This thesis is mainly focused on the analysis of scheme of parallel operation of induction generator and the synchronous generator in isolated MHP environment and voltage and frequency control of such scheme at varying consumer's load demand.

The objectives of the investigations reported in this thesis are as follows:

- To develop the mathematical model of the proposed scheme of parallel operation of induction generator and synchronous generator in MHP scheme.
- To perform the steady state and transient analysis of the proposed scheme.
- To investigate the controllers for controlling the frequency of the proposed scheme at varying load conditions.
- To investigate the controllers for balancing the reactive power generation and consumption in the scheme to ensure the constant terminal voltage at varying load conditions.

MathLab Simulink is used as the simulation tool for analyzing the proposed scheme of parallel operation. The simulation models of synchronous generator and induction generator available in the MathLab Simulink library are used to simulate the parallel operation scheme. Development of mathematical models and simulink models of Electronic Load Controllers (ELC), reactive power compensators such as Thyristor Switched Capacitor (TSC), Fixed Capacitor Thyristor Controlled Reactor (FCTCR), Static Synchronous Compensator (STATCOM) with hysteresis band current control and the PQ-STATCOM with the new concept of voltage and frequency control and integration of these components in the parallel operation scheme are the main contributions of this research work.

The d-q equivalent circuit models of synchronous generator and induction generator are used in the parallel operation scheme. Since the synchronous generator and the induction generator have different types of load-frequency characteristics and frequency controllers, their parallel operation with their respective frequency controller would be complex. The scheme of parallel operation is simplified by operating the induction generator at its full rating without speed governor and allowing the synchronous generator along with its ELC to response the change in consumer load. The feasibility of this mode of parallel operation scheme is

experimentally verified and it is found that the connection of an induction generator in parallel with the synchronous is much simpler than connecting two synchronous generators in parallel. The scheme does not require synchronizing panel hardware and a commercially available induction motor can be used as generator in the absence of governor. The installation of an induction generator as addon generator to the existing synchronous generator offers advantages of lower capital cost and less maintenance. The transients appeared in the armature current of synchronous generator and stator current of induction generator at the instant of switching of induction generator are 2.6 pu and 5 pu respectively. Even an induction motor draws 5 to 8 pu of current when directly started with rated input voltage. Hence the transients appeared in the armature current of synchronous generator and stator current of induction generator at the instant of switching on of induction generator are safe for the practical implementation of the parallel operation scheme. The transients appeared in the system bus voltage, armature current of synchronous generator and stator current of induction generator due to the load perturbation are negligible. There is a small voltage dip in the system bus voltage at the instant of switching of induction generator. It lasts only for 0.25 second, which is acceptable for practical implementation.

The study on steady state and transient analysis of the parallel operation scheme with ELC has been carried out. The simulation models of two types of ELC namely ac voltage controller based ELC and discrete resistance type ELC are developed. The simulation study shows that both types of ELC works satisfactorily for frequency control of the parallel operation scheme at varying resistive load conditions. However, the ac voltage controller based ELC suffers the problem of harmonics introduced due to the chopping of current waveform in the dump resistive load. The dump resistive load consumes the reactive power due to delay switching of dump load and the terminal voltage of the system is not constant at 1 pu even with purely resistive load. On the other hand, the discrete resistance type ELC is free from harmonic problem and the dump resistive load does not consume reactive power. However, it is unable to control the frequency and terminal voltage at varying inductive load conditions and hence requires external reactive power compensator. The simulation results of parallel operation of synchronous generator and induction generator with discrete resistance type ELC is verified by the experimental results.

The study on steady state and transient analysis of the parallel operation scheme with ELC and external Var compensator has been presented. The simulation models of two types of Var compensators namely - TSC and FCTCR are developed. The simulation study shows that both types of Var compensators works satisfactorily for voltage control of parallel operation

scheme at varying inductive load conditions. The TSC compensator provides step-wise control of reactive power and needs large number of triac switches and capacitor banks for smaller step control. Because of step-wise control of reactive power, the terminal voltage is not controlled accurately to 1 pu. On the other hand, the FCTCR compensator provides continuous control of the reactive power resulting a perfect control of the terminal voltage to 1 pu. However, it generates some harmonics due to the chopping of waveform of current through the reactor branch of FCTCR. Also it requires bulky and expensive capacitor and inductor for larger capacity plant.

STATCOM is proposed as external Var compensator for lager capacity plant to overcome the disadvantages of FCTCR compensator. The simulation model of STATCOM is developed. The hysteresis band current control principle is used in the STATCOM to generate the gate signals for the PWM inverter. The simulation results show that the performance of STATCOM is superior to that of the TSC and FCTCR compensators. It provides the continuous control of reactive power and able to keep the terminal voltage of the parallel operation scheme constant at 1 pu at varying inductive load conditions. It draws nearly sinusoidal current resulting negligible harmonics. It is also found that the STATCOM is able to provide fast response to minimize the transients in the terminal voltage arising due to the switching of the induction generator to the scheme. The voltage clip in the terminal voltage due to the switching of induction generator is found to be less in comparison to that in the case of TSC and FCTCR compensators.

STATCOM with a new concept to control the voltage as well as frequency of the parallel operation scheme at varying load conditions is presented. No separate ELC is required in this concept. The proposed STATCOM controls the active power as well as the reactive power. It is named as PQ-STATCOM in this study. The circuit configuration of the PQ- SATCOM is very much similar to that of the conventional STATCOM for reactive power compensation, except that it has an additional IGBT chopper at the dc side of the inverter, which controls the active power dissipation in the dump resistive load connected across the dc capacitor. The simulation model of PQ-STATCOM is developed and the steady state and transient analysis of parallel operation of synchronous generator and induction generator with PQ-STATCOM is performed. The simulation results show that the performance of PQ-STATCOM is comparable to that of the parallel operation scheme with the separate STATCOM and ELC for voltage and frequency control. Since the PQ- STATCOM does not need a separate ELC for frequency control, its cost is less than the total cost of STATCOM and discrete resistance type ELC.

Simulation study is carried out to explore the maximum capacity of IG that can be connected in parallel with the 16 kVA SG without loosing the stability and power quality of the scheme. The simulation results show that the performance of parallel operation scheme with ELC and resistive load is satisfactory when 10 kW IG is operated in parallel with 16 kVA SG. When the capacity of IG is 11 kW, the terminal voltage and frequency of the generated voltage exceeds the acceptable limits of ±10% and ± 2.5 % respectively. When the capacity of IG is 12 kW, the parallel operation scheme collapses completely. 1 fence, in the case of parallel operation scheme with ELC and resistive load, the maximum size of IG that can be connected in parallel with the 16 kVA SG without loosing the stability and power quality of the scheme is 10 kW. However, in the case of parallel operation scheme with PQ-STATCOM and inductive load, even a 15 kW IG can be operated in parallel with the 16 kVA SG without loosing the stability and power quality.

The main issue considered in this research work is to use induction generator as an addon generator to the existing MHP plant equipped with the synchronous generator in order to fulfill the increasing load demand. Most of the existing MHP plants equipped with synchronous generator have ELC used for speed control. Wherever, the existing ELC is discrete resistance type, it is recommended that ELC should be re-used in the parallel operation scheme and STATCOM or FCTCR should be used for terminal voltage control. I VTCR compensator is preferable for smaller capacity plant, whereas STATCOM is preferable for larger capacity plant. Wherever the existing SG is equipped with ac voltage controller based ELC, it shall be replaced by P-Q STATCOM for better performance. I'Q-STATCOM can control voltage as well as frequency of the scheme. Since no separate ELC is required with this scheme, its cost is cheaper than the total cost of ELC and STATCOM. In case of parallel operation scheme with ELC and resistive load, the maximum rating of the IG that may be connected in parallel is 62.5 % in compare to the rating of SG. For this IG rating, the fluctuations in the terminal voltage and frequency are limited within the acceptable range securing the power quality and stability of the system. However, in case of parallel operation scheme with PQ-STATCOM, even a 15 kW IG can be connected in parallel with 16 kVA SG without sacrificing the voltage and frequency stability of the parallel operation scheme.

Graduation Year December 2007

Thesis Title: **EFFICIENCY DETERIORATION IN PELTON TURBINES DUE TO SAND-PARTICLE-LED-BOCKET EROSION**

Submitted by: **Tri Ratna Bajracharya**

Supervisor: **Prof. Dr. Chandra Bahadur Joshi**

ABSTRACT

Erosion of hydraulic turbines is a common problem in the hydropower plants. Sand erosion is most prominent for turbine erosion resulting decrease in turbine efficiency. Even one percent loss of turbine efficiency leads to remarkable decrease in energy generation along with high economic loss. In Nepal, no research related to sand erosion of Pelton turbines in real situation has been earned out. The main goal has been to determine the sand erosion of runner buckets and their effects on the efficiency of Pelton Turbines in operation to different parameters.

Experimental studies conducted so far have been focused only on a specimen basis and not on actual hydropower systems. Therefore, a detailed investigation of sand erosion of Pelton turbines in actual hydropower systems is required. Accordingly, under the present study an experimental setup has been developed and fabricated. Hypothetically, it is assumed that the efficiency of Pelton turbines will decrease with erosion of buckets while operating them in sand laden flow. In order to develop the experimental setup for present study, the experimental setup developed by various investigators have also been reviewed. A field study of the prominent site of a sand laden river has been carried out.

It has been found that the sand concentration is the strong parameter for the mass loss of Pelton buckets. The mass loss has been observed mainly on the bucket's splitter. It is found that the mass loss increases with the operating hours for all the values of sand concentrations considered.

The effect of operating hours on mass loss for different sand concentration values has been investigated. It has been found that the rate of erosion is increased with the increase operation

time of the turbine. The variation in mass loss with the operating hours of the turbine has been found similar to all the buckets.

Based on the data collected, a correlation for mass loss as a function of sand concentration and operating hours has been developed by using regression analysis.

The effect of sand concentration and operating hours on the splitter thickness of the buckets is also investigated. It has been observed that the splitter thickness near to the bucket notch becomes thicker as a result of blunt occurred due to the blunt caused by erosion.

In order to compare the, efficiency of a sand effected runner with the original runner the value of the efficiency has been determined for different values of concentration for different flow rates. It has been found that efficiency of the turbine decreases with increase in operating hours and the variation is found to be non linear. Based on the collected data, a correlation for efficiency as a function of concentration and operation hours has been developed, which predicts the value of efficiency matching very reasonably with the experimental results.

Graduation Year March 2008

Thesis Title: **COLOUR CORRECTION ALGORITHM FOR REPRODUCING SPOT COLOURS**

Submitted by: **Jyoti Tandukar**

Supervisor: **Prof. Dr. Dinesh Kumar Sharma**

ABSTRACT

It is well known that colors are specified by a three tuple. Unfortunately, unlike the specification of length (for example in metres) or weight (for example in grams), the three tuple does not result in the same perception when used on colored or white paper, on a LCD or CRT computer monitor, or in dyes for the carpet industry.

We propose a swift, dynamic color correction algorithm based on the color produced, its evaluation in real time using a standard colorimeter, and the desired color as specified by the end user. Unlike prior methods, our approach does not need device calibration and characterization.

We use a variation of a restoration algorithm to relate the input to the output. A transform matrix is "updated" in real time with feedback based upon the error between desired target and obtained output. The entire color correction process can be viewed as the training of weights in a neural network. Due to its near real time nature, the algorithm is agnostic to uncertain variables such as temperature and viewing conditions. The algorithm is validated in a lab environment on a computer screen based on a dataset of 125 colors, and is further tested on set of 1000 colors.

Since this algorithm reproduces desired colors based on only three dyes, the total number of base colors required for color reproduction process in the dyeing industry is radically reduced. The findings of this research are expected to be of significance for the computer industry as a whole, leading to simpler methods of color reproduction.

Keywords: color, color correction, algorithm, color reproduction, neural network, dyeings CMY dyeing, generic dyeing, generic color reproduction, dynamic color correction.

Graduation Year March 2008

Thesis Title: **Functional Spaces and Related Topics**

Submitted by: **Geeta Bhakta Joshi**

Supervisor: **Prof. Dr. Shailendra Kumar Mishra**

Dr. Shankar Raj Pant

Dr. Sarla Devi Bhardwaj

ABSTRACT

The theory of sequence spaces occupies a very important role in Analysis which has applications in several branches of Mathematics. The study of sequence spaces was motivated by the classical results of summability theory. The first attempt to study the summability methods in abstract sense was done by O.Toeplitz in 1911, when he gave necessary and sufficient conditions for a matrix to be regular, that is, which preserves the limit for the convergent sequences. The first application for the functional analysis to the theory of summability was done by Mazur in 1927 when he proved his now famous Mazur's Consistency theorem; which won him the prize of the University or Lvov. In 1950 Robinson considered the action of infinite matrices of linear operators from Banach space of sequences to that space. A finite account of these results can be found in Maddox [49] and Wilansky [74].

nature. This thesis consists of five chapters. The first chapter is introductory in

In the second chapter we will be extending the results related to Choudhary and Mishra [11]. For a bounded sequence of strictly positive real numbers $p = (p_1)$, (p) is a linear metric space with the total paranorm g defined as

**3{x} =x }=(d) <8

Graduation Year 2009

Thesis Title: **COMPOSITE ACTION OF BRICK IN –FILL WALL IN RC FRAME UNDER LATERAL LOAD**

Submitted by: **Prajwal Lal Pradhan**

Supervisor: **Dr. Mohan Prasad Aryal**

ABSTRACT

This paper introduces a recursive algorithm for simulating stress-strain curve of structural materials like concrete, brick, mortar etc., whose initial modulus of elasticity and ultimate stress values are known. Using this algorithm, at every nodal value of strains, modulus of elasticity (gradient of stress- strain curve*) is* determined. A material constant is used to reflect the material behavior precisely. For the verification, some structural materials like bricks and mortar samples were taken into consideration and their stress-strain curves were plotted. Since, below the yield limit, the pattern of the load-deformation relationship was found to be linear. The algorithm was implemented only beyond this limit. Further, both the results from simulation as well as experimental investigations were verified.

Key words: Simulation, Initial modulus of elasticity, Ultimate stress-strain, Yield limit

Graduation Year December 2009

Thesis Title: **SEDIMENT HANDLING IN HIMALAYAN RIVERS USING HYDROCYCLONES**

Submitted by: **Hari Prasad Pandit**

Supervisor: **Prof. Dr. Narendra Man Shakya**

ABSTRACT

The sleep catchments of the 'Himalayan Rivers endowed with abundant water offer a huge potential of hydropower generation. However, harnessing this potential is a very challenging task. The inherent land erosion and incessant rainfall phenomena in this geologically rugged and fragile region generate extreme sediment load. This sediment load, usually undesirable in a diverted flow is excluded adopting various exclusion measures at headworks. While the bed load is excluded at intake, settling basins are commonly used for trapping suspended sediment to minimize wear and tear in hydro-mechanical equipment and accessories.

Although these units are usually designed to exclude sediment coarser than 200 pxn, enormous damage of equipment and accessories has also been reported due to finer sediment load consisting of very hard minerals such as quartz and feldspar. Recent studies have revealed, while the coarser particles damage the surface exposed to outer hydraulic contour, the damage due to the finer particles (<100 jam) increases considerably, because they get entrained in the turbulent boundary layer, which encases all hydraulic surfaces, and results in a sand blasting of the surface. Not only does this involve huge maintenance cost, but there is also a substantial revenue loss due to reduced equipment efficiencies. Thus, more efficient devices are required to remove finer sediment particles from the diverted flow. A hydrocyclone could be one such device, which has so far been successfully used in other industries such as mineral processing, coal refineries, wastewater engineering.

This research analyses the experimental results of two test rigs consisting of hydrocyclones of 0.22 m and 0.38 m diameter. While the smaller hydrocyclone was tested with Rietema's geometry, the larger hydrocyclone was tested modifying the geometry of overflow as well as underflow outlets of gMax profile of Krebs Engineers. The experiments were conducted both with axial as well as tangential overflow outlets. In total, 108 tests were carried out varying

design and operating parameters. The results were compared with that obtained by other investigators. The findings from the test results showed a better hydraulic and sediment removal efficiency of the modified hydrocyclone compared to that of other existing hydrocyclones. Further, the hydraulic efficiency due to tangential overflow outlet was found much better than that due to axial overflow outlet. Moreover, the sediment removal efficiency of both the hydrocyclones was found much better than that of the conventional settling basins pointing out larger implications for suspended sediment exclusion in high-head hydropower plants of Himalayan region.

Graduation Year November 2010

Thesis Title: **HOUSING FOR THE URBAN POOR IN KATHMANDU VALLEY – SOME LESSONS TO BE LEARNT**

Submitted by: **Mahesh Shrestha**

Supervisor: **Prof. Dr. Jiba Raj Pokharel**

ABSTRACT

Rapid growth of population in urban areas has generated new setbacks in developing countries. Most local governments in the developing world have not played a meaningful role on addressing issues concerned with housing the urban poor. In Nepal, increase in urban population is 6.65 percent compared to the national average of 2.27 percent. National urban population is 14.2 percent, yet Kathmandu valley's share of urban population is 54.5 percent. The contribution of the urban areas to the national economy in Nepal is 60.68 percent, whereas the annual investment in the urban areas is only 2 percent.

23 percent of the urban population in Nepal is poor taking the official Nepali poverty line of US$ 110.60 per person per annum. Institutional role is crucial in the reduction of poverty related problems and urban poor housing drawbacks, but implementation of policies have not been effective due to lack of good governance and centralized decision making process.

In this context, the hypothesis for the research was created based on (i) the experience of several Asian countries which shows that secured housing is a key contributor to reduction and elimination of urban poverty. And (ii) in Nepal, poverty has fast been linked with urbanization as more and more people move to cities and urban areas that are unable to cope with the combined pressure of rising populations and limited resources.

The contention above revealed that it is unlikely that a narrow assessment of one presumption alone will suffice to explain the phenomenon of the problems of housing the urban poor in Kathmandu valley. Consequently, this leads to the questions: What are the critical factors/ determinants for providing housing to the urban poor of Kathmandu valley? What is the proposed model of housing for the urban poor of Kathmandu valley?

Keywords: policies, poverty, urban shelter

Graduation Year October 2010

Thesis Title: **PARTICIPATORY APPROACH FOR CONSERVATION OF CULTURAL HERITAGE IN TRADITIONAL SMALL TOWNS OF KATHMANDU VALLEY**

Submitted by: **Sudha Shrestha**

Supervisor: **Prof. Dr. Sudarshan Raj Tiwari**

ABSTRACT

Rapid urbanization has created numerous problems in Nepal. Serious threat on cultural heritage, pressure on infrastructure and services and society changing to heterogeneity from homogeneity has added social, cultural and religious problems in the society. In Nepal, conservation practices also limited only up to built heritage in larger cities like Kathmandu, Patan and Bhaktapur.

Kathmandu Valley consists of many small traditional towns with high heritage, social and cultural values. But because of population pressure in larger cities these small towns are also seriously affected.

Participatory approach is important for development of any cities. Previously implemented plans and programs failed to introduce participatory approach in Nepal although; in the Newari community there was a system of people's participation in the form of guthi. Guthi a social institution is working till date in Newari society. Guthi deals with socio cultural and religious matter such as regulation of daily ritual in the temple. It organizes festivals and manages urban infrastructure and services like water supply, drainage, solid waste, road, bridge, maintenance of cremation places and cremation of dead bodies of guthi members and many more.

Formerly, these problems were tackled by guthis. Due to various reasons, several guthis arc disappearing from the society; conservation of cultural heritage and management of urban infrastructure and services became difficult. This study will try to highlight the essence of guthi mainly participatory approach, which could be utilized by the local government in their future plans and programs to conserve cultural heritage and maintenance and management of urban infrastructure and services.

Graduation Year June 2013

Thesis Title : **COMMUNITY BASE EARTHQUAKE VULENRABILITY REDUCTION IN TRADITIONAL SETTLEMENT OF KATHMANDU VALLEY**

Submitted by: **Punya Sagar Marhatta**

Supervisor: **Prof. Dr. Jiba Raj Pokharel**

ABSTRACT

The title of the presented research is Community based Earthquake Vulnerability Reduction in Traditional Settlements of Kathmandu Valley. Its main objective is to understand the communities in the traditional settlements of Kathmandu Valley, their earthquake vulnerabilities and capacities. Similarly it has the objective of identifying appropriate community based approach for earthquake vulnerability reduction in selected communities of the valley. The research was initiated in spring 2008 at Institute of Engineering under Trans-Himalayan University Network for Development and Research (THUNDER) with NUFU funding.

This research was important since its inception because of the vulnerability of Nepal especially Kathmandu valley against earthquakes. Therefore, research started studying the history of earthquakes in Kathmandu valley. It located the first recorded history of earthquake in Kathmandu Valley in 1223AD. Similarly, it studied the literature to define communities in Nepalese context. It also considered definitions of vulnerabilities to understand vulnerability in Kathmandu context. It went through the approaches adopted to reduce such vulnerabilities. During the literature studies, researcher studied the participatory development, participation and people centric development approach. In order to gain better understanding on disaster risk management, researcher studied contemporary documents available in the form of practices, policies and acts referring to disasters in Nepal. Likewise, studies were carried out in the area of community based disaster risk management. According to the studies conducted, it came to a conclusion that there exists a significant gap in understanding the vulnerabilities of communities regarding earthquake disasters. The contemporary earthquake vulnerability reduction practices in Nepal are overwhelmed by advocacy of reduction of physical vulnerability. The overwhelming advocacy of physical vulnerability of structures has overcastted the social and cultural vulnerability in the communities. However, the research considered that there exist physical, social and cultural vulnerabilities in Nepal which could be reduced and one of the tools to reduce those vulnerabilities is by involving communities. In other words, it could be said that earthquake vulnerabilities could be reduced through community based approach. Research considered the fact that increasing participation in disaster risk reduction is a challenge due to several factors like lack of resources, lack of institutional capacities, lack of motivation to the participants and immediate benefits to them. Therefore, research was conducted to explore the appropriate community based approach.

In order to fulfill the objective and find answer the research questions, research adopted case study method considering Kathmandu valley as a major case study area and several cases within it. It is considered to be an exploratory research. It was carried out following steps of proposal writing. literature review, identification of research methodology and case area identification. After case area identification, the case studies were carried out. During the

case studies, there were literature studies, case studies of community based organizations and consumers' cooperative, household questionnaire survey, participation in multiple activities related to disaster risk management were carried out. The research did data analysis and arrived at the conclusion after accomplishment of case studies.
The proposal writing was carried out at the beginning of the research. It was accomplished by April 2008. The next step was to carry out the literature review. Although literature review is a continued process, the first and major round of survey was carried out during May 2008 to March 2009.

After the literature survey, researcher started to identify the case study area and started conducting

the field studies which comprised largely with secondary data collection through literature,

participations in meetings, in-person interviews, site visits, household questionnaire survey and participation in different activities related to the research topics. The household questionnaire survey was conducted during May 2009-June 2010. The researcher with the involvement of one of the community groups in Patan surveyed 256 households with a research

population of 6321 households. The questionnaire contained 78 major questions with 181 variables.

The next tool of the research was participation. In this process, there were activities like radio interview, seminar, training, conferences participation and paper presentations, elective course offerings, awareness building, guest lecturing, participation in traditional rituals and festivals etc. during the research period. The participation enabled researcher to understand the actual context in the case area and contributed in knowledge sharing. The period of field work ended in the month of June 2010.

