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Need and Choice of Data Analysis Tools for Researchers

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Abstract

This article intends to help the students of graduate and postgraduates students by giving needed information about data analysis what they need to do. The methodology adopted in this article is the review of the literature related to data analysis of research. There are two approaches to data analysis: one is qualitative and another is quantitative. Qualitative approaches include content analysis, discourse analysis, narrative analysis, etc, and quantitative use descriptive statistical tools to describe the data and inferential statistics to estimate the population parameter and estimate the trends that could be in the future.

Keywords: data analysis research Methods, methodology of research, information

Background

The research includes three steps: problems what researcher see, collection of relevant data that relates with the problems, and analysis and interpretation of data. When data is processed, it takes the form to give meaning which we call information. In short and simple explanation would be to say data can be a number, symbol, character, word, codes, graphs, etc. and information is data put into context. Information is utilized by humans in some significant way (such as to make decisions, forecasts, etc.). Analysis of data refers to changing data into information. Characteristics of data are: Data is unorganized and unrefined facts, an individual unit that does not provide specific meaning, it is original, insufficient to justify or argue. The information comprises processed, organized data presented in a meaningful context. Information is logical. It gives meaning, for instance, the mark of a particular student is data and his average mark is information. There are two types of data we use in research:

Statement of the problem

There is always a problem when students are asked to conduct research then the first question comes to mind how data are found, how they are collected and how they are analyzed, what tools are used and how to know what data analysis tools to be used, etc. and The main of reason to write this study is our observation seeing our students always are confused on how data of their research is to be analyzed. There are lots of data analysis tools and techniques. In qualitative and quantitative research, both have so many options for it and which are most appropriate to use. Most often they see some literature written in this regard prescribe what to use. But students side such articles is absent. This is the reason this article is written.

Research questions

The main research question is how to choose the research analysis tools and know what is appropriate. How data

are classified, what different types of data are required for different types of research, what different types of tools are used to analyses them, What software will be used and appropriate.

Research objectives

The main objective of the research is to identify the data analysis techniques for different types of research and different objectives. And to determine the factors affecting the choice of analyzing tools. if wrong tools are used it will raise the issues of reliability and validity of the research.

Methodology

The methodology adopted to write the research is review of literature related to different data analysis methods and use for quantitative and qualitative data.

Review of literature

There have been various types of data being used in the research. These are presented in the Table.

Table 1: Types of data, Nature of data, Source, Data collection methods, Data analysis tools

Types of data	Nature of data	Data source	Data collection methods	Data analysis tools
Primary data	Quantitative data	Human being System Interview, focus group, observation	Observation Questionnaire Interview schedule Focus group discussion Experiments survey	Descriptive statistics Inferential statistics
	Qualitative data		Observation Questionnaire Interview schedule Focus group discussion Ethnographic Literature review	
Secondary data	Quantitative data	• Published documents • Journal, • Books • Internet sites and blogs • Social media Human being • Internal sources • Organization's health and safety records • Mission and vision statements • Financial Statements • Magazines • Sales Report • CRM Software • Executive summaries • External sources • Government reports • Press releases • Business journals • Libraries • Internet	Approval from the authors Approval from the organizations Some are open source like world development reports	Content analysis Narrative analysis Document analysis Phenomenology
	Qualitative data			

Source: (Data Collection Methods: Definition, Examples and Sources | QuestionPro, n.d.), (WEBB, 1949)

Primary data analysis: analyzing data you collect

Authors agree on some benefits of and demerits of

primary and secondary data. (Primary or secondary data analysis: which method should you choose? n.d.)

Primary data analysis is the original analysis of data collected for a research study. Analyzing primary data is the process of making sense of the collected data to answer research questions or support or reject research hypotheses that a study is originally designed to assess. The choice of data analysis methods depends on the type of data collected, quantitative or qualitative. Quantitative data are collected when researchers rely on measurement or assigning numerical values to units, to indicate the relative levels or degrees of the variables under investigation, whereas qualitative data are textual data that is produced in the form of participants' transcribed or researchers' descriptive accounts. This entry provides an overview of basic quantitative and qualitative data analysis techniques.

There are several advantages of primary data. They are: You can validate the reliability of the data and You have what you need for your analysis. It has disadvantages also. These are Primary data analyses are expensive and You will need to do your data preparation.

Secondary ata analysis: analyzing data you collect

Data that are already used and published by others are called secondary data. The advantages of secondary data are: Secondary data analyses are quicker and (often) a cheaper and wide range of data sources available for secondary data analysis. The disadvantages are Data validity and coverage You don't control the structure of the data in a secondary data analysis

Steps in Secondary Data Analysis

The process of secondary data collection and analysis include several steps((Steps in Secondary Data Analysis | Online Resources, n.d.) and (Mccaston & Advisor, 1998)researchers, institutions, other NGOs, etc.)

Determine your research question – As indicated above, knowing exactly what you are looking for

Locating data– Knowing what is out there and whether you can gain access to it. A quick Internet search, possibly with the help of a librarian, will reveal a wealth of options.

Evaluating the relevance of the data – Considering things like the data's original purpose, when it was collected, population, sampling strategy/sample, data collection protocols, operationalization of concepts, questions asked, and form/shape of the data.

Assessing the credibility of the data – Establishing the credentials of the original researchers, searching for a full explication of methods including any problems encountered, determining how consistent the data is with data from other sources, and discovering whether the data has been used in any credible published research.

Analysis – This will generally involve a range of statistical processes

Classification of data

It is the process of arranging data into homogeneous (similar) groups according to their common characteristics. Raw data cannot be easily understood, and it is not fit for further analysis and interpretation. The arrangement of data helps users in comparison and analysis. For example, the population of a town can be grouped according to sex, age, marital status, etc.

A planned data analysis system makes the fundamental data easy to find and recover. This can be of particular interest for legal discovery, risk management, and compliance. Written methods and sets of guidelines for data classification should determine what levels and measures the company will use to organize data and define the roles of employees within the business regarding input stewardship. (Classification of Data: Meaning, Definition, Objectives, n.d.)

The objectives of classifications are: (1) to consolidate the volume of data in such a way that similarities and differences can be quickly understood, (2) Figures can consequently be ordered in sections with common traits, (3) To aid comparison (4) To point out the important characteristics of the data at a flash (5) To give importance to