Next important period of research was period of data analysis, findings and conclusion. It started in the month of July 2010 and ended in August 2011. During this period, researcher did two credited course in University of Alberta, Canada on Community based resource management and Risk and vulnerability. The data analysis phase has contributed to establish new knowledge as conclusion. According to the data analysis, research identified the existence of several active community based organizations are active in selected communities for community development. They have developed a mechanism of fund raising and collection of such resources for their activities. The household questionnaire survey in Patan revealed that all selected roles are highly vulnerable in physical terms and are moderately vulnerable in social and cultural terms. Hence, along with physical vulnerability reduction, it is needed to increase the adaptive capacities of local communities. The data analysis also revealed that the historic trend of community participation for common good is still active and moderately high in traditional settlements of Kathmandu valley. It also explored that communities in such settlements are interested to participate in earthquake vulnerability reduction activities if such activities avail the livelihood opportunities. According to the data, communities are interested to contribute some amount of their earnings for a community pool of resources as there is an opportunity to develop such pool at community level for disaster risk reduction.

The data analysis contributed to find the answer to the research question. According to the findings of research, it could be narrated that despite of existing physical, social and cultural vulnerabilities in terms of earthquake disasters, the long history of participatory physical and social development activities as the culture and tradition of communities has contributed for the evolution of present day

community based initiatives. Such initiatives are actively engaged in the area of common cause, community benefits and use of common properties at local level at present. The moderately high participatory trends should be capitalized to reduce the earthquake vulnerability in the selected communities. While capitalizing participatory trend, culture, tradition and interest, the program goal should be focused on recurrent issues of community people and increase their adaptive capacities. In order to increase the adaptive capacity, resilience governance should be established. In order to establish and operate in a perpetual manner, resources and funds are required at local level. The concept of 'community basket' would be appropriate in fostering the existing consumers' cooperative or developing a new one at the local level to work in earthquake vulnerability reduction in particular and in the area of Disaster Risk Management in general.

At the end of fourth year of studies, in April 2012, the researcher submitted the preliminary draft copy of dissertation and findings and did a departmental presentation to Departmental Research Committee of Department of Architecture and Urban Planning, TU. Researcher also revisited the case study area of Patan, interviewed the youths involved in the research earlier, and reviewed and revisited the existing knowledge in community based disaster management and in research methods. According to the reviews and revisits, the findings and answers to the research questions were validated. The review and revisits also contributed to understand the resilience governance in details. Besides, the research methodology adopted in this research appeared to be close to the contemporary research method called as community based participatory research' which is popular in North America since last 25 years. The researcher then rewrote the dissertation addressing the comments, suggestions and remarks from supervisors, professors and the community people and submitted the final draft in September 2012.

The researcher admits that there are some limitations of the study. This research has not been able to study the management aspects of consumers' cooperatives. Such cooperatives are important to foster resilience governance at community level as the research has identified. Similarly, the research has not been able to discuss on resource generation at local level as needed. It just highlighted the concepts developed by one of the local youth groups in Patan in the name of Heritage Walk. Such concepts are to be studied in details as those could contribute for perpetuity of resource generation to be utilized through cooperatives. The research has proposed process of vulnerability assessment to incorporate physical, social and cultural aspects of the selected communities however it has not been able to develop a complete tool for the purpose. Hence there is a need of vulnerability assessment tool developed in future.

Graduation Year December 2013

Thesis Title : A STUDY ON THERMAL PERFORMANCE OF TRADITIONAL RESIDENTIAL BUILDINGS IN KATHMANDU VALLEY

Submitted by : Sushil Bahadur Bajracharya

Supervisor: Prof. Dr. Sudarshan Raj Tiwari

ABSTRACT

This thesis seeks to investigate in to the aspects of thermal behavior of traditional residential buildings in traditional settlements of Kathmandu valley. It inquires how people have been living in these traditional houses in winter as well as in summer from generation to generation for many centuries. Till today, the quality of traditional houses of Kathmandu is same as in the Lichhabi and Malla period more than fifteen hundred years back. This thesis posits that, it is possible to achieve thermally comfortable environment in cool winter and hot summer in Kathmandu through the use of time-tested, thermally comfortable traditional design, materials and technology. The present thesis takes a closer look at the theories, practice and psychology of thermal environment in general and residential environment of Kathmandu in particular. Nicol (Humphreys 1978) has conclusively identified that, the indoor neutral comfort temperature of any acclimatized population directly relates to the mean outdoor temperature. Thus the neutral comfort temperature varies for every geographical region as local people adapt themselves to remain comfortable (Humphreys 1978). However, there are no studies done in Nepal that have reported thermal comfort and thermal behavior of traditional residential building in traditional settlement of Kathmandu valley. There are however few studies done in Nepal that have reported evaluation of thermal comfort in different building in different climatic regions of Nepal. It begins with a brief review of the concept of traditional residential building from the past to the present followed by analysis of climate of Kathmandu and short review of passive design aspects of various controls used in composite climate. This thesis then proceeds to analyze the detailed field data collected, with a view to identify the indoor thermal environment with respect to outdoor thermal environment in different seasons taking into consideration various variables such as design, planning, orientation, material, construction technology, room height, etc. This collected field data is then compared with the contemporary residential buildings of Kathmandu. Therefore, a detailed field data has been conducted, in order to get a deeper understanding of thermal behavior of these buildings in traditional settlement of Kathmandu. Regression analysis has then been performed to obtain thermal performance of x buildings

with different conditions. A new formula was invented from regression analysis to predict indoor air temperature from outdoor temperature in these buildings. The regression equation obtained for Kathmandu is tested with Nicol's data (Nicol et al. 1994) and Rijal data for Bhaktapur of Kathmandu valley in Nepal. This thesis then analyzed the data collected in a laboratory with experiments of different materials and construction technology adopted in traditional, contemporary and modern green buildings in Nepal. This collected lab data has been analyzed with a view to identify the role of materials and technology with collected field data for indoor thermal environment. There is field information about the thermal comfort sensation, preference and recommendation of residents of different buildings of these settlements. The thesis concludes that, thermal behavior of traditional residential building, adapted in various ways to the changing thermal regime for thermal comfort is better than that of contemporary buildings. It finds evidence to prove that planning, material and technology used better for local climate are to the satisfaction of the local people

Graduation Year April 2014

Thesis Title : **TEMPORAL AND SPATIAL VARIATION IN SOLAR ULTRAVIOLET RADIATION AND ITS CALIDATION OF SATELLITE ESTIMATES IN NEPAL**

Submitted by: **Niranjan Prasad Sharma**

Supervisor: **Prof. Dr. Bal Krishna Sapkota**

ABSTRACT

This thesis presents the Solar Ultraviolet Index (UVI), comparison in four measurement sites of Nepal: Kathmandu (27.72°N, 85.32°E), Pokhara (28.22°N, 83.22°E), Biratnagar (26.45°N, 87.27°E) and Lukla (26.45°N, 87.27°E), located at an elevation of 1350m, 800m, 72m and 2850m respectively from the sea level. The comparison is based on (I) ground-ground comparison and (II) satellite-ground comparison. The measurement instruments used are the NILU-UV irradiance meter, the Ozone Monitoring Instrument (OMI), the Microtops II Sunphotometer and the Moderate Resolution Imaging Spectroradiometer (MODIS). The study was done for all sky conditions. During the study, the mean bias difference for Kathmandu (KTM) and Biratnagar (BRT); KTM and Pokhara (PKR) was found to be 4.8% and -38.1% respectively (Paper I). The higher and lower mean bias difference indicates large and small deviation in UV data. The UVI in PKR was found to be higher than the UVI at KTM and BRT (Paper I). The study shows that OMI overestimate the ground based (GB), data and the correlation between satellite derived and ground measured ozone was found to be 0.91 and 0.89 in Kathmandu and Lukla (LUKL) respectively (Paper II). During winter season the relative percentage difference between GB and OMI UVI was higher in Biratnagar in comparison to other sites (Paper III). During this study the higher values of Aerosol Optical Depth (AODs) and OMI estimation were observed during the months of March to May (Paper IV). Further study showed that the ratio of predicted OMI, UVI to that determined from ground based measurement is less than 1.21 except for Lukla (Paper V). More importantly, this work validated the satellite estimation. Comparing the predicted data on the basis of regression equation, the ground based data was matched

Graduation Year April 2014

Thesis Title : PHYSICAL AND CHEMICAL PROPERTIES OF AEROSOLS OF HIMALAYAN REGION AND THEIR IMPACT ON SOLAR RADIATION

Submitted by: Ram Kumar Sharma

Supervisor: Prof. Dr. Bal Krishna Sapkota

Prof. Dr. Mohan Bikram Gewali

Prof. Dr. Berit Kjeldstad

ABSTRACT

This thesis presents spatial and temporal variation of elemental carbon and black carbon in four measurement sites of Nepal: Kathmandu (27.72°N, 85. 32°E), Bhimdhunga (27.73°N, 85.24°E), Nagarkot (27.42°N 85.31°E) and Biratnagar (26.45°N and 87.27°E). Total solar radiation and its correlation with aerosols are also presented. In addition to this, variation in particulate matters and aerosol optical thickness of Kathmandu is also included. Kathmandu is densely populated, capital city of Nepal. Bhimdhunga and Nagarkot are rural outskirt of Kathmandu. Biratnagar is a suburban industrial area located in the Terai region (Flat land) close to the industrial state of India, Bihar. These four study sites are located at an elevation of 1350m, 1459m, 1905m, and 72m respectively from the sea level. The instruments used were Aethalometer, Pyranometer, Microtops II Sun photometer and Ambient Air Sampler.

Elemental Carbon (EC) and Black carbon (BC) aerosols were measured from 2008 November to December 2010 using Aethalometer. The same instrument was deployed in Biratnagar (290 km east from Kathmandu) from January to May 2011, in Nagarkot (32km east of Kathmandu) from July 2011 to January 2012. Carbonaceous aerosols were also monitored in Bhimdhunga (18km west of Kathmandu) in January 2013.

Twenty-four hours particulate matters samples in Kathmandu show variation of particulate matters from 56.4-105.1μg/m³ and black carbon varies between 4.7 and 21.8 μ g/m³ (Paper IV).Particulate matters show 13 nonionic and 10 ionic components with highest concentration of Si followed by Fe irrespective to the nature and mass of particulate matters analyzed(Paper IV). Organic carbon (OC), Elemental carbon (EC) and Total (TC) obtained from thermal analysis of particulate matters show concentration variation of OC in between 4.8-18.2 μg/m³ where as EC from 3.9-10.2 μg/m³. The variation of TC lies in the range of 8.7-2.0 μg/m³. This shows the contribution of OC in particulate matters from 7.2-29 percent where as EC between 6.5-20 percent. There is more contribution of OC than EC in the particulate matters of Kathmandu. Aerosol optical Depth (AOD500) was between 0.2-1.0 within October 2009 to March 2010. Angstrom exponent (a340-675) for the same duration lies between0.41 and 2.82. Most of the time, a was greater than 1 inferring the domination of small size particle. Monthly average of total solar radiation was maximum in May (21.9+5.5) MJ/m² and minimum in December (11.8±1.4) MJ/m². Monthly average carbonaceous aerosol and total solar radiation shows negative correlation (r = -0.9).

Two high peaks of EC and BC were observed in Kathmandu, one in early morning around 09:00 and another in late evening around 20:00 local time (Paper 1). Highest monthly

average value (14.9+2.3)μg/m³ was observed in January and lowest (3.1±0.6) μg/m³ in July. Winter shows the highest value and monsoon monitors the lowest one. There is higher anti correlation between BC and Rain than BC and wind in Kathmandu. Further, the variation of black carbon in Kathmandu is influenced by local events like festivals and strikes (Paper I). BC is reduced nearly half to its concentration in strike days than the general working days (Paper II). Rain plays a significant role for reduction of BC from atmosphere. The contribution of BC by vehicles and industries is nearly 50 percent in Kathmandu (Paper III). In Bhimdhunga, EC and BC both show a single peak in diurnal pattern. This variation was not very distinct in Nagarkot. Monthly average of EC and BC provides a maximum (3.6±1.3)μg/m³ and (3.9±1.7)μg/m³ in November and lowest in July (1.3±0.4)μg/m³ and (1.1±0.3)μg/m³ respectively. In Biratnagar, carbonaceous aerosol was observed with two high peaks, one in the morning around 9:00 and another 20:00 late evening local time. It was found that evening peak is larger than morning peak indicating more fuel consuming activities in the evening than morning (Paper V). Monthly averaged highest value of EC and BC were recorded in January 20.7μg/m3 and 20.1μg/m³ respectively while lowest 3.2μg/m³ and 3.3μg/m³ in May. Highest value in January is attributed to winter and transboundary effect of aerosols (Paper V). Monthly average total solar radiation was minimum for the month of January and it gradually increases up to April. Further it has been found that spatial variation of aerosols and solar insolation is due to alteration in the source of pollution. Moreover its temporal variation is due to the change in weather pattern of the particular location

Graduation Year June 2014

Thesis Title: MATRIX TRANSFORMATION BETWEEN SWQUENCE SPACE AND THEIR PRACTICAL APPLICATION

Submitted by: Vinod Parajuli

Supervisor: Prof. Dr. Shailendra Kumar Mishra

Prof. Dr. Geeta Bhakta Joshi

ABSTRACT

The study of sequence spaces was motivated by the classical results of Summability theory in Functional Analysis. The results obtained by Cesaro, Borel, Nörlund and others at the turn of 20th century stimulated interest in general matrix transformation theory which deals with characterization of matrix mappings between sequence spaces by giving necessary and sufficient conditions on the entries of the infinite matrices. The first application of analysis to the theory of Summability was done by Mazur in 1927 when he proved now his famous Mazur's consistency theorem. An outstanding contribution and plenty of work have been done in the field of sequence spaces in last 50+ years.

Kizmaz [41] introduced the concept of difference sequence spaces. The work of Kizmaz was further generalized by Et and Cloak [66], Tripathy and Esi [19]. Tripathi, Esi and Tripathi [20]. Esi, Tripathy and Sarma [3] and others. In the meantime in constructing new sequence spaces the role of the infinite matrices

G(u,v) = (9nk):called generalized weighted mean;0≤ k ≤n0,k>nA= (Snk) (-1)-k 0, =n-1≤ k ≤n

0 < k < nork > n called the difference operator matrix; 1, S = (Snk):0≤ k ≤nk>n

the operator matrix A, which can be expressed as a sequential double band matrix

given byA1 -2 0 00002-30 and combination of them has been considered to represent difference operator. In thisconnection we have constructed new matricesk+1, S" =λ = (ank) = which is a lower unitriangular matrix and an operator sparse band matrix 2, which otherwise can be expressed as a sequential double band matrix given by 40000 to introduce the new sequence spaces.0 This thesis consists of six chapters.

Chapter one contains introduction with preliminaries and reviews.

Chapter two has been divided into two parts. The sequence spaces w(p), wo(p) and w. (p) were introduced and studied by Maddox [45]. In [12], the authors have introduced the sequence spaces Co(u, v; p), c(u, v; p), l(u, v; p) and in [29] I(u, v; p) and established some properties. Following this in the first part of chapter two, we introduce a set of sequence spaces w(u, v; p), wo(u, v; p), wo (u, v; p) by the application of the generalized weighted mean matrix G(u, v) as the operator, study some properties and find B- dual of w(u, v;p). We also characterize the matrix classes (w(u, v; p), la). (w(u, v; p), c) and (w(u, v; p).co). Recently in [78], the sequence spaces co(u, v; p. A), c(u, v; p. A), lo (u, v; p. 4) and I(u, v; p. A) have been introduced. Following this in the second part of chapter two, we introduce the

sequence spaces w(u,v; p,A), wo(u, v; p. A) and w(u, v; p. 4) by using the combination of the matrix G (u, v) and the difference operator matrix 4, study some
properties and find B-dual of w(u, v; p. A). We also characterize the matrix classes

(w(u, v; p. A), c), (w(u, v; p. A), co) and (w(u, v; p. A), n(t)).

Chapter three has also been divided into two parts. In [15] Choudhary and Mishra have introduced and studied the sequence space I(p) which is the set of all sequences whose S-transforms are in the space (p). Following this in the first part we introduce a new sequence space (p. 4) which is the set of all sequences whose S" = A transforms are in I(p). We compute B- dual of [(p. 2) and characterize the matrix classes (l(p. 2), c), ((p. 2). Co) and ((p.2), l). Similarly in the second part we introduce a set of new paranormed sequence spaces (p,A), c(p. A) and co(p,A) which are generated by the infinite matrix λ. We also compute the basis for the spaces c(p. 2) and co (p. 2), obtain B- dual of them and characterize the matrix classes (Loo (p. λ), Loo), (Loo (p. 2), c) and (l(p. 2), co).

In Chapter four, we introduce a set of new paranormed sequence spaces L. (u, v; p. A,) c(u, v; p,A) and co(u, v; p. ;) generated by the combination sparse band matrix A and the generalized weighted mean matrix G(u,v). We establish some topological properties, obtain the basis for c(u, v; p,A,) and co(u, v; p. A,) and find ß- duals. We characterize the matrix classes ((u,v. p.), I) ((u, v; p.), c) and (Loo (u, v; p. λ)). Co). Besides we give characterization theorem for the case of mapping that guarantees the given rate of convergence from the sequence space L. (p) to the new sequence space lo (u, v; p. 2).

In chapter five, we present a practical application of sequence space. In [26], the sequence spaces and function spaces on interval [0, 1] for DNA sequencing have been introduced and studied. The authors have introduced new sequence spaces by using generalized p-summation method and proved that these spaces of sequences and functions are Banach space. Based on the sequence spaces and function spaces on [0,1], we examine the behaviors of sequences generated by DNA nucleotides. We extend the results of authors [26] by introducing new basis function E-1 (v = 1,2,3,...n) which is the extension of existing basis function (EN) defined in the polynomial function on [0,1]. Besides, we introduce a new sequence
b = (bn) = Σvna, which can characterize DNA sequence where a, E (A, C,T,G) and A: Adenine, C: Cytosine, T: Thymine and G: Guanine are four types of nucleotides.

We conclude our thesis by providing conclusions and recommendations in chapter six.

Graduation Year December 2015

Thesis Title : **PREPARATION AND CHARACTERIZATION OF ACTIVED CARBON FROM LAPSI (CHOERASPONDIAS AXOLLARIS) SEED STONE FOR THE REMOVAL OF ARSENIC (III) FROM WATER**

Submitted by: **Rinita Rajbhandari (Joshi)**

Supervisor: **Prof. Dr. Raja Ram Pradhananga**

Dr. Lok Kumar Shrestha

ABSTRACT

Lapsi (Choerospondias illari, an indigenous fruit tree of Nepal) seed stone which contains about 32.3 % fixed carbon was used as a precursor for the preparation of high surface area activated carbon. Thermogravimetric analysis (TGA) was used to monitor the course of pyrolysis. A series of activated carbons were prepared from Lapsi seed stone powder (particle size < 300 pm) by chemical activation method using zinc chloride (ZnC) as an activating agent under Ny atmosphere. Effect of percentage of activating agent, carbonization temperature and carbonization time on the surface area, pore structure, pore volume and adsorption capacity was systematically investigated. The ratio of Lapsi seed powder (LSP) and ZnCl; were varied from LSP: ZC-1:0.25 (AC-0.25), 1:0.50 (AC-0.50), 1:1 (AC-1), 1:2 (AC-2) and 1:4 (AC-4) and carbonization temperature from 400°C to 800°C and carbonization time from 3 hour to 6 hour.

The prepared activated carbons were characterized by Fourier Transform Infrared (FTIR) spectroscopy, X-ray diffraction (XRD), Raman scattering, Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). Surface areas, pore volumes and pore size distributions were evaluated from nitrogen adsorption- desorption isotherms by Brunauer, Emmett and Teller (BET), Barrett-Joyner-Halenda (BIH), and Density Functional Theory (DFT) methods. It was found that surface area increases significantly with increasing LSP ZnCl; ratio from 1:0.25 to 1:0.5 and then remain apparently constant. However, total pore volume increased continuously with the LSP-ZnCl, ratio. Increase in temperature generally improved both the surface area and pore volume but increase in the carbonization time above 4 h decreased both the surface area and pore volume due to fusion of nanoporous framework into bigger pores. Chemical characterization of the activated carbons was performed by determining iodine and methylene blue numbers. Increase in carbonization temperature increases both the iodine and methylene blue number indicating increase in nanoporosity with high adsorptive capacity of the activated carbons. Quantitative analysis of carboxylic, phenolic and lactones functional groups was determined by the Bochm titration.

SEM observations showed highly porous surface structure of the activated carbons. XRD patterns exhibited broad peaks at diffraction angles 25 and 43 degrees corresponding to the (002) and (001) planes of graphitic clusters. These broad peaks are the indication the amorphous structure of the prepared activated carbons, which is further supported by Raman Scattering Spectra where two broad bands approximately at 1345 cm (D band) and 1588 cm G band) were observed. Thus the activated cathon prepared from Lape is amorphous materials having nanoporous (microporous

Activate carbon prepare with LSP to ZnCl, ratio 1:1, carbonized at 400°C for 4 hour (AC-1) as the optimum condition on the basis of economic reason and with reasonably high BET surface area, pore volume, lodine namber and Methylene blue Number was selected for iron impregnation for the adsorption of arsenic. The iron impregnation was camed by chemical precipitation method and the content of iron was examined using FTIR, XRD, Raman Scattering Spectroscopy and SEM. The butch adsorption studies of As (III) were carried out with iron impregnated activated carbon (AC-L/Fe) and the effect of pH, adsorption dose and contact time on the efficiency of As (III) adsorption was investigated Iron impregnated nanoporous carbon showed excellent arsenic adsorption capacity and could decrease arsenic content in water from 800 ppb to below 50 ppb. Maximum adsorption of 95.9% was achieved at pH > 6. The optimum conditions for adsorbent dose were calculated to 2gt at pill 6. The adsorption of arsenic progressively increased with time and reached equilibrium in about 120 minutes. The adsorption equilibrium data of As (III) better fitted with Langmuir isotherm than with Freundlich isotherm. The maximum adsorption capacity was found to be 2 mg/g. The adsorption free energy, AG was calculated to be -32.2 kJ mol. The separation parameter R was found to be 0.772, which shows the favorability of the adsorption isotherm. The kinetic data better fitted the Lagergren pseudo second order kinetics

Key words: activated carbon, Lapsi seed, adsorption, Arsenic (III), surface area, pore size distribution, adsorption isotherm, adsorption kinetics

Graduation Year January 2015

Thesis Title: **STUDIES ON ABSORPTIVE REMOVAL OF Pb(II), Ni(II) and Cd(II) IONS FROM WATER BY ACTIVED CARBONS PREPARED FROM LAPSI (CHOEROSPONDIAS AXOLLARIS) SEED DSTONE**

Submitted by: **Rajehswar Man Shrestha**

Supervisor: **Prof. Dr. Raja Ram Pradhanananga**

Prof. Dr. Bhadra Prasad Pokharel

Dr. Amar Prasad Yadav

ABSTRACT

Lignocellulosic materials such as coconut shell and fruit stones were abundantly used for the preparation of activated carbon because of their availability at a low price, hardness and high density. In the present study, Lapsi (Choerospondias axillaris) seed stone, a waste product of Lapsi, an indigenous plant of Nepal was used as the precursor for the preparation of activated carbon. The percentage of carbon, hydrogen, nitrogen and sulphur and proximate analysis of Lapsi seed stone powder were recorded. The percentage of carbon, hydrogen, nitrogen, oxygen and sulphur was found to be 49.98 %, 5.07 %, 1.47 %, 43.47 and 0.01 % respectively. In proximate analysis the moisture content, ash content, volatile matter and fixed carbon content were determined and found to be 0.29%, 2.94%, 63.97% and 32.8 respectively.

A series of activated carbons was prepared by chemical carbonization and thermal carbonization of the precursor. In chemical carbonization Lapsi seed stone powder (particle size < 300 um) was carbonized with concentrated sulphuric acid and a mixture of concentrated sulphuric acid and concentrated nitric acid. The resultant carbons were characterized by FTIR, Boehm titration and SEM. The use of nitric acid induced more oxygenated surface functional groups with higher adsorption capacity for Pb(II) and Ni(II) ions. The effect of pH, contact time and adsorbent dose was studied by batch adsorption technique. The optimum pH for adsorption of Pb (II) and Ni(II) was found to be 5 The adsorption equilibrium data was analyzed by Langmuir and Freundlich adsorption isotherms. Langmuir isotherm was found to be better fit than Freundlich adsorption isotherm. Adsorption kinetic data followed pseudo second order kinetics. Negative values of Gibbs free energy for adsorption (AG) show the spontaneity of the adsorption of the metal ions.

In thermal carbonization Lapsi seed stone powder was carbonized in horizontal tubular furnace with different amount of phosphoric acid as activating agent. Thermogravimetric analysis (TGA) of Lapsi seed stone was carried out to determine optimum condition for carbonization. The effect of carbonization time, temperature

and different ratio of the precursor and phosphoric acid were also studied. The best activated carbon with high specific surface area was obtained when the ratio of lignocellulosic material

and phosphoric acid was 1:1 and the temperature of carbonization was found to be 400 "C with carbonization time 4 hours. The activated carbons prepared were characterized by determination of iodine number and methylene blue number. Surface morphology of activated carbon (AC) was accessed by SEM and surface functional groups were analyzed by FTIR. Surface area and average pore diameter of activated carbons was determined by N, adsorption/ desorption using BET isotherm. XRD analysis was carried to know the extent of amorphous structure of activated carbon. The Boehm titration was carried out to estimate acidic surface functional groups:

The adsorption of Pb(II), Cd(II) and Ni(II) from aqueous solutions by activated carbon was investigated by batch adsorption method. The effect of various parameters like pH, adsorbent dose and contact time on the removal of Pb(II), Cd(II) and Ni(11) was studied. Optimum pH for the adsorption of Pb(II), Ni(II) and Cd(II) was found to be at 5 and 6 respectively. The optimum adsorbent dosage for the adsorption of Pb(II). Ni(II) and Cd(II) was found to be 2g/L.The time required to reach equilibrium is about 180 minutes. The adsorption equilibrium data was analyzed by Langmuir and Freundlich adsorption isotherms. The Langmuir isotherm was bette fit than Freundlich one with higher values of coefficient of determination (R2-0.990, 0.998 and 0.997 for Pb(II) Cd(II) and Ni(II) respectively). Monolayer adsorption capacity of Pb (II), Ni (II) and Cd(II) are 131.0 mg/g, 37.0 mg/g and 28.0 mg/g respectively. The adsorption kinetic data were analyzed by pseudo first and second order kinetics. The kinetic data were better followed pseudo second order kinetics. The values of Gibbs free energy constant (AG) are -26.6 kJmol" for Pb(II), -24.7 kJmol' for Cd(II) and - 25.5 kJmol for Ni(II). The -ve values of the Gibbs free energy indicated that the adsorption process is spontaneous.

Keywords: Adsorption, Activated carbons, Lapsi seed stone, Heavy metals, Chemical activation,. Adsorption capacity, Adsorption isotherms, Adsorption kinetics

Graduation Year April 2015

Thesis Title: **ESTIMATION OF GLOBAL SOLAR RADIATION POTENTIAL IN NEPAL**

Submitted by: **Khem Narayan Poudyal**

Supervisor: **Prof. Dr. Bal Krishna Sapkota**

Prof. Dr. Binod Kumar Bhattarai

Prof. Dr. Berit Kjeldstad

ABSTRACT

This research work aims to estimate and measure the daily global solar radiation (GSR) using CMP6 pyranometer at low altitude of Biratnager (26.45" N, 87.27° E, and 72 m), mid altitude of Pokhara (28.22° N, 83.32° E, 800 m), high altitude of Lukla (27.69° N to 86.73° E, 2850 m) and metropolitan city Kathmandu (27.72°N, 85.5°E, and m) since 2009. The annual average GSR in Biratnagar, Pokhara, Lukla and Kathmandu was 4.21, 4.87, 3.70, and 4.69 kWh/m2/day respectively. There is an average 10.81 percent increment of GSR (average 0.48 kW/m²/day) per km with increase in altitude on clear sky days (Paper I and II). In addition, Kathmandu is located about 550 m above Pokhara even though the GSR values are more in Pokhara than in Kathmandu. This might be due to the result of special topography with the bowl shaped valley, and local weather condition which is different than in Pokhara. The measured data was also used to study the diurnal, monthly, and seasonal variation of GSR. The maximum value of GSR was found during the spring season and minimum in winter. However, in Lukla, the minimum amount of GSR was found in summer due to more cloudy days. In Lukla, coefficient of determination was obtained as high as 0.97 that ensures the strong relationship between cloud transmittance factor and clearness index (Paper III).

The modified Angstrom-type equation was used to find the regression coefficients. The regression coefficients, 'a' and 'b' were calculated as (0.40, 0.15), (0.43, 0.23) and (0.21, 0.26) for Biratnagar (BRT), Pokhara (PKR) and Kathmandu (KTM) respectively. The regression coefficients and sunshine duration are utilized to estimate the GSR for the years from 2011 to 2013 in the three sites BRT, PKR and KTM. The obtained regression coefficients and sunshine duration were used to estimate GSR where there is no ground based data (Paper IV).

The Donatelli-Campbell-Bristow-Bellocchi (DCBB) model was selected to estimate GSR. Calibrating and validating this model with statistical tools, obtained coefficients, maximum and minimum temperatures were utilized to estimate the GSR for Kathmandu, Nepal (Paper V).
Coefficients of DCBB model and temperatures (Tmax, Tmin) were used for the prediction of GSR for different years 2010, 2012 and 2013. The predicted value of GSR in KTM for the year 2020 is estimated to be 5.38 kWh/m²/day.

Calculation shows one percent of the total area of Nepal can generate solar PV energy and solar thermal energy is 798.48 x 106 kWh and 1479.37 x 10° kWh per day respectively.

Graduation Year April 2016

Thesis Title: **NANOPORE ENGINEERING OF ACTIVED CARBON FROM LIGNOCELLULOSIC MATERIALS FOR DEFLUORIDATION OF WATER**

Submitted by: **Sahira Joshi**

Supervisor: **Prof. Dr. Raja Ram Pradhananga**

Prof. Dr. Bhadra Prasad Pokharel

Dr. Mandira Adhikari

ABSTRACT

Fluoride in drinking water above permissible levels is responsible for dental and skeletal fluorosis in human beings. Defluoridation is an effective technique to remove the excess fluoride from drinking water. Present study focused on the synthesis and characterization of nanoporous carbons from Lapsi (Choerospondias axillaris) seed stone and Supari nut (Areca catechu) for defluoridation of water.

A series of nanoporous carbons were prepared from various lignocellulosic materials using zinc chloride, phosphoric acid and sodium hydroxide as activating agents. Pore structure of resultant carbons was studied by determining iodine number and methylene blue number. Characterization of Lapsi seed stone and Supari nut was carried out by thermogravimetric analysis and elemental analysis. Surface morphology, crystalline structure and graphitic nature were investigated by SEM, XRD and Raman spectroscopy respectively. Surface area of activated carbons was determined by nitrogen adsorption/desorption using BET isotherm. Surface functional groups were analyzed by FTIR and Boehm titration. Pores in activated carbon were engineered by controlling ratio of activating agent to precursor, carbonization temperature and carbonization time.

The elemental analysis shows that carbon contents of Lapsi seed stone and Supari nut were 47.77% and 40.83% respectively. Thermogravimetric analysis indicates that the temperature required for carbonization for both lignocellulosic materials was 400 °C.

The nanoporous carbon with high surface area and porosity was obtained at (i) ratio of precursor to activating agent of 1:1 (ii) temperature of carbonization of 400 °C and (iii) carbonization time of 3 hours respectively. Under these preparation conditions, highest iodine number and methylene blue number of NaOH activated Lapsi seed stone carbon was found to be 758 mg/gm, 201 mg/gm and that of H3PO4 activated Supari nut carbon was 888 mg/gm, 369 mg/gm respectively. The NaOH activated Lapsi seed stone carbon shows highest BET surface area of 1002 m^2/gm and lowest value (ca. 0.94) of intensity ratio of G band and D band indicating a relatively lesser degree of graphitization. FTIR spectra show the presence of oxygenated surface functional groups such as hydroxyl, carbonyl and carboxyl. Result of Boehm titration shows that the H3PO4 activated Supari nut carbon contains higher amount of acidic surface functional groups such as carboxyl carbonyl and lactonic.
Nanoporous carbons having high surface area were modified as adsorbents by incorporating with Al3+, Fe and Zr" ions. Defluoridation of water using these adsorbents was conducted by batch adsorption method. In all cases, the optimum conditions for defluoridation of water are

(1) pH-2 (ii) adsorbent dose-20 gm/L and (iii) contact time - 180 min. The adsorption equilibrium data was fitted more to the Langmuir isotherm than to the Freundlich isotherm. Monolayer adsorption capacity of Zr-impregnated Lapsi seed stone and Supari nut activated carbon was 1.7 mg/gm and 6.5 mg/gm respectively. Adsorption capacity of Al2O3-Supari nut activated carbon composite and Fe2O3-Supari nut activated carbon composite was found to be 7.6 mg/gm and 4.8 mg/gm respectively. Among the prepared adsorbents, Al2O3-Supari nut activated carbon composite shows the best adsorption performance for defluoridation. Engineering of nanopores in the activated carbon from lignocellulosic materials and modification of carbon by incorporation of Al3+ Fe" and Zr" ions produced a good adsorbent for defluoridation of water.

Keywords: Adsorption, Nanoporous activated carbons, Lignocellulosic materials, Chemical activation, Adsorbents, defluoridation.

Graduation Year February 2017

Thesis Title: **RESIDENTIAL ENVIRONMENT FOR MULTICULTURAL URBANISM; A CASE OF NEIGHBORHOOD RESIDENTIAL PUBLIC SPACE OF KATHMANDUU**

Submitted by: **Sanjaya Uprety**

Supervisor: **Prof. Dr. Jiba Raj Pokharel**

ABSTRACT

This thesis seeks to contribute to the ongoing discursive construct on the debate of multicultural urbanism by studying it in different contexts of the old town of Kathmandu, which otherwise has been informed mostly by Western experiences. In a general sense, Multicultural urbanism is a way of life of people of different cultural backgrounds in cities. Such way of life has emerging properties which aims for finding out creative ways of living together with the differences. In a conferred sense, it can be conceived as the process of socio-cultural formation as a result of the social interactions between the urban dwellers having the different cultural background and their relationship with the physical environment, collectively known as human-environment relationship. In this, public spaces provide a setting for such social-cultural formation.

Human environment relationship as the basic building block of multicultural society has been the subject of various academic and practical investigations in Western nation- states, where multiculturalism is a social reality due to rapid immigration, to understand the process of social-cultural formation (collective national culture) at the national level. However, the equally important building block of multicultural society that is social- cultural formation at the micro level or at the level of residential living was found given scant attention. In growing Nepali multicultural contexts of urban living too, this has been a case especially in the development of the multicultural residential environment' in both existing and new residential development areas. Since public space is considered as one of the key elements of socio-cultural formation at micro level of multicultural living. this thesis examines the traditional multicultural residential environment of Kathmandu Valley. The traditional neighborhood exhibits a good traditional organization of residential public spaces to respond to the historical multicultural living of the Newar society in the past and the changing multicultural reality of the present. It also examines the new residential development to understand how human-environment relationship differs from the traditional residential setting

The Spatial practice involving use and appropriation of public space has been considered as one of the key elements of human-environment relationship. In a multicultural residential context, the neighborhood public space provides the material setting for participation in spatial practices and inter-cultural interactions between different ethnic groups. As such, this thesis explicates the multicultural dimension of neighborhood public spaces of a traditional residential neighborhood of the old town of Kathmandu, which has been a multicultural urban center since historical times. Although changing socio-economically now, the organization of urban spaces of the old town still exhibits its multicultural character in terms of its spatial use and appropriation by different cultural groups. Historically, it developed as a multicultural center inhabited by the indigenous Newar community containing multiple ethnicities. By considering the original Newar identity containing multicultural groups who now live along

with other in-migrant ethnicities, the thesis examines how public spaces were organized over time in history, to form the basis of multicultural urbanism.

The thesis takes a closer look at the theories focused on the implications of multiculturalism, multicultural urbanism, and public space. In doing this, the liberal political theory of multiculturalism is reviewed so as to highlight the theoretical underpinnings of different forms of multiculturalism and its implications on the social- cultural formation, both at the national and local level of multicultural living. On reviewing the urban social theory related to public spaces, it is learned that there is no conceptual closure of the role of public space in socio-cultural formation. While the enlightened traditions of urban planning and urban design conceptualizes public space as planned sites for social interactions resulting from chance encounters environmental psychology, the new visions of planning see it as a social setting for meaningful public participation and civic engagements for socio-cultural formation. Although such participation and engagement are at the core of the pervasive theorizing of multiculturalism, this is limited to the sense of providing definite concepts related to the socio-cultural formation at the level of local living. In this sense, multicultural urbanism in this thesis is conceived as "sensitizing concept (Blumer, 1969: 148)" and the literature review provided a 'guide for inquiry' rather than suggesting a definite set of substantive hypotheses. From literature study, it is learned that all multicultural debates in many ways focus on participation in inter-cultural interactions to overcome the cultural differences both at the national and the local level of living. At the local level of living, the literature survey was suggestive of the significance of residential satisfaction in socio- cultural formation in a multicultural residential environment. Using the Lynch (1981) framework of control as a strategy for human-environment relationship, the guide for the inquiry was elaborated.

The nature of multicultural reality (ontology) of the residential neighborhood could not be approached objectively to claim absolute truth or the likely truth about the multicultural phenomenon as in positivists and post-positivists paradigms. So the methodology for the study included interpretivism research strategy or phenomenology which is linked to Webber's verstehen (interpretive understanding) as the main approach and valid source of knowledge (epistemology) within the interpretivist research paradigm. Since verstehen required observation of the phenomenon in its natural setting so that focus is on to interpret how the respondents make sense or meaning of their own circumstances, two variation case studies were carried out using the "sense of place" as the frame-work of analysis. Data has been collected in two case study areas; the traditional neighborhood of Yetkha and the newly planned residential neighborhood of Gongabu Residential Area (GRA) located outside of the old town. Long interviews were carried out including sixteen selected residents from Yetkha-Baha neighborhood and 10 residents from GRA. The qualitative data generated were classified and interpreted for understanding the reality of multicultural urbanism of the neighborhood.

The thesis begins with the contextualization of the traditional planning concept as the basis of human-environment relation in the Newar town setting, through the explication of the historical urban development of Kathmandu, from ancient times to the changed context of today. It examines the structural forces that have an important bearing on the Newar society and Newar identity by describing the contended notion of Newar identity, the normative role of social institutions (Guthi) and the concept of the caste system and its traditional spatial implication. Through the study of a typical residential neighborhood of Yetkha-Twah, the study highlights the concepts of traditional planning and resident's participation in the use and appropriation of public spaces in this urban fabric. The spatial practice in relation to use and

appropriation of the neighborhood and town spaces is examined to explain the socio-cultural formation among different cultural groups of Newars. By means of on-site observation, the thesis then analyzed a typical residential cluster, Yetkha Baha within Yerkha neighborhood. In this, the concept of participation is explained in relation to the neighborhood public spaces and its consequences on socio- cultural formation under multicultural condition. The main factors emerging from residents' sense of place in the case study area are identified. These factors are then used to assess the sense of place and its relation to the neighborhood public spaces in a newly- planned residential neighborhood, Gongabu Residential Area, located outside of the old town.

In direct connection to the research question, the thesis finds that the historical basis for multicultural urbanism, over a period in Kathmandu's history, stemmed mainly from the medieval period when small settlements characteristic of trade streets and market squares of Kirata and Lichchhavi periods were integrated into one traditional urban center (chapter four). Former public spaces characteristic of market activities provided towns with an important arena for the assimilation of successive migrant groups from the Northern Himalaya and the Southern Plains with the indigenous population of Kathmandu. The 'diametric or moiety model' of the genesis of old Kathmandu which is expressed in human territoriality through periodic ritual calling and actualization of a town's public spaces, the enduring presence of a ritual king or 'Thakajuju' even today in respective moieties, and each moiety having a spatial entity of a protective deity suggested the integration of ethnicities of earlier small settlements. Such integration. among others, aimed at creating strong relationships and positive social bonds between different ethnicities from these moieties. The absence of a strong and dominant value center as a consequence of the religious faiths of Hinduism and Buddhism throughout the medieval period indicated a level of co-presence and tolerance significant of a collective culture.
Similarly, another aspect of the historical basis of multiculturalism is found to be related to the organization of town spaces based on the cosmic principles of Mandala planning which is characteristic of moral and physical ordering of the town spaces. It provided the basic cosmic canons for structuring the Newar society into a caste hierarchy based upon purity-impurity oppositions and its spatial implications. The case of Yetkha- Twah (chapter five and six) showed the visual evidence of the Mandala as a pervasive model in the design of the built environment at the conceptual levels of human existence and its purposeful actions starting from the dwelling, its site, orientation and relative proportions to the town layout as a whole, combined with distinct socio-cultural activities. Accordingly, the spatial disposition of caste hierarchy was made by forming various caste-based socio-economic neighborhoods from families having the same profession. Such neighborhoods were organized around various hierarchies of public spaces which served as boundaries as well as the material setting for social interactions between different castes. The basic idea of this cosmic Mandala set-up seemed to reduce the overall heterogeneity caused by multiple ethnicities through their spatial management into pockets of ethnic neighborhoods. Such ethnic neighborhoods maintained their own ethnic identity and shared the common conditions of city life with other ethnic groups through the shared public spaces which were organized in such a way that interactions were a necessary condition of residential living. As man-made environments, each ethnic neighborhood was formed with mixed religious faiths and its public spaces had religious monuments to represent a mix of Hindu and Buddhist cultures and community artifacts (viz. wells) to be socially used by neighborhoods containing diverse ethnicities. The pattern contributed to the creation of a 'mosaic scenario.' in which interactions between the different ethnicities were sought and socio-spatial provisions were made through the organization of communities along caste lines and shared spatial networks. Socio-spatial provisions in a way

served as an understandable boundary between mosaic tiles bringing larger interactions between different Newar cultural groups.

Such an arrangement is found to be the characteristic of intercultural and fragmented pluralism forms of the multiculturalism of which the former is more prominent. The findings give useful leads to clarify the theoretical concepts of understanding of the
multicultural urbanism. And in the changed multicultural context of today, the thesis finds that the satisfaction of the residents is the key to the socio-cultural formation or multicultural urbanism. The satisfaction level of the residents is related to the transformative potential of the built-form and the capacity for the multiplicity of the neighborhood public spaces to cater to the economic, socio-cultural and safety needs of the residents. The potential for transformation and multiplicity of the neighborhood spaces is characterized by the organization patterns of neighborhood spaces, in terms of the configuration of residential blocks, shared ownership and inclusive social and physical accesses to common public spaces and socio-cultural resources for different income groups.

The thesis concludes that the basis for socio-cultural formation is expressed in a number of behavioral and attitudinal variables related to the social relationship among multicultural groups and their relation to the physical environment. In the context of participation to control the residential environment, there are noticeable distinctions as well as commonalities between the old and the new contexts of planning. There are conceptual similarities in the way residents participate in controlling the environment they dwell in. The organization of neighborhood public spaces is important for the residents, as it can provide the setting for natural, meaningful and goal-oriented participation. This evidences that the multicultural relations are the consequences of the meaningful engagements not by choice but as a necessary condition, created by the organization of public spaces. Given an interaction setting for natural participation, people will adapt to the place and in such adaptation process, multicultural relations are formed. In the lack of such necessary condition, intercultural interactions were voluntary and optional; there was often no common and clearly defined goal, which resulted in weak socio-cultural formations as in the case of new context of planning in Gongabu Residential Area. It thus contributes in fulfilling the gap in the urban theory of multicultural urbanism by identifying the 'natural participation' as the necessary condition for multicultural living and a particular way of public space organizations can provide the setting for such natural participation

Graduation Year May 2018

Thesis Title: DEVELOPMENT OF ROBUST INVISIBLE WATERMARKING ALGORITHM USING SLANT TRANSFORM

Submitted by: Roshan Koju

Supervisor: Prof. Dr. Shashidhar Ram Joshi

ABSTRACT

Digital data can be stored and transmitted efficiently, effectively and economically. They can be copied without any loss of fidelity and copy of data exactly resembles with the original one. They can be edited easily as one can access the exact discrete locations need to be changed. For such cases, Digital Watermarking Technique can be used for copyright protection and authenticity.

In this thesis, an invisible hybrid digital watermarking is proposed using Slant transform along with discrete wavelet transform and singular value decomposition. To evaluate the performance of algorithms, the scaling factor is varied from 0.01 to 0.1. Proposed watermarking algorithms are tested for various geometric attacks and compression attacks. Apart from developing watermarking schemes, the selection of better color space for embedding watermark images in case of color images is also discussed. Mathematical tools like peak signal to noise ratio, normalized correlation, bit error rate, accuracy. precision and recall were used to validate the results.

Imperceptibility test was carried out using peak signal to noise ratio. Algorithms were found to be highly imperceptible as PSNR value observed in all cases were greater than 35 dB. Bit error rate and Normalized cross correlation values were used to evaluate recovery test and robustness. It was observed that watermark recovers better with higher values of scaling factor. That is value of normalized correlation values increases as value of scaling factor. Similarly, value of bit error rate decreases as value of scaling factor increases. For robustness test images were passed through various attacks like histogram equalization, median filtering, sharpening, blurring, cropping at various position, JPEG compression, Gaussian and Salt and Pepper noise attacks and found to be robust against them.

Keywords: copyright protection, frequency domain watermarking. Jpeg 2000 compression, semi blind watermarking, slant transform

Graduation Year May 2018

Thesis Title: **A STUDY OF AEROSOL OPTICAL DEPTH AND ITS ALTITUDE VARIATION IN NEPAL**

Submitted by: **Manoj Kumar Thapa**

Supervisor: **Prof. Dr. Binod Kumar Bhattarai**

Prof. Dr. Shekhar Gurung

ABSTRACT

Atmospheric aerosols, through their direct and indirect effects, provide a predominantly cooling contribution to the global radiation budget. Their integral optical activity is summarized in the Aerosol Optical Depth (AOD) that can be derived from the measurements of transmitted solar radiation. This thesis presents spatial and temporal variation of AOD measured at Simara (27° 10' N, 84° 56' E), Kathmandu (27° 37' N. 85 22'E), Kharipati (27° 41'N, 85° 27'E), Nagarkot (27° 40′ N, 85° 12'E) and Chandragiri (27° 40' N, 85°12' E).

Aerosol optical depth was measured using Microtops II Sunphotometer (Serial No. 12575 and No. 17893) in clear sky condition for different periods between December 2011 and February 2017. Angstrom's parameters a and B were used to characterize AOD. The measured AOD shows a clear diurnal variation having maximum value (1.20 on 2 May 2012) in the morning and a minimum of (0.22). The high value of AOD in the moming is due to the high relative humidity (80.5%) than in the late noon. The data shows a seasonal variation with high values in pre-monsoon (0.95) and low (0.40) in post-monsoon. The post-monsoon increase of AOD is due to the high industrial emission and wind speed producing large quantity of wind driven particles. Moreover the values of AOD in pre-monsoon (0.45) are higher in longer wavelengths, and they show that coarse particles contribute more to the variation than fine particles. The values of AOD in Kathmandu lies between 0.203 ± 0.050 (December) and 1.022 ± 0.351 (May).

Generally, aerosols are characterized by Angstroms exponent a and coefficient B. The average value of a in Kharipati was 1.011 0.158 indicating the domination of fine particles in air and 0.845±0.300 in Nagarkot, showing coarse particles are dominating. An anti correlation between solar radiation and Angstrom's coefficient ß was observed in Kathmandu Valley. This relies on the fact that ß representing aerosol number concentration in vertical column produced more extinction of solar radiation. The average value of ß lies in between 0.257 0.071 to 0.400 0.233 during the measurement period in Kathmandu inferring heavy particulate pollution. In Chandragiri, a and B were observed to be 1.348±0.308 and 0.025 ± 0.020 respectively showing blue and clean Rayleigh atmosphere.
AOD decreases with the increase in altitude because of thin atmosphere. This study found the altitudinal variation of AOD is obtained by the equation y = 0.733 where y = AOD and x = altitude in meters. The thesis concludes thw AOD are the better parameters to quantify the air pollution than the traditional high volume sampling method.

Graduation Year December 2018

Thesis Title: **MULTI-CRITERIA EVALUATION OF RURAL TRANSPORTATION PROJECT: A CASE STUDY OF NEPAL**

Submitted by: **Sahadev Bahadur Bhandari**

Supervisor: **Prof. Dr. Rabindra Nath Shrestha**

Prof. Dr. Padam Bahadur Shahi

ABSTRACT

Transportation projects are pillars of the overall development. The demand for such infrastructure is always of a high priority for any community and for the country. However, scarce public resources are not in a position to realize such requirements or the demands. In other words, proper and rational utilisation of limited public funds is the focus of the planning and it must be supported by the justification of the supremacy of a particular project over other similar projects before the implementation of such projects. Therefore, project selection process must have an adequate methodology based on well-defined criteria and their considerations. The evaluation of such competitive projects is indispensable for decision making towards the implementation. There are various methods in practice for conducting the evaluation. Most of the conventional methods are based on the monetary matter, i.e. related to the costs and benefits in terms of money. However, transportation projects, especially rural roads are built for the achievement of several objectives and these projects should be supported by the principle of sustainability. This research is focused on the identification of criteria and sub-criteria and their respective weightages for the evaluation of competitive rural road projects.

The study is instigated by the rigorous literature review of evaluation techniques of transportation projects during the planning stage. Various multi-criteria tools such as Regime, AHP, PROMETHEE, Multi-Attribute Utility Approach, TOPSIS Method, Weighted Scoring Method, ANP, MOORA, Likert Scale, and GIS have been accustomed before entering into the core objectives of the research. AHP and Likert Scale were found more suitable to quantify the weights of evaluation factors of the transportation projects. The qualitative approach of the research is comprised of a pilot questionnaire survey cum in-depth interview and main questionnaire survey with Nepalese and foreign experts working in this in Page pondents (y- Nepalese and Tiny-dess frigem replied the Google form, which had been by mail to them. The the questionna tionsin wrey simed at the determination of imponen of proly Matified sub-crera, which would be worked out for the evaluation of sund myn projects. The quantitative part of the research consists of analys of eyes in be determination of weights and scores of evaluation criteria. Similarly, research covers the formulation of mathematical models for the quantification of soms of the evaluation criteria o rank the project The multi-criteria evaluation process has been exemplified by the detailed case study with the application of simple additive weightage (SAW) TOPSIS, MOORA, PROMETHEE, CEA and BCA This study identified thinees sub-criteria on the principles of sustainability. These factors economic (construction cost, maintenance cost, vehicle operation cost, travel time cost

pollution cost, accident cost), social aspects (population served per km, access to educational services, access to other services, mad as a community priority), and environmental aspects fencroachment on social or cultural heritage, the possibility of natural hazards, impacts on natural resources). The weights of these factors have been determined by the application of Likert Scale and AHP. This research has put forward the fundamental methodology for the calculation of scores of these factors for the evaluation of rural transport projects.

Four rural road projects in Dang District were evaluated for the application of various methods, including the multi-criteria approach ie. Likert Scale and AHP as the case study. Specifically, the multi-criteria evaluation factors with their respective weights have been verified by calculating the scores of each road project for ranking them in order to decide the priority level for their implementation.In the research, various multi-criteria methods (SAW, TOPSIS, MOORA, and PROMETHEE) have been applied based on the sustainability principle.

The results of the application have been compared and found similarities within the accepted level of confidence. It is concluded that ranking of alternatives with MCA methods depends on weightage, scaling of criteria and aggregation methods. Similalry, the research result was also compared with DTMP tools, cost-effectiveness analysis and economic analysis. Research objectives have been fully accomplished by embracing the previously determined research methodology. The research that the multicriteria approach based on the sustainablility aspect with the identified thirteen the sub-criteria and respective weights are applicable for the evaluation of competitive rural road projects in the context of Nepal.

Keywords: AHP, Evaluation Criteria, Environmental Aspects. Likert Scale, Multi-criteria Analysis, Vehicle Operation Cost

Graduation Year October 2018

Thesis Title: **ELEMENTS OF ECO CITY IN TRADITIONAL SETTLEMENTS OF KATHMANDU VALLEY**

Submitted by: **Sangeeta Singh**

Supervisor: **Prof. Dr. Sudarshan Raj Tiwari**

Prof. Dr. Mahesh Shrestha

ABSTRACT

The twentieth century is marked by increasing urbanization and growing number of cities all over the world especially in the Asian and African cities. While cities have played a key role in the overall socioeconomic growth of the nations, this has also created an imbalance in the natural ecosystems with more and more urban ecosystems being created on a global scale. The urban environment in the cities with its physical, economic, social and cultural components, however are often in conflict with the natural environment and natural ecology in many aspects, leading to ecological and sustainability problems. The vicious cycle of climate change as a result of growing disturbance of natural ecosystem due to increasing number of cities, and the increasing vulnerabilities of the cities to climate change impacts have led to the issues of sustainability of cities. Since urban growth cannot be curbed, the future city planning initiatives need to focus on planning cities in balance with nature. There is growing realization that urban ecological planning is imperative in city planning and that it should be done preserving the natural resources and in doing so, disturbing the natural ecosystems to the least possible extent. Eco city planning is one of the new paradigms in urban ecological planning approaches that has been first propagated by Richard Register in planning sustainable cities in the twenty first century and he emphasizes in "building cities in balance with nature"(Register, 1998). Eco city has been defined variedly by different authors since then including the San Francisco declaration in 2008, which defines an Eco city as an "ecologically healthy city". There is however a clear gap in literature in explaining the principles, parameters and elements of eco city planning in an explicit manner, and clarity is missing especially in the ways in which eco city planning can be achieved, and there is a lack of understanding of the standards and framework as well indicators for the same. Although some explanations and standards do exist, these have been in the context of the developed nations that are heavily dependent on energy and are hardly applicable to the culture driven societies of the East. According to an Eco city survey (Joss, 2008), 178 number of Eco cities have been planned on a global level, however the impact and the consequences of these cities in terms of the ecological benefits have yet to be observed. This requires a framework for assessing the level of sustainability in all of these initiatives. This new paradigm of Eco city planning however is not an entirely new concept. There have been several concepts that can be linked with the ecological aspects while planning cities and urban areas in the past, in the different periods in history. A closer look at these initiatives of the past, reveal that understanding of these concepts from an ecological perspective, might be worthwhile and some of it might still be applicable in the present context. 4 There seems to be a gap in

linking these with the ecological aspects. The urban planning initiatives in the preindustrial period, and especially in the East, is seen to consist of measures that were directed towards achieving ecological balance while planning settlements. The planning principles followed in ancient Kathmandu Valley during the Licchhavi period is a glaring example of how cities were planned in balance with nature and how socio cultural and religious norms and practices were directed towards achieving this. Some of these principles might still be directly applicable in the modern context. This study attempts to fulfil these gaps in literature discussed above and has the main objective of exploring the key elements of Eco city in the traditional settlements of Kathmandu valley, focusing on Shakharapur in particular, and Kirtipur in general. The specific objectives are to study and explore the various planning principles, parameters and applications associated with eco city planning, to explore the models and practices/approaches in the global context, explore the elements of eco city and the tools for eco city planning and to identify key lessons as these could provide guidelines for application or reinforcement of ideas unto eco city building attempts in modern day urban development. The research is based predominantly on constructivist paradigm focusing on constructed reality, the ontology being relativist and epistemology subjective. The strategies for research focus on approaches such as phenomenology, ethnography, case studies, hermeneutics etc. Literature review forms the major part in the research due to its exploratory nature and it has been done on an exhaustive basis, focusing on mainly four major areas. The first part of the literature deals with the ecological planning principles in the various periods in history considering mainly the pre-industrial period in the West and in the Eastern part of the globe, and also on the postindustrial (after industrialization) and modern principles of the 21st century on the global level. At the local level the planning principles in the ancient Nepal during the Licchavi period (around 2nd century BCE) have been explored. The second part includes the understanding the natural ecosystems on earth and its linkages with cities, whereas the third part of the literature focuses on some of the case studies on ecological cities across the globe and in the local context. The fourth part of the literature is based on the study of existing standards and frameworks for eco city planning. 5 The literature review forms the basis of defining the five key elements of eco city such as land, water, energy, air and wellbeing. Among the five elements of Eco city defined, only two elements, namely land and water have been taken for further exploration and in formulating the tools for eco city planning. The qualitative assessment tool has been developed for assessing the level of sustainability of settlements based on the conceptual tool matrix that has been established mainly through the assessment of tools that have been used for ecological planning in various periods of history. The tools for urban ecological planning thus developed, were tested in a traditional settlement of Shankharapur of Kathmandu valley through a set of performance indicators, in order to check its applicability. The result of the assessment suggest that the level of sustainability is high and marginal in most of the dimensions and parameters related to the elements land and water in Shankharapur and it still has the potential of being developed into an Eco city. Some minor modification were incorporated in the initially developed tools to make it more applicable in case of traditional settlements, based on which the guidelines for Eco city planning have been formulated for traditional settlements. The analysis of the traditional settlement planning shows that the settlements have been well planned both from the ecological sustainability and disaster resilience perspectives. These are

the basic parameters that are key to most of the planning concepts of the twenty first century like the eco city, green city etc. The philosophy behind the planning of traditional settlements can be adapted to suit the modern context so that the traditional settlements can be regenerated and can be developed into the modern day eco cities that are also disaster resilient. The research has contributed significantly in adding to the knowledge base, especially in understanding the planning principles, parameters and applications associated with eco city planning and in the identification of key elements and the tools for Eco city planning for small settlements. The research has come up with the framework for assessment of level of sustainability of small settlements and also guidelines and tools for eco city development of small settlements. In the context of rapid urbanization and increasing number of municipalities in Nepal, this research can provide significant guidelines for planning the cities in an ecological manner. Tools for eco city planning considering the elements energy, air, and wellbeing which has been the limitation of this study can be the area of further research in this field. Some other areas of research could be in exploring the eco city elements in the smart city concept and policy framework for eco city planning for small settlements etc

Graduation Year January 2019

Thesis Title: **CLIMATE CHANGE ADAPTATION IN URBAN AREAS THROUGH BLUE LAND USE AUGMENTATION**

Submitted by: **Ajay Chandra Lal**

Supervisor: **Prof. Dr. Jib Raj Pokharel**

ABSTRACT

This thesis seeks to contribute to the ongoing discursive construct on the debate of climate change and blue land use nexus for its adaption at local level. Observations over the past 157 years show that surface temperatures have increased by about 0.74°C over the past hundred years (between 1906 and 2005). Linear trend illustrates that there is little change prior to about 1915. From about 1940 to 1970 the increasing industrialization and World War II increased pollution. Patterns of linear global temperature trends from 1979 to 2005 estimated at the earth surface reveals that it is increasing at the rate of 0.1770 c per decade (IPCC, 2007). The warming for the next 20 years is projected to be about 0.2°C per decade (UNFCCC 2011). The fifth assessment report of IPCC 2013 further confirms the rate of change of global annual climate change. Anthropogenic greenhouse gas (GHG) emissions have been identified as the dominant cause of the observed warming since the mid-20thcentury, and will largely determine global mean surface warming by the late 21stcentury and beyond. Future climate will depend on committed warming caused by past anthropogenic GHG emissions, as well as future anthropogenic GHG emissions and natural climate variability. Anthropogenic GHG emissions are mainly driven by population size, economic activity, lifestyle, energy use, land use patterns, technology and climate policy. Nepal is not an exception. Observations from 110 stations during 1981 and 2010 show an increasing trend of temperature rise up to 0.55°C per decade (MOSTE 2014). In a similar study, Shrestha, Wake, Mayewski, & Dibb (1999), cited in MoE (2010a), find consistent and continuous warming in the period 1996-2005 at an annual rate of 0.06°C based on an analysis of temperature trend data from 49 weather stations. Likewise, using data from 45 weather stations, Practical Action (2009) finds consistent and continuous increase in the maximum temperature at an annual rate of 0.04°C in the period 1996-2005. In general, precipitation trend is positive in most of the country with maximum increase of about 15% of the annual amount per decade over few isolated pockets (Figure1.7, right). Some places in west Nepal show negative trend. However, due to huge topographical variation, low density of hydro metrological stations, the climate projection at local level may not hold good mainly because the models does not take care of local variations. In this iv context the local experiences and knowledge in three ecological zone of central development region of Nepal has been researched. At local level people relate climate change with their local environment. For the local people of mountain climate change means melting of bitumen of road in summer, less snowfall, drying of water sources like springs, longer summer vacations in schools and less vacations in winter. For the people in hills, climate change means frequent flooding, overflowing of drains and long summer. For people in Terai, climate change means heat wave, cold wave and extended drought. Winter vacations in schools, unpredictable rainfall and increased intensity of precipitation resulting into flooding of urban and rural settlements.

The majority of the people across the region associate the impact of climate change with decreasing agricultural yield, disaster and rise in insects and pests. It concluded that tempreture is increasing which is being adapted by local people with green land use in Mountain while Blue land use in Terai region. In this context, the pond city, Janakpur has been studied where more than 59 ponds are within the city fabric and another 150 ponds in fringe area. The study reveals that blue land use contribute immensely in adapting the heat of climate change. The rising trend of temperature in context of Janakpur is relatively slower than cities like Biratnagar and Birgunj situated in similar topography and socio economic fabric. The research further illustrate that the temperature nearer to the pond is about 20 c lower than normal city fabric. The uniformly distribution of ponds within the city fabric reveals that more than 40% of HH are living within 100m distance from the pond where temperature is about 10 c less than normal city temperature. Similarly about 10 percent of household are within 25m from the ponds. Further the wind rose diagram reveals that the city should have east west axis to enhance the cooling impact of ponds. The research further indicates that augmenting blue land use in cities could be a strategy to adapt climate change. In countries like Nepal where most of the Terai towns have ponds which have lost its importance due to changed context could be revived for cooling the city and augmenting the ground water table. Conservation and development of ponds or blue land uses in city could be adopted as retrofitting strategy of city for adapting the climate change. Further in new cities that are being planned have an opportunity to introduce the network of ponds/blue land use around v which the city could be designed. Blue space could be introduced as a part of landscape and recreational activities which will not only beatify the city but also provide sink for changing climate and extreme events.

Graduation Year January 2019

Thesis Title: **CLIMATE CHANGE AND ITS IMPACT ON URBAN AREA: THE CASE OF THE KATHMANDU VALLEY**

Submitted by: **Inu Pradhan Salike**

Supervisor: **Prof. Dr. Jib Raj Pokharel**

ABSTRACT

This thesis seeks to contribute to the ongoing dilemma on the issue of impact of climate change and urbanization on urban pluvial flooding. Urbanization and climate change are the phenomena that are now playing an important role in the development of infrastructure. Nepal, which is following the world trend in urbanization, has also acknowledged the impact of climate change. It is clear that the lifeline of the city like the drainage systems would be increasingly overburdened during extreme precipitation events, which has been stretched to its limit by the increasing population. The combine drainage system of Kathmandu valley is affected by climate change and urbanization resulting to pluvial flood. So, the quantitative delineation of the contribution of impact of urbanization and climate change is required for better planning and adaptation. The trend of climate change in Kathmandu valley was analysed with RClimdex software based on the rainfall data from 1971-2011 of Kathmandu valley where an increasing trend in the extreme event was noticed. The statistical downscaling model (SDSM) was used to downscale GCM data which is used for the projection of future precipitation. The IDF curve was developed based on the Gumbel distribution and Horner equation for different time series for the estimation of design storm in future. The relationship between increased imperviousness due to urbanization and extreme event due to climate changeresulting to increasing urban runoff and floodingwas explored in the study area. The PCSWMM software was used to analysis the urban drainage on the bases of four parameters namely flooding volume, node flooding, node surcharge and conduit surcharge. The validation of the model was conducted with questionnaires survey on the site. The finding of the research pointed that the increase in urbanization contributes to the increase in pluvial flood. Moreover, the climate change condition with present urbanization has further increased the flooding while the future climate change condition with present urbanization has the maximum impact on the pluvial flooding. Key words Urbanization, Climate change, IDF curve, Urban drainage, Pluvial flooding

Graduation Year January 2019

Thesis Title: DYNAMIC MODELLING AND RESPONSE OF PELTON TURBINE

Submitted by: Mahesh Chandra Luitel

Supervisor: Prof. Dr. Tri Ratna Bajracharya

ABSTRACT

This thesis work presents the method to study the dynamic response of the shaft of a Pelton turbine. Free vibration analysis of the system is carried out to determine the critical speeds of the system. Similarly forced vibration analysis is carried out to determine the steady state amplitudes of bending vibration in transverse directions due to impact of water jet. Mathematical models for the bending vibration of Pelton turbine assembly are developed by assuming Pelton wheel as a rigid disk attached on a flexible shaft. Equation of motions are derived for two different models by modelling the shaft as a rotating Euler-Bernoulli beam and a rotating Timoshenko beam respectively. Impact provided by the water jet is represented by Fourier series expansion. Critical frequencies of the system are determined from both models by performing free vibration analysis and compared. Similarly, response due to impact of water is also determined by performing forced response analysis of both models and compared. Forced response result is also compared with experimental result and found to be convincingly close.

Graduation Year February 2019

Thesis Title: **DEVELOPMENT OF SUSTAINABILITY FRAMEWORK FOR SUSTAINABILITY ASSESSMENT OF INSTITUTIONAL SOLAR PV SYSTEM IN NEPAL**

Submitted by: **Ram Prasad Dhital**

Supervisor: **Prof. Dr. Tri Ratna Bajracharya**

Associated Prof. Dr. Rajendra Shrestha

ABSTRACT

Realizing the importance of renewable energy in rural areas, with the support of various development partners, Alternative Energy Promotion Center (AEPC), a focal agency for promoting renewal energy technologies under Government of Nepal, has been promoting Solar Photovoltaic (PV) systems for electrification as an appropriate means to enhance rural livelihoods and conserve environment in rural areas. As the aim of these systems are to increase access to energy services for livelihood enhancement, it has become very important to assess whether these systems installed and being installed across different parts of Nepal are sustainable or not. This research aims to develop a sustainability framework and carry out sustainability assessment of Solar PV projects installed in Nepal till the period of 2013.

In the context of Nepal, technical, economic, environmental and social are the four major criteria that are found to reliably measure sustainability. By assigning weightages computed using Analytical Hierarchy Process to each criterion and sub-criteria of sustainability metrics framework. It was seen that Technical was the most important criteria in sustainability assessment of Solar PV Project (33%). This is followed by Economic, Environmental and Social where they weigh 27%, 22% and 18% respectively.

An empirical sustainability framework is developed to assess the sustainability of the sampled PV Projects. It was seen that 74% of the projects are found to be weakly sustained whereas 10% of the projects are not sustained. Although most of the PV projects passed Technical Sustainability Metrics (SM) criteria, only 14 (17.5%) of the sampled projects qualify Economic Sustainability Metrics (SM2) criteria. It was found that SM; was one of the major criteria that make solar PV projects unsustainable. 95% of the projects qualify against Social Sustainability Metrics (SM). But it performed poorly compared to Environmental Sustainability Metrics (SMs). An economic criterion is found to be one of the weakest factors that lead to project unsustainability. No revenue generation, lack of proper operation and management, inability of proper linkage with productive end use and lack of government periodic monitoring after commissioning are found to be some of the major sub-factors leading to the unsustainability of projects.
The result generated from sustainability assessment were verified by collecting the data from the survey of 9 sub-criteria of sustainability metrics and performing AHP for measuring the sustainability of renewable energy system (Solar, Biomass, Micro Hydropower and Grid Technology). By using AHP, Grid technology were ranked at top priority (32%), which is followed by Micro Hydropower (29%), Solar (23%) and Biomass (16%). The stakeholder analysis were carried out so as to identify the key stakeholders, energy consumption rate, benefits from the project and their level of satisfaction. So, the result from AHP model and Stakeholder analysis were similar to the sustainability assessment of solar PV project as well as the reasons for weakly sustainable and unsustainable project were found during validation.

The sustainability framework has developed and proposed sustainability framework can be used as a benchmark for sustainability assessment of other renewable energy project. Since this field study has conducted in 2013/2014, there has been a significant reduction in prices of Solar PV System. The total cost would have been less and even the less revenue would have made those systems either highly sustainable or sustainable. Further study is recommended to address the cost reduction aspects of the PV system

Graduation Year August 2019

Thesis Title: **ANALYSIS AND MODELLING OF TWO POT MUD IMPROVED COOKSTOVE**

Submitted by: **Hari Bahadur Darlami**

Supervisor: **Prof. Dr. Bhakta Bahadur Ale**

Prof. Dr. Govinda Raj Pokharel

ABSTRACT

Millions of people around the world are using biomass fuels to fulfill their energy requirement for cooking and space heating. Two pot raised mud Improved Cookstove (ICS) is one of the most promoted cookstoves in the context of Nepal. There is a need to study the effects of different parameters on the performance of two pot raised mud ICS. Fabrication and performance test of cookstove has been obtained experimentally. During experimental analysis, different parameters such as changing combustion chamber height, chimney height, construction material, door area and entry area of enter connecting have been changed. During experimental analysis, total emission and fugitive emissions has been measured. Experimental result has been compared with mathematical model which has been developed in MATLAB by using combustion, transient heat transfer and flue flow formulae. For existing cookstove maximum thermal efficiency of 18% has been found at firepower 4.5kW. While changing individual parameters, maximum thermal efficiency has been determined at chimney height, air fuel inlet opening and interconnecting tunnel entry area of 113cm, 148cm2 and 56.95cm2 respectively. Similarly, best combustion chamber height and grate height has been obtained as 20cm and 2cm respectively. Thermal efficiency of cookstove at all best dimensions have been found 22.44%. With use of grate and insulation in the inner lining of combustion chamber in best dimension thermal efficiency have been obtained 23.64% and 23.63% respectively. Thermal efficiency of cookstove has been found 24.70% with the fabricating in optimum dimension, use of 2cm grate, insulating material and secondary air supply. Thermal efficiency has been raised to 25.6% by the supplying secondary air through air-fuel inlet. In model analysis, it has been found that 48% heat lost through the flue gas. For best dimension cookstove, heat absorbed by cookstove during model analysis has been found 22.58% while experimental analysis it has been found 22.44. Net benefit of initial cookstove and final cookstove have been found NPR 16,569 and NPR 23,619 respectively. Marginal abatement cost of best dimension cookstove has been found lowest 735 tCO2eq

Graduation Year August 2019

Thesis Title: **ENERGY EFFICIENCY IMPROVEMENT IN GREEN WIRELESS COMMUNICATION**

Submitted by: **Madhu Sudan Dahal**

Supervisor: **Prof. Dr. Jagannath Shrestha**

Dr. Shree Raj Shakya

ABSTRACT

Due to increasing demand of wireless communication, the number of radio base stations has been growing immensely, which will consequently increase the energy consumption. This situation creates a big challenge to the environmental impact and ever increasing energy cost. Wireless networks consume about 0.5 percent of the total global energy consumption. The wireless network is designed for maximum traffic load, but the traffic load is unevenly distributed resulting in wastage of energy consumption most of the time during low traffic. This thesis focuses on the energy modelling based on the traffic generated and develops energy saving techniques: Dynamic Transmitter Shutdown Technique and cell zooming. The main contributions have been given in the areas of energy efficiency assessment, development of energy saving techniques and based on the conducted the pilot test on the real system. The precise evaluation of energy efficiency is the first step to develop the energy models based on the real time traffic. The available models till date have not considered the impact of traffic load on network energy consumption. When the traffic increases, the power consumption of base stations also increases, however, this phenomenon differs in heterogeneous base stations. These differences are analyzed through regression models, expressing interdependence among instantaneous base stations power consumption and traffic load. Based on the measurements of three micro and macro base stations of Nepal for ten consecutive days, linear models have been proposed. The results reveal that the proposed linear models fit better for macro base stations than for micro base stations. Energy consumption is seen to change along with the traffic loads during high traffic, but during low traffic, energy consumption does not change, therefore intelligent energy management system as per the traffic generated is essential. A macro base station is found to be more energy efficient than a micro base station due to its higher coverage range, however, a macro base station consumes about two times more power than a micro base station. Hence, micro base station is suitable for areas with higher concentration of users where high data rates are required while macro base station is suitable to ensure coverage only. Traditional energy saving techniques like switching off certain base stations completely during low traffic creates problems in restoring to optimum capacity when the traffic increases. There is the potential of saving energy consumption along with maintaining the quality of service and reducing the resulting environmental impact by introducing dynamic transmitter shutdown technique. An algorithm of dynamic transmitter shutdown technique during low traffic is proposed. The algorithm depends on automatically switching off unnecessary transmitter when the traffic is low and switching on required transmitter when the traffic starts to

increase. With this technique, base stations dynamically adjust the number of transmitters to be enabled based on the user traffic and required channels without compromising the service quality. The measured results revealed that the proposed model reduces the energy consumption of base stations by up to 18.8 % as compared with the traditional static base stations. An algorithm for cell zooming has been proposed, where the coverage areas of base stations can expand and contract based on the traffic load. This is achieved by switching off the low traffic base stations and compensating for the coverage loss by expanding the neighboring base stations by increasing the transmit power. With this algorithm, the number of base stations to be enabled is dynamic, increase the transmit power of those base stations and switch off base stations based on the user traffic without compromising the service quality. This algorithm is derived from the pilot test and the results revealed that the proposed algorithm reduces the energy consumption by up to 20 % as compared with the normal working base stations. Finally, this study highlights the total energy demand of Nepal Telecom and forecasts the energy demand as per the growing subscribers trend. The total forecasted demand is 138 MkWh for 2030 A.D., out of which 50.77 MkWh is from non-renewable energy sources like coal, specially imported from India resulting in 57,218 tons of CO2e emission. 50.77 MkWh energy can be generated from mature technology like solar PV using an area of about 31 hectares of land. In this way, Nepal Telecom could use complete green energy sources to provide its services. The output of this dissertation can be highlighted in the fact that it suggests efficient energy saving techniques for wireless network designers and operators to achieve the green cellular communication goals and increase the service quality.

Graduation Year October 2020

Thesis Title: **MATHEMATICAL MODELLING OF MARKOVIAN QUEUEING MODELS AND THEIR APPLICATIONS**

Submitted by: **Sushil Ghimire**

Supervisor: **Prof. Dr. Gyan Bahadur Thapa**

Prof. Dr. Ram Prasad Ghimire

ABSTRACT

To be in a queue for the service is a natural phenomenon in daily life. Spending minimum time in the queue is possible only when there is the proper management abide by the rules and regulations. In the study of queueing theory, there are different models based on the arrival patterns and the service facilities. Those who come for service are called customers and the one who provides the service are called servers. This thesis focuses to present some of the mathematical formulations for some of the queueing models in which arrival patterns and the service facilities follow Markov process. The main purpose of establishing different queueing models is to provide better service in the minimum cost reducing longer waiting times. The real life scenario of limited resources motivated us to study the finite capacity queueing model having single and multiple servers. On the other hand, in day to day life we have experienced some of the queueing systems in which either arrivals or the services or both occur in batch mechanism. We have investigated the queueing model including time dependent arrivals and services in which customers arrive in the system following Poisson process and are served exponentially. To observe the application in flexible manufacturing system, multi-server finite capacity queueing models have been studied where fixed number of regular servers are available to serve limited customers. All the regular servers come to the service facility according to the number of customers present in the system. If the system exceeds a certain quota there are some additional servers ready to serve the upcoming customers. A comparative study of queue length and waiting time for finite and infinite capacity queueing models has also been carried out. There is another realistic situation in the queueing theory for which server stops working so that system partially or fully appears to be breakdown. In this situation, service will be interrupted by the broken-down server. We have computed some performance measures considering transient arrival and service for finite capacity queueing model under breakdown. In this thesis, batch arrival and batch service queueing models are taken into account. If there are the batch of 'b' customers, all are served together. On the other hand, if there are the customers less than the batch 'b', they are served individually with the different service rate. A queueing models in which arriving customers get service without lining up is studied to calculate optimal rate of service along with queue length and the waiting time. All these performance measures are verified numerically using MATLAB simulation with the suitable interpretations. To observe the applicability of queueing model in the real life situation, a case study has been carried out at Tribhuvan International Airport, Nepal. Data for the arrival and departure are studied for five days to calculate the performance measures.

Key Words: Queue, Performance Measure, Customer, Server, Batch, Steady State, Finite Capacity, Supply Chain, Production

Graduation Year November 2020

Thesis Title: **AUGMENTING SUSTAINABILITY-REVIEWING CONCEPTS AND PRACTICES OF ECOVILLAGE IN LOCAL REGIONAL CONTEXTS**

Submitted by: **Bijay Singh**

Supervisor: **Prof. Dr. Sushil Bahadur Bajracharya**

Prof. Dr. Martina Maria Keitsch

ABSTRACT

Different interpretations of sustainability result in the sustainability gap between actionimplementation and policy-making. Among many local-level initiatives, the ecovillage concerns human actions and forwards sustainability. The research seeks a better understanding of the ecovillage's sustainability to mitigate the sustainability gap. The research was three-folded. The first part presented literature review of the ecovillage and developed three themes- resource management, community organisation and knowledge sharing, based on the collaboration between EVs and mainstream society. The second part presented Social System Theory as a supplement to the qualitative research process and reflect on the ecovillage's sustainability concerning its relationship with mainstream society. The third part comprises multiple case studies: Schloss Tempelhof, Hurdal Ecovillage, Bandipur Bazar and Jhong. They were analysed by reflecting on the narratives, EV themes, cultural value, and regional cooperation. The comparative analysis of cases illustrated different forms of sustainability in EV themes. Despite the collaboration with mainstream society, each case presented a unique process of collaboration. In Schloss Tempelhof and Jhong, actions were translated as parts of policies. In Hurdal EV, actions were transformed as per policies. In Bandipur Bazar, actions were transited into policies. They illustrated the difference in collaboration with mainstream society according to their ability to maintain local values and extents of their regional cooperation. The research concludes that actions serve two purposes- problem-solving and maintaining the societal values, and a criterion for the mitigation of the sustainability gap. Ecovillages remain intact through values and store the knowledge of means-selection in social norms, transferable across space and time. Furthermore, the mitigation of the sustainability gap requires understanding actions as the link between values and policies, and their interpretations through concrete entities. The research also interpretes the planning process as a causality of a selection of means, and goal settings based on local values and mainstream policies. Finally, from the practitioner's perspective, the research reveals some unexplored aspects of EV's sustainability

Graduation Year November 2020

Thesis Title: **ENERGY EFFICIENCY IN URBAN LANDUSE AND TRANSPORT PLANNING FOR HOME-BASED DAILY TRIPS, A CASE STUDY OF KATHMANDU VALLEY**

Submitted by: **Ashim Ratna Bajracharya**

Supervisor: **Prof. Dr. Sudha Shrestha**

Prof. Hans N. Skotte

ABSTRACT

Escalating transport energy demand is one of the major issues for the Kathmandu Valley, with a rapid increase in mobilization and urban sprawl. The Kathmandu Valley is the center for economic activities and educational opportunities where the daily trips that constitute work trips and educational trips have a dominant share. In this context, this research is aimed to study travel behavior, urban landuse and transport system in relation to transport energy demand for home-based daily trips, in the context of the Kathmandu Valley. Trip data of workers and students were collected from the household survey, carried out in different parts of the study area, using random sampling. Daily trips have a significant share in travel demand with about 2.1 million trips per day with modal share of private vehicles showing higher, as compared to other modes. Mode choice and trip length were studied in relation to the socio-economic and demographic background and it was found that the role of gender, age and income and household vehicle ownership were found to be influential to the travel behavior, more importantly for work trips. Travel behavior was studied in relation to urban form for the travel energy assessment. Work trips are observed to vary more spatially, than educational trips. The correlation analyses of work trips show that population density and public transport accessibility, are having little impact on travel energy, whereas increasing distance from the central business district is found to have a significant rise in travel energy. Four-Step Urban Transport Model, was developed to study the travel pattern in macro scale and for carrying out scenario analysis. The currently daily trips consume 3666 TJ annually. Cars and motorcycles contribute to most of consumption, accounting for over 80% of total transport energy. Current willingness to shift to Public Transport like Bus Rapid Transit System, leads to the reduction in transport energy up to 44% for trips along the zones with access to the service. With the balance between Trip Production and Attraction, whereby Employment and Educational Services are provided in accordance to travel demand of work and education trips, respectively, the reduction is achieved by 6%. The reduction is further increased significantly by shift from motorized private more to nonmotorized modes of transport. The research exemplifies the benefits of using travel behavior analysis and transport modelling for studying daily trips in macro scale, to promote energy efficiency in landuse and transport planning, in context of the Kathmandu Valley

Graduation Year December 2020

Thesis Title: **ASSESSMENT OF THE LAND USE/COVER AND CLIMATE CHANGE IMPACTS IN THE URBANIZED RIVER BASIN, THE CASE OF BAGMATI RIVER BASIN**

Submitted by: **Suraj Lamichhane**

Supervisor: **Prof. Dr. Narendra Man Shakya**

ABSTRACT

Land use/cover (LULC) change in the form of urbanization and climate change are affecting water resources in many urbanized basins around the world, and the Bagmati River Basin in central Nepal is not an exception. Kathmandu Valley (KV) watershed located in the headwaters of the Bagmati River Basin is urbanizing at a higher rate and hosting 29% of the urban population in the country. Urbanization and associated land use/cover (LULC) change, population increase, excess water demand, encroachment of open land, and climate change results over-stress in the surface as well as subsurface water balance of the basin. Rise in impervious built-up area, excess surface runoff, reduction of groundwater recharge dynamics and corresponding impacts in the river runoff exacerbate water scarcity, more specifically in the dry period. Groundwater is, and will continue to be, the main source of water supply in the KV, however, both supply side (i.e., recharge) and demand side (i.e., pumping) of groundwater are affected due to urbanization, thus, putting more pressure on the groundwater resources in the KV. However, there is no comprehensive understanding of groundwater dynamics under the scenarios of changing LULC, climate, and pumping rates. This study therefore develops projected future scenarios of LULC, climate, recharge areas, and pumping rates and then uses multiple models to assess impacts of – i) LULC change on potential recharge areas; ii) projected climate change and LULC change on spatio-temporal distribution of surface water availability; and iii) urbanization on groundwater dynamics. The LULC change was modeled using CLUE-S model. Results showed 6.51% decrease and 4.9% increase in agricultural and built-up areas, respectively, during 2010 - 2018; however, projected to change by +21.4%, -20.5%, and -0.9% in built-up, agricultural, and forest areas, respectively, during 2020-2050. In terms of recharge areas, 6% of the open land is projected to convert into impervious areas every decade. Future climate was projected based on an ensemble multiple Regional Climate Models (RCMs) under Representative Concentration Pathways (RCP) scenarios. Results revealed that average annual values of maximum temperature, minimum temperature, and precipitation in the KV watershed for the period of 2010 to 2050 are projected to increase by 0.19oC, 0.33oC, and 24%, respectively, for RCP4.5 scenarios and 0.89oC, 0.96oC and 1%, respectively, for RCP8.5 scenarios. Current and future water balances under the scenarios of LULC change and climate change were simulated by developing a hydrological model in the Soil and Water Assessment Tool (SWAT) platform. Simulated future mean annual river discharge under RCP4.5 scenario ix showed projected increase by 37%, 21%, and 36%, due to climate change (CC) alone, LULC change alone, and combined (both LULC and CC) scenarios at the Khokana station for 2050. Similarly, under

the RCP8.5 scenario, future runoff is projected to change by -14%, +21%, and -14% for the aforementioned scenarios during the same period. LULC change resulted increase in average annual flow, however, decrease in base-flow. The decadal average rate of groundwater contribution to the river discharge for the RCP4.5 and RCP8.5 scenarios declined with 58% and 68%, respectively, for the integrated scenario due to less infiltration by the expansion of the built-up area. Finally, impacts of urbanization on groundwater dynamics were evaluated by developing a groundwater flow model using MODFLOW code. Urbanization was reflected in the model as encroachment in groundwater recharge areas as various pumping rate scenarios. The pumping rate included the integrated pumping from the deep and shallow aquifer. Finally, future pumping scenarios were developed using three types of population growth rates; 1% for the developed areas (with greater pumping rate of > 100 m3 /day), 1.5% for newly developing areas (pumping rate between 50 to 100 m3 /day), and 3 % for the areas in the peripheral parts of the valley (pumping rate less than the 50 m3 /day). Simulated results showed significant drawdown in the inner and northern areas compared to the other parts. Except the cases of dry pocket areas, maximum drawdowns in the basin for the combined and only pumping scenarios for the dry season are -5.25 m and -4.87 m, respectively during 2020-2050. The drawdowns induced due to encroachment of recharge areas -1.09 m, -3.63 m for dry and wet seasons, respectively. Findings from this study using multiple models and scenarios indicate changes in water balance, potential shrinking of recharge area and subsequent decrease in recharge volume, and depletion in groundwater levels in some areas. These phenomena have implications in river basin hydrology. Therefore, appropriate planning and management of watershed conservation activities, water resources, and water supply systems are essential to use both surface and groundwater resources in the valley in a sustainable way

Graduation Year February 2021

Thesis Title: **CLIMATE INDUCE LANDSLIDES-PROSPECTIVE OF ECO-ENGINEERING TOWARDS MITIGATION AND RESILIENT COMMUNITIES IN PANCHASE GEOGRAPHIC REGION, NEPAL**

Submitted by: **Sanjaya Devkota**

Supervisor: **Prof. Dr. Narendra Man Shakya**

ABSTRACT

Analysis of historical rainfall data indictaed that the rain-intensity has increased in Nepal's densely populated middle mountain region where construction of unplanned rural roads are concentrated. Many of the rural roads in the hilly area of Nepal are not operational during monsoon season either blocked by landslides or are not drivable. These roads require huge investment to clear the debris to make them operational. Often, the road clearance is delayed by months or becomes the road abandoned because of unavailability of resources to clear the landslide debris. From the geomorphological prospective Nepal's rural roadside slopes are highly vulnerable in terms of failure where assessment of slope stability and protection measures are limited. The adopted approach of rural road construction has led to frequent rainfall-induced shallow landslides that toll human lives, damage agricultural lands and economic activities and degrades the environment leading the rural community to be fragile and less resilient. Rainfall intensity phenomenon can be better understood through Intensity-DurationFrequency (IDF) model, which is limitedly used in Nepal for project planning and hazard-risk reduction. There are researches, which have used IDF to predict extreme rainfall in Nepal; however, such IDF were not specifically established in the context of Nepal. In addition, models and techniques are developed to model the slope stability. Among such models physically based deterministic infinite-slope stability model is popular because its simplicity and follows the physical laws. The uses of physically based models are commonly used by the academia that provides better information to the policy makers, and professionals, which is also limited in use in Nepal. Further, the increased frequency of roadside shallow landslides in the mountainous topography of Nepal needs to examine sustainable solution measures to protect the rural communities, which is also practiced in limited knowledge. To comprehend the issues of rainfall and the threat of rainfall-induced shallow landslides, a research was contextualized to examine the possible extreme rainfall intensity, its impacts on slope stability and explore cost-effective and long-term solution measures. The research consists of three main objectives: 1) to explore the rainfall variability and trend followed by the construction of IDF model for a geographic region; 2) to parameterize a physically based deterministic infinite-slope stability model utilizing the rainfall intensity, evaluate the probability of failure, perform the model quality assessment, and assess the parameter effects; and 3) to model perennial, climate resilient and fast growing local/nonlocal grass species adopting local knowledge, identify and examine the species Key Performance Indicators (KPIs) for better implementation of eco-engineering measures for

long-term solution of rainfall-induced shallow landslides. The interdisciplinary research was conducted in Panchase geographic region (283 km2) in central-western mountain region spans in Kaski, Parbat, and Syangja Districts of Nepal. The region is popular because of its biodiversity, ethnic composition, and rainfall (~4,500mm annual average). In addition, Phewa Lake that brings enormous economic opportunities at local level is also located in the region. However, the region is under the threat of shallow landslides and soil erosion due to human activities and intense rainfall. The increased number of landslide and soil erosion in Panchase region not only threating the people's livelihood but also degrading the biodiversity and Phewa Lake quality. The scale of research was top-down, from the geographic region to watershed landscape followed by a specific component such as roadside slopes. At the regional scale, over 30 years of daily rainfall data around the study area were obtained from the Department of Hydrology and Meteorology (DHM) performed homogeneity test and examined the missing values. Utilizing the homogeneous and quality rainfall dataset of eight stations (i. e. Khairenitar, Pokhara-Airpor, Bhadaure-Deurali, Lumle, Karki-Neta, Kusma, Syangja and Walling) rainfall variability in the geographic region was analyzed in terms of rainstorms and dry/wet days followed by Mann-Kendall (M-K tau) and Sens's slope test to detect any nonparametric trend. The mathematical IDF model requires fine time resolution rainfall data to develop, which was not available for the study area. The scarcity of fine resolution rainfall data was accomplished by disaggregating the available daily rainfall data to synthetic hourly series. To disaggregate modified Bartlett-Lewis Rectangular Pulse (MBLRP) method was implemented in 'HyetosMinutes'. Point IDF models were first developed mathematically for the gauged locations using the hourly synthetic and daily datasets. Together with the point IDF and Lmoment based regional frequency analysis (FRA) regional IDF was established for the Panchase geographic region. The regional IDF model results was validated using the short term (2014-2016) hourly recorded rainfall data available from the automated weather station installed within the geographic region. The rainfall intensity derived from the IDF model established in this research and the soil physical, hydrological properties and terrain attributes a physically based deterministic infinite-slope stability model was parameterized. The infinite-slope stability model chosen to implement the rainfall induced wetting-front depth. Model parameters were prepared from in-situ tests and laboratory analysis. Topographical attributes were derived from 12.5x12.5 meter resolution DEM and root-cohesion was adopted from the literature. Separate soil-depth model was developed from the 865 point measurement data and terrain attributes. The stability model was implemented in GIS firstly for for the deterministic approach estimated the safety factor of the landscape slope. Four safety factor scenarios were estabilised considering, no-rain, 5-year, 100-year, and 500-year rain-intensities for the landscape of Phewa Lake watershed (~111.5km2). Model performance was evaluated through receiver operating characteristic (ROC) curves. The physically based slope stability models are sensitive to some parameters, which were assessed adopting one-parameter-at-a-time (OTA) techniques. This research suggested examining of plant species performance for the long-term solutions of rainfall-induced shallow landslides mitigation through the eco-engineering approach. The approach provides mutual co-benefits by restoring the degraded ecosystem services and provides livelihood oppertunities. The species suggested by the community were used to demonstrate the eco-engineering alongside of the roads and Rhizotorns in three locations in Gahrelu,

Tilahar, and Bhatkhola respectively in Kaski, Parbat, and Syangja Districts Panchase geographic region of Nepal. Local communities were engaged to establish, maintenance and monitoring of the demonstration sites, who keeps tracking the plant survival and growth and maintain the database. After 18 months of the establishment, the first row of the Rhizotorns was excavated to assess the roots architect such as depth, strength, diameters, density and derived the root-cohesion. The root-shoot dry bio-mass was analyzed in the laboratory. Accordingly, nine KPIs of the model plant species were identified, and established multi-criteria based PCA model to assess the plant quality for the ecoengineering. The performance of the eco-engineering used to restore the gullies or to protect the soil slopes in the demonstration sites was assessed through the focus group discussion (FGD) and key-informants interview (KII) from the communities' perspective. Utilizing the results obtained at various stages of the research and community engagement a framework for 'eco-engineering for eco-safe roads' was contextualized. Panchase mountain sitting in the middle divides the study area into eastern (Kaski District) and western (Parbat and Syangja Districts) geographic regions. The analysis of available daily rainfall data suggested that the region has two distinct meteorological environments in terms of rainfall amount, duration, and intensity. The rainfall amount was Institute of Engineering, Pulchowk Campus PhD Dissertation, 2019 ~ vi ~ higher in the eastern part than that was recorded in the western part. Over the 30 years of period the numbers of monsoonal dry days were increased in eastern part while the annual mean rainfall was unchanged indicted increment in the rainfall intensity. However, no clear trend was detected in the western part except in Syangja where monsoonal dry days were decreased with increased numbers of rainstorms. The recorded daily and disaggregated hourly rainfall data were useful to compute the reference and point IDF models for the gauged locations. The point IDF models were regionalized adopting L-moment based RFA methods dividing the region into two subregions (eastern and western). It was noticed that the region contains some degree of heterogeneity leading to produce five sets of empirical models for the geographic region. The chosen infinite-slope stability model was parameterized and implemented for the four scenarios of rainfall (i. e. no-rain, 2.64cm/hr. 4.65 cm/hr. and 5.7 cm/hr.), firstly for the deterministic approach and secondly for eh probabilistic analysis. The quality of the four deterministic models was performed and the best model was selected to performed probabilistic analysis. The probability of failure model was achived by defining the variance of random variables. The probabilistic model depicted five classes of failure probability such as less than 1%, 1%-25%, 25%-50%, 50%-75% and 75%-100% respectively represents the low to high probability of failure. The suggested model depicted about 13.73% of Phewa Lake watershed area was under the high probability of failure provided 80% of initial soils degree of saturaiton. About 33.15% area of the watershed governed less than 1% of failure probability. Evaluation of the model performance depicted that the probability of failure model showed better results over the deterministic model. The parameter such as terrain slope was found most sensitive followed by soil internal friction angle, soil-cohesion, and soildepth to the model results. The affect of terrain slope angle, wetting-front depth, and soildepth was negative and non-linear while soil and root cohesions showed linear positive affects. The angle of internal friction contains near linear positive affect to the model results. The analysis showed that the importance of appropriate procedural to be followed while preparing the model parameter. The knowledge and

experience owned by the local were applied to select the local perennial grass species [Amriso (T. maxima), Urlo-Khar (C. microtheca), Napier (P. purpurreum), Salim-Khar (C. gryllus), Kans (S. spontaneum), Kush (D. bipinnata), and Babiyo (E. binata)] for eco-engineering and identified the locations to establish the demonstration sites. A non-local Vetiver (C. zizanioides) grass was also added for the Institute of Engineering, Pulchowk Campus PhD Dissertation, 2019 ~ vii ~ evaluation as the species is known to its deeper rooting depth (3-4 meter), climate resilient and effective in slope protection. The research was able to identify nine KPIs such as plant survival rate, canopy cover, root-shoot dry bio-mass, root-diameter, root-strength, root-arearatio, deep and shallow rooting depth, and root-cohesion and established PCA model. The Analysis suggested the non-local Vetiver (C. zizanioides) grass with the root-cohesion of ~14.08kPa can perform better among the local grass species. Amriso (T. maxima) depicted better results in terms of rooting depth and root-cohesion (8.27kPa) amongst the local species. Vetiver (C. zizanioides) and Amriso (T. maxima) fall under the category of deep rooted species (>50cm) while others were the shallow rooted (< 50 cm) under this research. Plant species contributes various ways to protect the soil slopes; however rootcohesion illustrated an important parameter. Except root-cohesion soil physical parameters of landscape slope can be considered independent while root-cohesion depends and vary on plant density and species root morphology. The measured root-cohesion in this research was considerably high than the used (1kPa) in this study from the literature to model the slope stability of Phewa Lake watershed indicated that the plant species for eco-engineering should be chosen appropriately. FGD and KII iterated the effectiveness and sustainability of eco-engineering for the rural roadside shallow landslides mitigation and soil-erosion control. The people accepted the techniques to be expanded in other similar geo-morphological environment. Also, they realized that the eco-engineering considerably reduced the annual maintenance cost of the rural roads. In addition, mitigation of landslides enhances the local economic activities, and provides better access to the health-care, education, and resources that contributes to improve community resilience. The adopted procedure for the development of IDF model in fine-time resolution data-scarce situation can up-scaled for larger geographic region of Nepal, leading to better management of rainfall induced hazards and infrastructure planning and design. The physically based slope stability model portrayed the importance of various parameters contributing to destabilize/stabilize the soil slopes. Among others plants root-cohesion depicted to be the important parameter in eco-engineering, if used appropriately chosen species that considerably improves the soil-cohesion thereby the slope stability. The methodology and procedures implemented in this study was observed suitable at resource scare situation and guides to better understand the impacts of rainfall-intensity, slope stability, and eco-engineering to mitigate the shallow landslides.

Graduation Year February 2021

Thesis Title: **CONCEPTUAL FRAMEWORK IN DECISION-MAKING OF MITIGATION MEASURES IN FLOOD RISK MANAGEMENT: A CASE STUDY OF KOSHI ALLUVIAL FAN, NEPAL.**

Submitted by: **Mukesh Raj Kafle**

Supervisor: **Prof. Dr. Narendra Man Shakya**

ABSTRACT

Flood of the Koshi River in 2008 and its consequences severely influenced life of hundred thousands of people in Nepal and millions of people in India. Those consequences motivated to conduct this research. Overall aim of this study is to develop a conceptual framework in decision-making of mitigation measures in flood risk management. The Koshi alluvial fan, one of the largest fans in the world is selected for case study. The study is conceptualized and structured in two parts: Inundation risk assessment with a two-dimensional hydrodynamic model and selection of the best flood risk management strategies using MCDMs.

For hydrodynamic modelling, the model software Nays 2D carried out numerical simulation. The study identified hazardous areas within the study reach in different flood frequencies of 25, 50 and 100 years return periods. Model calibration was based on observed and simulated water surface elevations. Statistical parameters Root Mean Square Errors (RMSE) and Correlation R2 between measured values and simulation results were 0.31 m and 99 % respectively.

Generated flood hazard maps and hydraulic parameters compared water surface elevations and existing embankment reduced levels. It was observed 100 years flood would not overtop existing embankments in the study reach. However, human settlements along the east bank beyond embankment namely Mahendranagar, Prakashpur, Paschim Kusaha, Haripur are identified as high-risk areas for inundation and erosion. Similarly, Thoksila and Bairawa along the west bank are marked high-risk zones. Within the embankment Koshi Tappu Wild Life Reserve, a small island is recognized as high- risk areas for both inundation and erosion.

Structural measures were proposed to mitigate such water-induced risks. Five alternative structural measures incorporated seven evaluation criteria. Effectiveness of each structural measure was evaluated with hydraulic modelling. Three different weighing methods – Eigen - vector, Entropy and integrated (Eigen-Entropy) methods were used for obtaining criteria

significances. Comparison results illustrated that integrated Eigen-Entropy method as the best weighing procedure in the particular case study. Preference ranking of alternative measures was carried with six MCDM models- TOPSIS, SAW, ELECTRE, VIKOR, AHP and MAUT. Overall assessment indicated that construction of sleeper dikes, a second line of defense constructed some distance outside from the existing embankment, as a structural measure; along riverbanks was the best solution in flood risk management strategy within the dominance of Chatara to Koshi barrage of Koshi alluvial fan.

Non-parametric stochastic tests and stability analysis were used to select the best proper model. The results showed that MAUT, a multi-attribute utility and value functions model with compensatory nature, was the best-preferred MCDM method for preference ranking of mitigation measures in the particular case. Research findings were validated with different robustness tests - fuzzy set theory and aggregation method. The most critical decision criterion, robust criterion and the most critical alternative measures were identified with sensitivity analysis.

Decision criteria - costs (C1) and social/environmental impact (C5) were found the robust criteria whereas criterion safety and sustainability (C3) was found the most critical decision criterion followed by technical complexity (C2), impact on irrigated area (C6), and cooperation with India (C7) and time of implementation (C4) in order. Similarly, preference ranking alternatives - Construction of flood a storage basin (A4) and raising embankments over time (A1) were found the most critical alternative measures. By knowing which data are more critical, a decision maker can more effectively focus his/her attention on the most critical parts of a given MCDM problem.

Policy makers and local authority can utilize results of this study to combat against induced disaster, planning flood preparedness and sustainable flood risk management of Koshi alluvial fan. With implementation of recommended measures, society along the river banks and vicinity area of Koshi River in Nepal and millions of people of northern Bihar, India will be highly benefited.

Findings of this research recommend decision makers to pay high attention and precision while considering safety and sustainability parameter for other multi-criteria decision making (MCDM) problems in the Koshi alluvial fan. In addition, the methodology proposed in this study can be applied for selection and prioritization of flood controlling measures in other large trans-boundary rivers and flood plains in Terai regions of Nepal.

There are some other issues, which were not addressed in the current study. These issues are- the non-structural measures like flood forecasting, flood warning system, emergency planning, acquisition and relocation, flood insurance, public information and education etc. Further research towards inundation in the case of breaching of embankments and risk situations may be explored.

Keywords: Flood risk; Hydrodynamic; Inundation; Simulation; Two-dimensional, Nays 2D, MCDM, Entropy, Eigen-vector, AHP, ELECTRE, TOPSIS, SAW, VIKOR, MAUT, KTCC, SCC.

Graduation Year July 2021

Thesis Title: **IDENTIFICATION, CLASSIFICATION AND PRIORITISATION OF BARRIERS TO RURAL ELECTRIFICATION IN NEPAL**

Submitted by: **Bindu Shrestha**

Supervisor: **Prof. Dr. Sushil Bahadur Shrestha**

Prof. Dr. Sudarshan Raj Tiwari

Prof. Dr. Martina Maria Keitsch

ABSTRACT

The household sector is one of the most energy-consuming and gendered spheres in society to influence the energy transition. The energy-efficient concept has a major contribution to the sustainability of a social shift. The women's movement for social change has a long history compared to energy efficiency advocacy. However, women's participation in energy efficiency policy is relatively low worldwide, including in Nepal. Women still spend three folds higher on household chores than men, particularly in Asian countries. Despite having a pivotal role in energy usage and saving, their participation in energy decision-making has been less prioritized, resulting in a gender-blind energy policy. The past energy studies have focused on technological energy issues with limitations of gender differences in energy-related decisions. This lacuna needs to be accomplished by linking energy, gender, and sustainability as a common goal in Kathmandu urban households. This research has examined a three-dimensional matrix of energy culture, generation, and location, keeping a gender lens in the energy decision-making process and introduces gender mainstreaming strategies to fulfill the lacuna combating possible challenges. The study results reveal that the lower-income groups spend (13%) a larger share of their income on household energy but remain poor-quality and uncomfortable kitchen environment. Only 20% of households' kitchens contain kitchen-hoods to rental households. Kathmandu inhabitants' income and electrical appliances establish a moderate positive correlation ($r = 0.48$, P). The Newar groups spend 13% to 20% of total income on monthly energy bills than other groups depending on social and contextual circumstances. Besides, gender differences are visible in energy purchase decisions due to socialization, responsibility, preferences, upbringing, education, and income factors. However, females have demonstrated higher energy practice and consciousness. The female participation in energy decisions has lowered 23% in female headship, and joint ownership supplements a 22% reduction. At the same time, female participation in energy decisions is reduced electricity bills by 16% in nuclear families and 13% to 17% in different locations of Kathmandu. Males exhibit slightly higher energy knowledge and interest in energy-related technology. Nevertheless, Kathmandu urban households are still insubordination and subjugation culture. It concludes that innovative technical interventions are essential, combining capacity development, technical education, and a proper information dissemination system. The government should initiate a robust energy strategy mainstreaming gender by strengthening six major frameworks integrating legal, methodological, financial, participatory, political, and institutional bodies to achieve sustainability

Graduation Year July 2021

Thesis Title: **IDENTIFICATION, CLASSIFICATION AND PRIORITISATION OF BARRIERS TO RURAL ELECTRIFICATION IN NEPAL**

Submitted by: **Madhusudan Adhikari**

Supervisor: **Prof. Dr. Bharat Raj Pahari**

ABSTRACT

In Nepal's more than 100 years electrification history, rural electrification was very slow and what are the main barriers to this is principal research question. This study analyzes the main barriers to rural electrification (RE) in Nepal. 27 barriers RE barriers are identified, divided in six groups analyzed and ranked based on judgment of RE expert's using a framework model developed in analytical hierarchy process (AHP), one of the multi criteria decision analysis (MCDA) tool. Experts are asked to rank RE barriers based on three factor/criteria namely cost to remove, the impact of removal and the time to remove RE barriers identified. These factors are also ranked to know their relative importance. In order to bring the diverse in-depth ranking patterns, the RE experts are classified into numbers of category and sub-categories based on specific expertise, type of organizational association and years of experience in RE. It is found that impact of removal is ranked as the most important factor/criteria for prioritizing barriers, followed by the cost to remove and the time needed to remove barriers was ranked second and third respectively. In analysis of ranking of RE barriers concludes that the financial, policy and geographical barriers as the first, second and third most important barriers, consistently in the first block; however their positions reshuffled in some sub-category of ranking. Legal and administrative, social and technological barriers are ranked as the fourth, fifth and sixth, respectively, placing them consistently in the second group. AHP priority weights of ranking reveals signification difference in first and second block but not much difference within a block. The findings of this research are quite in agreement with other similar studies, in Nepal and other countries. In the study period (2012-2019) electricity access has increased from 40% -77.8% of households. The analysis and discussion concludes that the main policy and financial barriers indentified in this study were softening by various policy and investment initiative taken by government of Nepal. Huge expansion of national and rural road network has overcome the geographical barrier in large extent. Positive development in the social barrier after the settlement of long-standing social conflicts attracted private and foreign investment in energy sector. Federal structure implemented brings governance near to people has positive impact in legal and administrative barrier and falling prices of solar and wind technologies has relaxed the technological barriers.

Graduation Year August 2021

Thesis Title: **POLYWORDNET : A WORD SENSE DISAMBIGUATION SPECIFIC WORDNET OF POLYSEMY WORDS**

Submitted by: **Udaya Raj Dhungana**

Supervisor: **Prof. Dr. Subarna Shakya**

ABSTRACT

This dissertation presents a new lexical resource which is named as 'PolyWordNet'. The PolyWordNet mimics the way how the senses of polysemy words and their corresponding related words are organized in a human mind. A related word of a sense of a polysemy word in a given context is a word that can disambiguate the meaning of the sense of the polysemy word in that context. The rationale behind the organization of words in PolyWordNet is that any simple sentence, which contains a polysemy word, also contains at least a related word (s). A sense of a polysemy word and its related word(s) in a sentence, therefore, have a strong semantic relation which can be used to disambiguate the sense of the polysemy word. Utilizing this semantic relation, PolyWordNet organizes the senses of polysemy words based on their corresponding related words. The organization of words in PolyWordNet is completely different as compared to the existing other popular lexical resources such as dictionary and WordNet. The words in a dictionary are organized based on the alphabetical order. Therefore, the words that spell alike come together but the words with similar meaning get scattered in the dictionary. In WordNet, the words with similar meaning are placed together based on the synonymy set. The polysemy words are the big problems in Natural Language Processing tasks since they create the ambiguity. No lexical databases deals with the organization of words based on these polysemy words. Therefore, the PolyWordNet is developed. The words in PolyWordNet are organized in such a way that the senses of polysemy words and their corresponding related words come together and form clusters. The results obtained from 63 runs of experiments performed on 3,541 words and tested by 4,105 different test sentences show the word organization of PolyWordNet is better for word sense disambiguation. These results also indicate that the word organization of PolyWordNet is acceptable and valid with reference to the popular lexical database- WordNet.

Keywords: Polysemy Word, Related Word, PolyWordNet, Word Sense Disambiguation

Graduation Year August 2021

Thesis Title: **IMPACT OF ENGLISH LANGUAGE PROFICIENCY ON THE QUALITY OF ENGINEERING EDUCATION IN NEPAL**

Submitted by: **Rup Narayan Shrestha**

Supervisor: **Prof. Dr. Jai Raj Awasthi**

Prof. Dr. Bharat Raj Pahari

ABSTRACT

This thesis presents the findings of the research entitled "Impact of English Language Proficiency on the Quality of Engineering Education in Nepal". The main objective of the present research study was to explore the importance of English language Proficiency in engineering education in Nepal. This research was based on phenomenological, interpretive paradigm of qualitative methodology and in-depth interview with students, policy makers and employers along with focus group discussion held with the teachers of various engineering faculties including civil, mechanical, electronics, Computer, electrical, and architectural engineering respectively. Based on purposive sampling of the research participants, semi-structured interview guidelines and the guidelines for focus group discussion as research tools containing open-ended questions, it revealed that there is a great role or importance of English language proficiency on the engineering education in the context of Nepal. It explored that English language proficiency is a key factor in determining the performance of engineering students in their academic career, further studies, job seeking and obtaining as well as job execution processes. It revealed that English being the medium of engineering education and engineering communication, it played a pivotal role in job-seeking, obtaining and job execution of engineering graduates in Nepal. It also revealed that English language proficiency being the part of generic communicative competence serving as a most important life skill for the engineering graduates, there is no possibility of imagining the proper enhancement and acquisition vi of engineering knowledge as well as skills leading to efficient execution of engineering duties especially engineering communication without it. It also explored that the existing syllabus of 'Communication English' being taught currently at IOE was useful to the students of engineering for developing the necessary communication skills in engineering students but due to insufficient teaching and learning hours allotted for it, it had not been able to yield the expected level of result, and therefore, it required further improvement.

Graduation Year August 2021

Thesis Title: **ANALYSIS, MODELING AND EVALUATION OF SERVICE PROVIDER LEGACY NETWORK MIGRATION TO SOFTWARE-DEFINED IPV6 NETWORK**

Submitted by: **Babu Ram Dawadi**

Supervisor: **Prof. Dr. Shashidhar Ram Joshi**

ABSTRACT

SDN and IPv6 networks are the latest networking paradigms emerged to avoid all the control, management, and operation complexities with issues of routing and security in legacy IPv4 networking system. But the lack of backward compatibility with IPv6 and SDN creates many challenges for service providers to migrate their legacy networking infrastructure into such latest generation networking paradigms. The adaptation of IPv6 addressing World-wide (just crossing 27% World-wide) is still not in a satisfactory level. Similarly, SDN implementation in the service provider networks is still in the early stages. In this regard, being underlying network layer paradigms, SDN and IPv6 joint network migration under the framework of Software-Defined IPv6 (SoDIP6) network is introduced. SoDIP6 network is an IPv6 capable network fully controlled/managed by SDN controller.

Present research considered IP routers migration in the ISPs/Telcos network and implemented adaptive neuro fuzzy inference system (ANFIS) to identify router status, whether it is upgradable or replaceable. ANFIS outperforms well as compared with other recent classification algorithms viz. linear regression, support vector machine (SVM), SVM optimizable, ensemble tree etc. Additionally, the joint migration analysis and modeling of SDN and IPv6 network optimized the total migration cost. For joint migration modeling, the cost metrics of individual and joint network migration to SDN and IPv6 are identified; then the joint migration problem is formulated with customer priority based on service level agreement (SLA) and implemented a greedy algorithm to migrate routers in the shortest path. Shared cost coefficient (μ) and the strength of correlation (ε) as optimization variables are introduced for SDN and IPv6 joint migration cost optimization. A joint migration cost optimization of up to 42.57% at $\mu = 2$ and $\varepsilon = 0.8$ has been achieved.

Migration of one ISP affects the business process of another interconnecting ISPs. Hence, an evolutionary approach for Tier-3 multi-ISP network migration has been simulated by following Moran's birth-death process for finite number of interconnected ISPs. Adaptation variable (Σ _4t) and strength of migration (δ_4t) are introduced for decision making of an ISP to evaluate fitness for migration. The increasing value of Σ _4t in the consequent previous

phases of migration and $\delta\_4t \geq 0.6$ is considered to decide for network migration implementation with higher utilities.

The functionality of legacy network interoperability with SoDIP6 network is evaluated using open network operating system (ONOS) controller and SDN-IP application in which longest span shortest path (LSSP) routers are migrated using breadth first router replacement (BFR) approach and the suitable placement of controller is identified using minimum control path latency (MCPL) between switch and the controller communication.

SoDIP6 network contributes to service provider sustainability with operational and capital expenditure reduction with significant saving in energy consumption. Energy efficiency of SoDIP6 network is evaluated using smart sleeping and dynamic adaptation of traffic volume in the link via simulation. For an end-access ISP network, 31.50% energy saving in switches and 55.44% energy saving in links of SoDIP6 network have been achieved as compared with legacy IPv4 network. A discussion on energy optimization and CO2 emission reduction practices with SoDIP6 network are provided with recommended sustainable solution using SoDIP6 network in the early stages of nationwide broadband network expansion in the context of Nepal.

Graduation Year December 2021

Thesis Title: STRAIN BASED APPROACH IN FATIGUE DAMAGE MODELING OF BRITTLE MATERIALS-APPLICATION TO CONCRETE AND WOVEN FABRIC GLASS COMPOSITES

Submitted by: Indra Narayan YAdav

Supervisor: Dr. Kamal Bahadur Thapa

ABSTRACT

Based on the modulus degradation rule of continuum damage mechanics by utilizing internal variable theory of thermodynamics connected to concrete and woven glass fabric composite materials under fatigue loading, a simple, reliable, better and computationally efficient theoretical fatigue damage model due to formation of microvoids, microcracks, nucleipropagation of microdefects and fractal is proposed. Since, most of the structural design software like FEM, ANSYS, SAP, and STAD PRO "etc." are based on deformation. It is difficult to quantify fatigue damage of brittle material through experiment. In order to fulfill this research gap, a theoretical strain-based governing equation for fatigue damage diagnosis is well developed as a damage model. The prescribed new theory is linked with a strainbased approach where "strain" is the main domain and is capable for the prediction of fatigue life of concrete, woven glass fabric composites as well as cementitious and brittle materials. A phenomenological strain-based fatigue damage model which includes fatigue strain, fatigue modulus, residual strain and irreversible strain in low cycle fatigue linked with a damage surface which is the product of strength reduction and strain softening as a new function reaches to failure on application of fatigue loading is developed. Investigational data from the fatigue test was employed to validate the model and the results show that the model can describe the fatigue damage progression of brittle materials applied to concrete and woven glass fabric composite materials under different fatigue loading by verifying the predicted fatigue life. Besides these, based on the stiffness degradation rule of laminate theory of composite engineering related to woven glass fiber composite materials which are brittle under fatigue loading, a low cycle theoretical fatigue damage model containing three material parameters is presented in this thesis. Theoretical degradation of Young modulus with respect to cyclic loading is developed and validated through the experimental results of U. Hansen (1999). The developed new model is capable of capturing the Phase I and II

damage. Degradation of Young's Modulus, alteration in the mechanical behavior, damage in elastic stiffness tensor, strength reduction, permanent deformations, evolution in strain, damage development corresponding to the normalized life, degradation of stress level from elastic to plastic regions and its accumulation subjected to variable frazzle fatigue loading including its verifications are discussed in this dissertation. In addition to these, an anisotropic damage model for concrete based on strain increment is proposed and written about in this thesis. A model is developed that is related to Poisson's ratio increment in compression loading, damage evolution in uniaxial compression, evolutionary equations for fatigue damage in concrete, model for elastic-damaging process, lateral strain evolution, modulus reduction, axial strain reduction, and degraded stressstrain curve for concrete material due to tensile strain increm

Graduation Year March 2022

Thesis Title: **SEISMIC PERFORMANCE OF MULTI-TIERED TEMPLES OF NEPAL**

Submitted by: **Chandra Kiran Kawan**

Supervisor: **Prof. Dr. Prem Nath Maskey**

ABSTRACT

Multi-tiered temples with high plinths or exposed foundations have always shown distinct evidence of seismic activity during the historic earthquakes and more recently in the recent 2015 earthquake. Temples with high plinth-like Nyatapola Temple and Taleju Temple of the Kathmandu Valley have been able to survive with minimal damage in major and minor earthquakes. This feature of temples signifies the important role of a high plinth during an earthquake. There has been no systematic study to assess the seismic capacity of the multi-tiered temples with the influence of the high plinth. Hence, this study has been undertaken to evaluate the seismic performance of temples with a high plinth.

The entire study has been divided into three parts- the first part of the study involves the soil sediment strata overlying the bedrock of the Bhaktapur City and its local effect on the free-field ground motion. The detailed investigation and the characterization of the high plinths in the tiered temples and their effect on the seismic behavior of the tiered temples constitutes the second part of the study. The strong ground motion parameters at the free-field of the Bhaktapur City, representing the typical city in the Kathmandu Valley, are acquired by using the one-dimensional site response analysis. The equivalent linear and non-linear properties of the soil were considered for the one-dimensional site response analysis. The lithological soil profiles of the study area were collected for the purpose. The dynamic properties of the soil such as shear wave velocity, shear modulus reduction curve, and damping ratio curve are chosen from the previous research works for the different soil classifications. A number of recorded/ simulated earthquake ground motions were selected as the input seismic ground motions for the study. The study in this part resulted into the development of the seismic hazard maps in terms of the peak ground acceleration (PGA), the amplification factor, the peak spectral acceleration, and the predominant periods of the studied area.

The extensive field investigation of the high plinth of multi-tiered temples was carried out including the post-2015 Gorkha earthquake damage assessment. The detailed damage assessment of the multi-tiered temples was carried out in the three Durbar Squares of the

Kathmandu Valley, namely, Kathmandu Durbar Square, Patan Durbar Square, and Bhaktapur Durbar Square. The dynamic properties, such as fundamental frequencies and damping ratios of the high plinths of nine temples, were also determined using microtremor instruments.

Based on the abovementioned two parts of the study, the seismic performance of the temples was evaluated with and without considering the high plinths. The prominent multi-tiered temples with high plinths were considered from the three historical cities of the Kathmandu Valley. The Finite Element modeling of the structural system of unreinforced brick masonry in mud mortar was done using macro-modeling. The materials of the structural components were assumed to be homogeneous, isotropic, and linearly elastic. The numerical model of the temple with and without consideration of a high plinth was evaluated using the commercial software package of SAP2000. The seismic analysis was carried out using free vibration analysis and linear time history analysis. The parametric study for each temple (with and without consideration of high plinth) is presented in terms of base shear, story displacement, drift ratio, and internal stresses.

The results indicate that the free-field motions are greatly influenced by the behavior of the local soil profile. The seismic hazard maps prepared for the free-field of the Bhaktapur City in terms of peak ground acceleration, amplification factor, and peak spectral acceleration indicate that the south-east and the western parts are seismically more vulnerable than other parts of the city. The fundamental frequency obtained from the microtremor measurement on the high plinth indicates that the high plinth of the temples is excessively rigid. The seismic performance evaluation of the temple with and without consideration of a high plinth indicates that the level of seismic vulnerability of temples largely depends on the rigidity of the high plinths.

The first part of the study has able to microzone the study area based on the free-field ground motion parameters, which can be used for urban planning purposes, preservation and conservation of historic monuments, and for disaster mitigation plans. The second part of the study proposed the empirical co-relation between the predominant frequency and height of the high plinth, which can be used in determining the fundamental frequency of an unknown temple's high plinth. The third part of the study points out the importance of considering a high plinth while seismic analysis of the temple is carried out. The outcomes of the study will help to formulate the retrofitting strategy or in any conservation works to mitigate the temples from the disaster in the future.

Graduation Year March 2022

Thesis Title: **TECHNICAL AND ECONOMIC ANALYSIS OF WIND ENERGY IN NEPAL**

Submitted by: **Raju Laudari**

Supervisor: **Dr. Kamal Baskota**

ABSTRACT

In the highly traditional and inefficient energy dependent countries like Nepal, effective exploitation of renewable energy needs serious attention. In this context, identification of potential locations for wind energy production is the particular interest of Nepal. Wind speed is the most important indicator for assessing the wind energy resource. Wind energy potential assessment is carried out either by micro-scale modeling or dedicated met masts or by means of both. Measuring wind energy potential by establishing masts demands high cost and longer time period. Hence, it is important to validate the available modeled wind climate data with the site specific measured data. The modeled wind data produced by High Asia Refined analysis (HAR) dataset are validated based on the measured data from 14 sites in this research. Statistical analysis is computed and also wind speed hourly data of all study sites are compared by presenting both sources data graphically. The statistical analysis supports that the modeled data and measured data do not differ significantly and there is a moderate correlation between these data sources. The validation result shows that the modeled wind dataset represents moderately the actual wind speed situation of the research sites. Thus, the modeled dataset is useful for preliminary assessment of wind energy potential in Nepal.

This research assessed the technical potential of wind farming at the 16 sites scattered in different ecological regions of Nepal. The wind speed, the hourly and seasonal variation of wind, the wind rose, the wind turbulence rate, the wind power density, the Weibull probability distribution and the frequency of the wind speed above cut-in speed are computed. The average wind speed at all the sites is found to be higher during the dry season from March to May. The wind speed of the modern turbine for power generation at eight sites is found to be above cut-in speed. However, the wind power density is found to be good only at the two sites and fairly good at the six sites. More than 50 percent time of a year at these eight sites had over 3.5 m/s wind speed. However, the turbulence rate at all the research sites

is found to be above the acceptance range of 25 percent. Among the study sites, Kagbeni, Thini, Jumla, Ramechhap, Vorleni, Patan-west, Hansapur and Baddanda are found to be technically feasible sites for wind energy generation in Nepal.

Shifting the energy mix of Nepal from the domination of traditional biomass followed by imported fossil fuel with the lowest share of renewable energy is a matter of urgency to drive the nation towards low carbon and self-energy reliance economy. In addition, the available clean hydropower resources are also vulnerable due to climate change and induced disasters. The full deployment of technically feasible wind energy can be an instrumental policy to break the current energy blend by increasing the share of renewable energy sources. The objective of this research is to analyze economic viability of wind energy in Nepal. The research reveals that none of the 16 research projects are economically viable for energy generation without incentives. Viability of wind energy is found high in the mountain region followed by the Mid-hill and the Terai after providing incentives. With incentive policies, full capitalization of wind energy reduces the use of 310 million liter fossil fuel annually, substitutes about 6.8 percent of annual import of petroleum fuel and gas, avoids 4.5 million tons of CO_2 emission annually, increases independency in energy supply and generates additional employment in the country. The financial surplus due to petroleum fuel import substitution and investment grant reduction will be sufficient to produce about 1248 megawatt additional renewable energy. Hence, the implementation of the suitable feed-in-tariff policy mechanism coupled with the scaling up plan of wind energy is the most appropriate policy for increasing viability of wind power generation and growing share of clean energy in Nepal.

Graduation Year January 2023

Thesis Title: **ENERGY DEMAND AND SUPPLY ANALYSIS OF NEPAL**

Submitted by: **Kiran Gautam**

Supervisor: **Prof. Dr. Amrit Man Nakarmi**

Dr. Shree Raj Shakya

ABSTRACT

Biomass has dominated the overall energy mix of Nepal. Its unsustainable use is not only increasing the pressure on the forest resources, but also deteriorating the environment and creating the problem like indoor air pollution. Nepal is hundred percent dependent on imported petroleum products as it has not found viable proven reserve yet. The import of petroleum products is increasing at an alarming rate (15.2% annually), which is creating not only a burden on the national economy but also raising the issue of energy supply security and environmental degradation.

In these circumstances, an updated analysis of demand and supply is essential. As the previous studies primarily cover the demand forecasting this study's objective is to carry out both demand and supply analysis and their impact on energy security of the nation. In addition to that, energy planning is not a one stop job it needs continuous update in changing context.

For the analysis of energy demand and supply scenarios of Nepal, the Model for Analysis of Energy Demand and the Low Emission Analysis Platform have been used. Taking 2017 as a base year, three scenarios have been developed based on economic growth rates viz - low or Business as usual (4.5%), medium (7.2%), and high (9.2%). Two additional policy scenarios policy-I and policy-II have been analyzed considering the medium scenario as the reference scenario to see the changes in energy demand particularly due to electricity penetration in residential and transport sector. The scenarios have been developed taking year 2020 as first scenario year till the year 2040. Further, eleven distinct and significant indicators "Energy intensity, Oil intensity, Oil use per capita, energy use per capita, electricity use per capita, share of fossil fuel in the total primary energy supply, Shannon-Wiener Index, Net energy import ratio, Vulnerability index, Emission intensity, Emission per capita" have been used to see the impact on energy security of the nation.

Total final energy consumption in the base year was 524.7PJ which is expected to reach 1162.80PJ, 1489.65PJ, and 1879.82PJ in low, medium and high scenarios respectively in 2040. Whereas in policy-I, it is expected to reach 1416.07PJ, and under policy-II scenario, it would reach 1336.10PJ by the year 2040 resulting in

average annual energy demand growth of 3.5\%, 4.6\%, 5.7\%, and 4.4\% and 4.2\% respectively in the low, medium, high, policy-I and policy-II scenarios. However, the final electricity demand will increase at the annual average growth rate of 8.4\%, 9.9\%, 11.7\%, 10.8\%, and 11.0\% in low, medium, high, policy-I, and policy-II scenarios respectively. The share of traditional fuel has been found to decrease in all the scenarios while the share of petroleum will increase in all scenarios. Per capita final energy demand would be 29.42GJ, 37.69GJ, and 47.56GJ, and 35.82GJ in low, medium, high, and policy scenarios whereas the per capita electricity demand will be 789kWh, 1145kWh, 1570kWh, and 1290kWh respectively in 2040.

The total primary energy supply requirement would be 1,216PJ, 1,566PJ, and 1,985PJ in low, medium and high scenarios respectively by the year 2040. Due to the intervention of electricity, there would be a saving of 136PJ of energy in the policy-II scenario compared to the medium growth scenario in the year 2040. However, there would be a need for an additional 3,706MW of power generation capacity to sustain the additional electricity requirement. The net energy import ratio would reach 34.56 in the high scenario from 15.62 in the base year while in the policy-II scenario it would be 31.34. One of the important energy security indicators is Shannon-Wiener Index which shows that there is an increase in diversification of the supply of energy resources in all the scenarios. The highest Shannon-Wiener Index is 1.48 in the Policy-II scenario. The Vulnerability Index in different scenarios shows that the highest vulnerability will be in the low scenario compared to all other scenarios whereas in the policy-I scenario there will be a reduction in Vulnerability Index by 2.2% and in Policy-II scenario by 8.8% compared to medium growth scenario by the year 2040. Therefore switching from traditional biomass and fossil fuels to electricity will help to reduce the pressure on the forest, dependency on imported fuel, increase energy diversity, reduce economic vulnerability, and reduce environmental emission thus helps in enhancing energy security and sustainable development of the country.

Since, the study has analyzed the various optional pathways that country can take to move forward, it can be a useful asset for policy makers and planners to plan ahead for managing supply and investment to achieve enhanced energy security for the country.

Graduation Year February 2023

Thesis Title: **LIQUEFACTION HAZARD ASSESSMENT OF KATHMANDU VALLEY**

Submitted by: **Mandip Subedi**

Supervisor: **Dr. Indra Prasad Acharya**

ABSTRACT

In Nepal, historic earthquakes have shown extensive liquefaction in different areas of the country, including its capital, Kathmandu Valley. The 1833 and 1934 earthquakes caused significant harm due to liquefaction. An earthquake of moment Mw7.8 struck on 25 April, 2015, keeping the epicentre at the central part of Nepal manifested extensive soil liquefaction across the Kathmandu Valley. Despite being a liquefaction susceptible zone, Kathmandu Valley soil in Nepal has limited studies on liquefaction potential. As a densely populated urban settlement, the assessment of liquefaction potential of the valley is crucial especially for ensuring the safety of engineering structures. In this study, the field reconnaissance concerning the liquefaction cases in Kathmandu after the mainshock of 2015 Gorkha Earthquake has been conducted. The field observations, alongside results from liquefaction evaluation, contrasts with the previous liquefaction studies conducted before the 2015 Earthquake for the valley. To evaluate the irregularity of existing maps with the ground manifestations caused by the 2015 Gorkha Earthquake, we utilised the geotechnical database gathered from 400 locations before the quake and 10 boreholes drilled after the 2015 Gorkha Earthquake to conduct quantitative analyses and modelling to assess the geotechnical characterization and susceptibility, hazard, and risk of liquefaction of the valley soil considering three likelyto-recur scenario· earthquakes. Some of the existing and frequently used analysis and computation methods based on deterministic and probabilistic approaches are employed for the assessments, and the obtained results are presented in the form of liquefaction hazard maps indicating factor of safety (FOS), liquefaction potential index (LPI), probability of liquefaction (Pr,) and probability of ground failure (Pa). The assessment results reveal that most of the areas in the valley have medium to very high liquefaction susceptibility, and that the central and southern parts of the valley are more susceptible. to liquefaction and are at greater risk of liquefaction damage than the northern parts. The assessment outcomes are validated with the field manifestations during the 2015 Gorkha Earthquake. The target SPT-N values (Nimproved) at potentially liquefiable areas are determined using back analysis to ascertain no liquefaction during the aforesaid three scenario earthquakes. The hazard maps prepared for different earthquake scenarios can be useful for future infrastructure planning in Kathmandu Valley. The FOS, LPI, El and Pc distribution maps created in this study enable us to

identify liquefaction prone locations in the Kathmandu Valley. Likewise, the liquefaction zonation maps prepared for different scenario earthquakes will help planners and designers in making safe and resilient settlement plans as well as infrastructure development strategies through scientific risk-sensitive land use planning. Moreover, information on liquefaction susceptibility will facilitate structural and geotechnical engineers to make evidence-based decisions on the type of structural foundation. Furthermore, the improved SPT-N (.Nimproved) map will assist us in determining the suitable method and extent of ground improvement needed in possible liquefaction susceptible locations in order to ensure no liquefaction.

Graduation Year February 2023

Thesis Title: Performance Analysis of a Hybrid Solar Power Plant Operation in Tandem with a Rice Husk Dryer

Submitted by: Ram Dayal Yadav

Supervisor: Assoc. Prof. Dr. Ajay Kumar Jha

Assoc. Prof. Dr. Nawraj Bhattarai

ABSTRACT

Rice husk is renewable energy from which energy can be harvested both in terms of heat and electricity. The rice husk used in the furnace of solar rice husk hybrid power plants and other rice husk-fired furnaces is found directly fed to the furnace without drying it. Feeding wet rice husk in the furnace, a significant amount of heat is required to evaporate and superheat the moisture of the rice husk. If the rice husk is dried before feeding it to the furnace, that significant amount of heat input is saved which in turn increases the furnace's efficiency. The objective of this thesis is to modify the existing furnace proposed by Srinivas and Reddy (2014) by implementing a Rice Husk Dryer, where waste heat of the flue is used to dry the rice husk before feeding it to the furnace to enhance the furnace efficiency. For the performance analysis of the modified hybrid power plant, the furnace efficiency, fuel efficiency, specific rice husk consumption, plant efficiency, etc. have been evaluated concerning moisture reduction of rice husk using MATLAB. A CFD analysis has been carried out for the temperature distribution, particle burnout, CO2, H2O, etc. distribution pattern of the furnace. It has been found that the furnace efficiency and plant efficiency have been increased and the specific rice husk consumption has been
reduced on modification. The results have been compared with Srinivas and Reddy and correlated with the actual furnaces. Compared to Srinivas and Reddy (2014), the furnace efficiency has been increased by 44.05% on RHD temperatures of 110◦C.

For RHD temperatures of 110◦C and moisture reduction of 10 − 100%, the plant efficiency has been found 19.29 − 29.06% for 60 bar operating pressure compared to 17.76% of plant efficiency without moisture reduction. The temperature and particle burnout have been increased while CO2 and H2O distributions have been decreased. A consistent Simulation result between the modified furnace and actual furnaces has been found. The modified furnace of the power plant has been found more economic, efficient, and environmentally friendly than the existing furnace. The modified furnace can be used to improve the efficiency of solar rice husk hybrid power plants and other rice husk-fired furnaces used in the industries.

Graduation Year February 2023

Thesis Title: **SPATIAL ANALYSIS OF PUBLIC BUS ACCESSIBILITY AND PASSENGER MODAL CHOICE BEHAVIOUR: A CASE STUDY OF KATHMANDU VALLEY, NEPAL**

Submitted by: Anita Prajapati

Supervisor: Prof. Dr. Tri Ratna Bajracharya

Assos. Prof. Dr. Nawraj Bhattarai

ABSTRACT

Public transport plays a crucial role in sustainable transport planning by providing economical and environmentally friendly service, reducing congestion, and providing medium to long distances for inhabitants having no other feasible alternatives. However, the effectiveness of public transport is vital in attracting more users with service at the doorstep. It is thus fundamental to provide good physical access to and from origins to destinations and optimize the total travel time, including waiting, transfer, and walk time. This study is carried out to analyze the accessibility to the public bus where public transport is yet to be formalized with proper schedule, transfer, and wait time. Public bus accessibility in Kathmandu valley is analyzed by developing a General Transit Feed Specification (GTFS) route planner incorporated nto the Geographic Information System (GIS) transport network model having the operational schedule and route variants such as frequency and schedule.

The results from public bus accessibility show 39% of the population has public bus coverage within 500m and within 10 minutes of walk time from the ward centroid. It is found that 35% of the valley area inhibits those 90% population indicating high population density in the inner area of the valley. The high population density of the valley shows good potential for public transport as it is most suitable for the dense population due to its ability to transfer a large share of the population with limited traffic. The population-weighted average access distance is estimated to be 894m, around 124% higher than the standard threshold distance (400 m) and 16 minutes, which is higher than the national urban average time of 12 minutes due to some share of the population needing to walk more than 30 minutes. The spatial analysis shows the city-centric area with a good level of accessibility compared to the peripheral area indicating city-centric road network development. The Public Transit Accessibility Index (PTAI) also shows that approx. 30% of the population has moderate to good access to the public bus in the valley. It categorizes the valley area with different levels of public bus service and identifies the area needing investment to improve the public bus service in the valley.

Along with access to public buses, the total travel time also plays a key role in making public transport the preferred mode of transport. For sustainable transport planning of the valley, the valley transport system is analyzed based on transport characteristics along with the modal choice behaviour attributed to individual travel time constraints using the TIMES model. The result shows that the travel time

budget available for the individual for daily travel constraints the choice of the public bus as the preferred mode of travel. The walk time to and from the transit access point obtained from the accessibility analysis adds to the total travel time via public bus which is already two times more than an individual travel time budget in the reference scenario as shown by per capita travel time which was estimated to be 0.97 hr/p/day in 2017 and would be 1.03hr/p/day in 2030, and 1.09hr/p/day in 2050, respectively which is slightly lower than the global average of 1.1hr/capita/day due to a large share of non-motorized travel in the valley. The longer travel time adds cost to public buses making them costlier than private vehicles.

The scenario analysis shows that the existing public vehicle cannot meet the growing passenger travel demand considering their travel behaviour. The public transport mode that can compete with private vehicles, such as the rapid transit mode, as indicated in scenario S5 would be needed to meet all travel demand within the available fixed time. The existing policy to increase electric vehicles and promote mass transport is analyzed in scenario S2 which shows the need of introducing electric public vehicles to meet the national target, but the larger share of low-speed vehicles would require threefold time than the actual time available in this scenario. Even though the cost of travel (excluding travel time cost) in public bus is lower, there is a high probability that people would shift to faster yet expensive modes due to time constraints as shown by S4 and S5 scenarios.

This shows a tradeoff between time, energy, and emission in modal choice. It indicates that just penetration of public transport and increasing its number in the market is not sufficient to promote public transport. The major effort should be in investing in infrastructures that improve access to the public transport networks as well as the overall service of the public bus. The investment in infrastructure to develop a well-developed public transportation system with efficient and frequent bus services, well-placed bus stops, and easy access to the bus system is required to encourage individuals to use public transportation more frequently. Individuals are more likely to choose public transportation as their mode of choice when it is easily accessible and convenient. The policy for future modal mix should thus carefully undertake the modal choice behaviour during transport planning. For improving the transport system of the valley, the priority should thus be on improving infrastructure for reducing both access dist

Graduation Year November 2023

Thesis Title: Sediment Erosion in Guide Vanes of Francis Turbine

Submitted by: Shekhar Aryal

Supervisor: Prof. Dr. Rajendra Shrestha

Assos. Prof. Dr. Ajay Kumar Jha,

Asst. Prof. Dr. Sailesh Chitrakar

ABSTRACT

The hydro-power plants under Himalayan basins are mostly characterized by heavy sediment load due to geographical and metamorphic constraints. Run-off-river projects with the limited size of the desilting basins allow suspended sediments to be carried into the turbine components, causing wear due to sediment erosion. In the case of high-head power plants consisting of Francis turbines, a large portion of the hydraulic energy is transformed into kinetic energy within the guide vanes. This causes various instabilities in the flow due to high acceleration and velocity. Some recent studies have shown that due to the combined effect of the secondary flow around the guide vanes and sediment carrying flow, the clearance gap increases, further aggravating the performance of the turbine. This study takes a reference from one of the power plants in Nepal containing Francis turbines. An in-depth analysis of the effect of the sediment in this power plant and sediment erosion in the turbine components has been performed. A CFD analysis of the guide vanes and runner blades corresponding to the same turbine has been conducted and the results are used to analyze the erosion pattern on the actual turbine. The detailed erosion analysis is made possible with a 3D scanner, such that the eroded regions can be captured and classified based on the flow behavior at those regions. Guide vanes and runner blades are found to be the predominant components affected by erosion. It has been seen that most affected regions are erosion-affected regions that originated from increasing clearance gaps between the guide vanes and facing plates caused by continuous leakage flow within the two sides of the guide vanes.

The broad range of dependent parameters, such as sediment characteristics, base materials and flow conditions, limits estimation of sediment erosion in hydraulic turbines. Some mathematical models have been proposed in the past literature and some of them have been incorporated in a CFD tool for predicting erosion and flow conditions. Rotating Disc Apparatus is a simplified experimental setup initially developed targeting erosion studies in Francis turbines. However, the closeness of the results obtained from this apparatus with the actual turbine remains uncertain. This thesis also investigates the flow phenomena inside the guide vanes region using RDA, and compares them with the actual turbine. A reference case of Jhimruk hydro-power plant has been taken in this study, which has been scaled down with a factor of 1:4 from its original size. The numerical fluid domain consists of four rotating blades distributed around the disc uniformly.The GVs were designed as symmetrical NACA0012 hydrofoils. The pressure distribution around the guide vanes inside RDA and the tip-vortices' development have been compared with the results from the past

research works. It is found that the flow field around guide vanes inside RDA matches closely with that of the real turbine. The stagnation point and development of the pressure and suction sides are similar to the actual guide vanes, which make the apparatus suitable for investigating the erosion after including the sediment particles. However, more investigations might be needed to determine whether to use the same apparatus for the runner blades or guide vanes under different operating conditions. Scanning electron microscopy (SEM) has been used to analyze erosion in various regions of guide vanes constructed of two different materials, Brass and Mild Steel. The mechanism of erosion in various parts of guide vanes is found to be highly related to the flow pattern in that part. Mild steel guide vanes displays corrosion attack and crack formation as material is removed, but Brass guide vanes shows plastic deformation during ploughing, cutting, and pitting. The weight of two Brass and two Mild Steel guide vanes before and after 390 minutes experiment were 249.44g, 241.27g, 283.89g and 276.78g and 244.5g, 236.0g, 280.9g, and 274.9g respectively.

Graduation Year March 2025

Thesis Title: **Experimental investigation on the performance of the vertical ultra-low-head hydro turbine with the variation of outlet flow level for canal flow application**

Submitted by: Raj Kumar Chaulagain

Supervisor: Prof. Dr. Laxman Poudel
Dr. Sanjeev Maharjan

ABSTRACT

This research work is related to an experimental analysis of a conceptualized hydro turbine for very low hydraulic heads applicable in canal flow with or without head drops. The concept is focused on simplicity and ease of manufacturing. The problem associated with the conceptualization step with the inlet flow disturbance and performance on submergence is addressed by introducing inlet approach profiles and outlet level control mechanisms. Three sections of the research include the development of a test rig, the selection of inlet approach profiles and non-rotating models of a turbine, and the development of a prototype of a turbine. The methodology adopted for each of the three sections of the research covers design, fabrication, and testing based on the conceptualization stage. The first section of research covers the development of a test rig with an overall size of 9 x 1.2 x 1.5 m^3 for a maximum 120 liters per second (LPS) flow rate and height of 1.5 m. The test conducted for its coefficient of discharge of rectangular notch was found 0.575 to 0.617 linearly increasing with flow rate.

The second section of the research focused on the inlet approach profile for a canal without head drop and the two-dimensional (2D) non-rotating model of the proposed turbine. The curve profile showed the best performance among the four tested profiles. The three different non-rotating models were tested for the prediction of upstream height on an open canal system. The model with 18^0 orifices opening showed an upstream value close to the actual turbine. The third section of this research is concentrated on the design and testing of the turbine on the same test rig. The design of a turbine with the conventional method was followed in three stages for runner sizing, blade profile, and guide vane profile assuming free vortex. Furthermore, the turbine was developed and tested with the variation of outlet flow level from 0 to 0.5 m of height. The experiments showed a maximum efficiency of 51.6% at 107 rpm on 0.4 m of outlet height for the constant flow and 53.8% at 0.25 m of outlet height for constant speed conditions. The uncertainty band of ±1.85% was known for maximum efficiency condition. The conclusion was drawn that the use of inlet approach profile and outlet level control on vertical ultra-low head (VULH) turbine systems is efficient. The performance obtained in line with the conventional propeller turbine demonstrated its relevance and positive impact on low-scale power generation without using a draft tube. The analysis showed enough space to increase the overall efficiency and capacity of the system through optimization. Also, for the field implementation of the system, socio-economic and environmental analysis with guidelines is recommended as a major task for the future. At last, the coverage of limitations and challenges faced during this research is expected to be beneficial for upcoming researchers in the ULH sector.

Graduation Year May 2025

Thesis Title: **Hierarchically Porous Activated Carbons Derived from Triphala Seed Stones for Adsorption and Energy Storage Supercapacitor Applications**

Submitted by: Chhabi Lal Gnawali

Supervisor: Prof. Dr. Bhadra Prasad Pokharel
Prof. Dr. Rinita Rajbhandari
Prof. Dr. Lok Kumar Shrestha

ABSTRACT

Biomass carbons exhibit high surface area and large porosity. Therefore, they are widely explored as the efficient adsorbents and electrode materials in high-performance supercapacitors. This dissertation research work reports the synthesis, characterizations, and supercapacitance performances of the novel activated carbon materials from Triphala (Terminalia chebula (Harro),Terminalia bellirica (Barro), and Phyllanthus emblica (Amala)) seed stones by zinc chloride activation at different temperatures under the nitrogen gas atmosphere. The prepared carbons were characterized by the thermogravimetric analysis (TGA), Fourier transform-infrared (FTIR) spectroscopy, X-ray diffraction (XRD), Raman scattering spectroscopy, scanning electron microscopy (SEM), and transmission electron microscopy (TEM). The surface area and porosity were estimated by nitrogen adsorption isotherms. The energy storage performance was studied by cyclic voltammetry (CV), galvanostatic charge/discharge (GCD), and electrochemical impedance spectroscopy (EIS) in an aqueous 1 M sulphuric acid (H2SO4) solution in a three-electrode cell set up. The Terminalia chebula seed powder carbonized at 700 °C (HrC_Z700) exhibited the highest specific surface area of 1382.6 m2 g-1 and total pore volume of 0.929 cm3 g-1. The material showed excellent adsorption properties. Iodine number ca. 1016 mg g-1 and methylene blue value ca. 346.5 mg g-1. Furthermore, the sample showed excellent electrochemical performance with a high specific capacitance (328.6 F g-1 at 1 A g-1), large capacitance retention at a high current density of 50 A g-1 (44.7%) and outstanding cycle performance of 98.2% after 10,000 successive charging/discharging cycles. The Terminalia bellirica carbonized at 700 °C (BrC_Z700) shows a specific surface area of 1303 m2 g-1 with a total pore volume of 0.873 cm3 g-1. Iodine number and methylene blue value were ca. 909.8 mg g-1, 357.2 mg g-1, respectively. Langmuir isotherm model described the adsorption of methylene blue in equilibrium with a monolayer adsorption capacity of 312.5 mg g-1. The electrode with the optimal xsample achieved a high specific capacitance of 319 F g-1 at 1 A g-1 good rate capability and long cycle life of 98.5% after 10,000 cycles. ZnCl2 activated Phyllanthus emblica seed stones also exhibit excellent surface textural properties. The optimal sample carbonized at 700 °C (AmC_Z700) attained a high specific surface area of 1436.3 m2 g-1 and total pore volume of 0.962 cm3 g-1. As a result, the electrode achieved a specific capacitance of 317.5 F g-1 at 1 A g-1 and long cycle life of 98.5% after 10,000 cycles. KOH activation further enhanced the surface textural properties of the Phyllanthus emblica seed carbon. A high specific surface area of 1946 m2 g-1 and total pore volume of 1.115 cm3 g-1 achieved upon carbonization at 900 °C. The electrode achieved a specific capacitance of 272 F g-1 at 1 A g-1 followed excellent rate performance (60% capacity retention at 50 A g-1) and an outstanding cycle performance of 98% after 10,000 cycles. These results demonstrated that the activated carbons from Triphala (Harro, Barro, and Amala) seed stones have potential for producing hierarchically porous carbon materials that can be used in high-energy storage supercapacitors and adsorption technologies. Keywords: Triphala, chemical activation, nanoporous activated carbons, electrochemical measurements, supercapacitor.

Graduation Year October 2025

Thesis Title: Biomass Material and Its Activated Carbon for Energy Application and Environmental Remediation

Submitted by: Manoj Kumar Jha

Supervisor: Prof. Dr. Hem Raj Pant
Prof. Dr. Ram Kumar Sharma

ABSTRACT

Environmental pollution, and energy crisis are the most important challenges these days. Fast industrialization and excessive energy consumption are making these issues worse. To overcome these unfavorable circumstances and attain environmental sustainability economical, facile and environmentally-friendly technologies need to be investigated. The use of locally available biomass, its carbonaceous material and composite show considerable promise in accomplishing the goal. The present study focused on the utilization of locally available Bhang (Cannabis) stem to make fine powder followed by carbon materials and composite. Raw powder was applied for dye removable whereas pristine activated carbon was applied for supercapacitor application. The composite of activated carbon was applied for arsenic removable from natural and synthetic water.

Bhang raw powder was prepared by grinding dry Bhang stem followed by sieving. The surface morphology and chemistry of raw Bhang powder were investigated. It was found that the raw powder was highly porous with the excellent surface having positive moiety with good affiliation to cationic dyes. Batch adsorption experiments were accomplished under several conductions inclusive of initial dye concentration, pH, adsorbent doses, and contact time. The Langmuir and Freundlich isotherm models were employed to confirm the adsorption behavior. Equilibrium data of the adsorption processes showed that the adsorption of methylene blue (MB) was fitted to the Langmuir isotherm with a maximum adsorption capacity of 97.5 mg/g. The adsorption kinetic data were very well described by the pseudo-second order kinetic model (R2 = 0.99), suggesting that the adsorption might be a

chemisorption process and the negative value of Gibb's free energy confirms that the adsorption process is spontaneous.

The elemental analysis showed that the raw Bhang powder contains about 34% of carbon. Therefore, we assumed that it will be suitable precursor for the preparation of activated carbon (ACs). Thermogravimetric analysis (TGA) was used to detect the course of pyrolysis. A series of ACs were prepared from raw Bhang powder using zinc chloride (ZnCl2), phosphoric acid (H3PO4), and potassium hydroxide (KOH) as activating agents. The optimum preparation conditions were studied by determining the iodine number and methylene blue number. The physiochemical properties of as fabricated ACs were studied using different characterization techniques. Here, surface functional groups present in ACs were analyzed by Fourier Transform Infrared (FTIR) spectroscopy. The surface morphology, crystalline structure, and graphitic nature were investigated by Scanning Electron Microscopic (SEM), X-ray Diffraction (XRD), and Raman spectroscopy, respectively. Elemental states were investigated by X-ray Photoelectron Spectroscopic (XPS). The surface area was determined by nitrogen adsorption-desorption using Brunauer Emett and Teller (BET) isotherm. The surface charge of activated carbon was determined by Zeta analyzer. The nanoporous carbon with high surface area and porosity was obtained at following preparation conditions; in case of zinc chloride the ratio of raw Bhang powder to activating agent of 1:1, carbonization time of 3 h and carbonization temperature of 500 °C. For phosphoric acid and potassium hydroxide activated carbons the impregnation ratio of 1:1, carbonization time of 3 h and carbonization temperature of 700 °C. Under these preparation conditions, the highest iodine number and methylene blue number of ZnCl2 activated carbon was found to be 934.2mg/g, 487.5 mg/g and that of H3PO4 activated carbon 909.28 mg/g, 504.58 mg/g and of KOH activated carbon 386.13 mg/g, 42.5 mg/g, respectively. The ZnCl2 activated carbon and H3PO4 activated carbon show the higher BET surface area than KOH activated carbon. The FTIR spectra show the presence of different oxygenated functional groups. The SEM images show the porous structure in the activated carbons. XRD spectra show two broad peaks at diffraction angles of 25 and 43 degree indicating the amorphous nature of carbon. XPS spectra investigated the presence of C, N, O, S, and P in different forms.

The nanoporous activated carbon obtained from impregnation of Bhang raw powder with ZnCl2 in the of ratio 1:1 carbonized at 500 °C for 3 h gives the reasonably high surface area, micro/meso porosity structure. Therefore, it was selected for the preparation of magnetic

activated carbon composite (MAC). The composite was prepared using Ferrous sulphate and Ferric chloride solution at 120 ℃ by hydrothermal approach. The composite was characterized by SEM-EDX, FTIR, XRD XPS, and Zeta analyzer. The batch adsorption studies were carried out with MAC-composite on arsenic adsorption and the effect of pH, contact time, and doses on the efficiency of arsenic adsorption was investigated. The MAC composite showed greater efficiency than pristine carbon. The Langmuir and Freundlich isotherm models were employed to confirm the adsorption behavior. Equilibrium data of the adsorption processes showed that the adsorption of Arsenic (III) was best fitted to the Langmuir isotherm with a maximum adsorption of 8.68 mg/g. The adsorption kinetic data were very well described by the pseudo-second-order kinetic model (R2= 0.99) suggesting that the adsorption of Arsenic (III) on MAC-composite might be a chemisorption process and the negative value of Gibb's free energy confirms that the adsorption process is spontaneous.

Another highly porous activated carbon with a high specific area prepared with raw Bhang powder using H3PO4 activating agent was used as an electrode material for supercapacitors. The electrochemical properties were investigated. The novel activated carbon exhibits a significantly high specific capacitance of 160 Fg-1 at a current density of 1 A g-1 in 6M KOH as well as excellent cycling stability with capacity retention of 101% after 3000 cycles at 0.5 A g-1.

Our findings suggest that locally available bio-waste Bhang stem powder can be used as an effective adsorbent for dye adsorption even in its raw form. It is also suitable for the fabrication of highly porous ACs with high supercapacitor. Moreover, its surface modification with magnetic nanoparticles showed the great potentiality in As (III) adsorption.

Keywords: - Bhang stem, Bio-waste, Dye, Activated carbon, Composite, Arsenic (III), Adsorption, Supercapacitor

Graduation Year November 2025

Thesis Title: Himalayan Essential Oils as a Green Solvents: A Novel Paradigm in Polymer Nano Processing

Submitted by: Dinesh Shah

Supervisor: Prof. Dr. Hem Raj Pant
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ABSTRACT

Nano/microstructured polymeric fibrous membranes and thin films have great demand for diverse applications such as filtration, adsorption and biomedical fields. However, toxic and volatile organic solvents, which are extensively being used in polymer processing such as in electrospinning and film casting, lead to adverse effects to health and environment. Moreover, residual toxic organic solvents present within nano/microfibrous membranes and thin films restrict their applications in the biomedical fields. Therefore, there is a need of green solvents to replace toxic organic solvents in polymer processing. Himalayan essential oils (EOs), which are generally not only nontoxic and environmentally friendly, but also available in wide spectrum, offer a promising green solvent property in polymer processing. Biocompatibility and antimicrobial properties of EOs further attract their application in biomedical fields. In this study, various Himalayan essential oils have been screened as green solvent in polymer processing.

Polymeric nano/microfibrous membrane and thin films have been fabricated using green solvent. Potential applications of as-fabricated materials in biomedical field have been studied. Solubility of common polymers namely polyacrylonitrile, polycaprolactone (PCL), polyurethane, Nylon-6, and cellulose acetate in Himalayan essential oils namely cinnamon oil, lemongrass oil, turpentine oil, eucalyptus oil, peppermint oil, citronella oil, and

wintergreen oil were studied by hit and trial method. PCL, an FDA approved polymer, was found to be soluble in cinnamon oil, wintergreen oil and lemongrass oil which suggest that these essential oils are possible green solvents for PCL processing. PCL solution in cinnamon oil, wintergreen oil and lemongrass oil were successfully fabricated into electrospun membranes by electrospinning method. Surface morphology study of as-fabricated electrospun membrane by scanning electron microscopy (SEM), showed that 16wt% PCL solution in cinnamon oil was successfully fabricated into nano/microfibrous membrane. This finding indicated that cinnamon oil is a promising green solvent in processing of PCL in nanoscale level. As-fabricated membrane was further characterized by different physicochemical methods. Fourier-transform infrared spectroscopy (FTIR) results revealed that x the cinnamon oil is sufficiently infused in PCL nano/microfibrous membranes. Contact angle measurements showed the hydrophilic nature of membrane.

Potential applications of as-fabricated electrospun membranes in biomedical field were studied. Antimicrobial testing and cytotoxicity assessment (MTT assay) were conducted to evaluate their antimicrobial properties and potential impact on cell viability. The results demonstrated that as-fabricated PCL electrospun nano/microfibrous using cinnamon oil exhibited good antimicrobial activity, biocompatibility and non cytotoxic activity. This is probably inherent property of residual cinnamon oil in fibrous membranes, hydrophilic nature of the as-fabricated membrane, leading to the ability to retain moisture, due to which natural moisture spreads evenly across the wound surface, maximizing contact and creating a moist environment thereby helping to accelerate the healing process compared to dry wound healing.

Thin film membrane formation property of PCL solution in cinnamon oil, wintergreen oil and lemongrass oil were studied. Solvent casing method was used for the fabrication of thin films in three green solvents. Physicochemical characterizations suggested the successful formation of porous PCL thin films. These findings further suggest that cinnamon oil, wintergreen oil and lemongrass oils are potential greens solvent in solvent casting process. These outcomes provide a new platform for Himalayan essential oils as alternative green solvents to conventional organic solvent for the fabrication of nano/microfibrous membranes and thin films from a variety of polymers for future advancements in polymer processing which would have high potential in tissue engineering and other various biomedical applications.

Key words: Essential oil, green solvent, electrospinning, polycaprolactone

Graduation Year February 2026

Thesis Title: Towards Massive Internet of Things (M-IoT) Over 5G Multitier Heterogenous Network for Interference Cancellation and Power Optimization

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ABSTRACT

In Fifth Generation (5G) multi-tier heterogeneous networks (HetNets), the integration of low-power nodes such as femtocells, relay nodes, and base stations leadsto substantial interference, posing challenges to maintaining efficient and reliable communication. Successive Interference Cancellation (SIC) is a key technique that enhances network performance by iteratively decoding and canceling stronger interfering signals before processing the desired signal. This study analyzes the impact of SIC in multi-tier HetNets comprising cellular users, device-to-device (D2D) users, relay nodes, and base stations. A stochastic equivalence model is developed to evaluate outage probability and successful transmission probability under varying SIC levels and interference cancellation scenarios. Results demonstrate that increasing the number of canceled interferers significantly enhances transmission probability while reducing outage probability.

To address the challenge of high-power consumption in 5G networks, this study proposes a power optimization model using a modified genetic algorithm (GA).

The model dynamically allocates transmission power to cellular users, optimizing both energy efficiency and spectral performance. Additionally, a weight-based user scheduling algorithm is introduced, considering factors such as distance and Received Signal Strength

Indicator (RSSI) to improve spectral efficiency. Performance analysis reveals that integrating power optimization with intelligent user scheduling leads to reduced power consumption, enhanced network efficiency, and effective interference management.

Furthermore, power optimization is evaluated across different frequency bands (700 MHz and 3500 MHz) to assess its impact on network performance. The modified GA algorithm demonstrates significant improvements in power efficiency, spectral efficiency, and interference mitigation while ensuring reliable network coverage. Analysis of power consumption with respect to the signal-to-interference-plus-noise ratio (SINR) threshold confirms that the optimized approach minimizes power usage while maintaining acceptable SINR levels. The findings highlight how modified GA provides a robust solution for optimizing power, reducing interference, and improving spectral efficiency, making it a valuable approach for next-generation 5G networks.

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Thesis Title: Multi-controller Placement Optimization with Load Balancing in Software-Defined Networking

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ABSTRACT

Software-Defined Networking (SDN) is the novel networking paradigm where decoupling of the control plane from the data plane has its inherent advantages. With the successful implementation of Software-Defined Networking in data center networking, the way forward for its deployment in the ISP/Telco network is becoming prominent. The research on SDN deployment and implementation for data centres and ISP/Telco is still continuing. The Controller Placement Problem involves placing the optimal number of controllers at the appropriate locations to achieve better performance (such as latency minimization, load balancing, energy efficiency, and enhanced reliability). To achieve scalability, the deployment of multiple controllers on a large scale in Software-Defined Networking is one of the key challenges.

In this regard, the current research status of the Multi-Controller Placement Problem over Software-Defined Networking with their specific challenges and a comprehensive review of the major performance metrics, i.e., latency and controller load balancing techniques, are properly presented. A novel population-based meta-heuristic algorithm, viz. The Naked Mole Rat algorithm, has been tested to optimize the location for controller placement based on switch-to-controller, controller-to-controller latency while maintaining load balancing among the controllers. The ideas and mechanisms are illustrated using two publicly available standard topologies, viz. Ernet and Savvis. The controller localization approach implemented with the Naked Mole-Rat (NMR) algorithm has better results compared to the Bat algorithm.

These days, researchers world-wide are more interested towards traffic engineering in Software-Defined Networking after its conceptual design and implementation. As internet usage continues to rise, the ability to identify and manage network traffic based on its priority has become a critical requirement. Even with multiple controllers deployed to handle the growing volume of data from intelligent devices, dynamic traffic patterns can still lead to unbalanced load distribution across controllers. Machine Learning has shown significant promise in enabling accurate traffic classification and optimal controller selection. Therefore, different classification models are evaluated to identify the most effective approach for real-time traffic classification. Among the models tested, the Classification and Regression Tree (CART) classifier achieved the best performance on the generated dataset, while logistic regression also demonstrated competitive results.

Furthermore, based on the evaluation of various algorithmic outputs for the training and validation dataset, and when execution time is taken into account, the classification and regression tree is found to be the best algorithm. During the process of evaluating the effects

of load balancing in a multi-controller Software-Defined Networking system, several load case scenarios are examined, and bit rate, packet rate, and jitter are measured. Here, the use of traffic classification-based load balancing improves the bit rate and the packet rate of traffic flow on a network and thus considerably enhances throughput. Finally, the reduction in jitter while increasing the controllers confirms the improvement in Quality of Service in a balanced multi-controller Software-Defined Networking environment.

Moreover, the increasing complexity and scale of modern software-defined networking demand advanced solutions to address security challenges, particularly distributed denial-of-service attacks in multi-controller environments. Traditional single controller implementations are struggling to effectively counter sophisticated cyber threats, which require a faster and scalable solution. When a distributed denial of service attack occurs, the network balance is disturbed. DDoS attacks pose a significant threat to multi-controller SDN environments, disrupting network services, and overwhelming resources. Traditional detection and mitigation techniques often do not handle the complexity and dynamic nature of these attacks. Integrating ML into SDN can improve near-real-time attack detection and mitigation, improving security.

Therefore, the design, implementation, and assessment of optimal placement of multi-controllers using K-means++ and OPTICS in real topologies are focused on. An Intrusion Detection System using the XGBoost classification algorithm within the software-defined networking environment is highlighted to detect and mitigate distributed denial-of-service attacks. Additionally, the Intrusion Detection System decouples from the controllers, preserves controller resources, and allows for efficient near-real-time attack detection and mitigation. The proposed solution overcomes previous research by autonomously identifying anomalous behaviors in the network by successfully combining the Controller Placement Problem and Distributed Denial-of-Service attacks security.

Additionally, the best strategy for placing multiple (newly added) SDN controllers using a nature-inspired algorithm, i.e., naked-mole-rat, to solve multi-controller placement issues, an intelligent traffic-driven controller load balancing strategy for multiple controllers applying machine learning and the SDN security issues of attack detection and mitigation in the data plane of the optimized multi-controller topologies are appropriately highlighted in this research. The experiment results perform better in each scenario. During the literature review, some key ongoing research areas and the future research direction regarding the various software-defined networking based controller placements in advanced next-generation networking technologies have also been discussed.

Finally, to enhance the proposed system's performance further, there is still room for improvement. Researchers might be able to improve the network by testing the proposed approach on larger and more complex topologies, including real-world scenarios; adding more traffic types and applications for more complex classification; using intelligent traffic classification and prediction in SDN; testing the model for present NetworkX topologies; and integrating it with edge computing, cloud services, and network slicing.

At present, the majority of researchers are working on the controller placement problem for data centres. However, they do not offer a particularly efficient approach for the large-sized ISP/Telco networks with multi-controller dynamic traffic loads and faults. The efficient and optimal choice of numbers and placement of SDN controllers is a challenge that might be solved intelligently through further research in this field. Therefore, further research is

needed to improve the network's performance, availability, and reliability while making it more balanced and safer.

Keywords: Software-Defined Networking, Controller Placement Problem, Naked Mole-Rat, Traffic Classification, Load balancing, Distributed Denial-of-Service attacks, Machine Learning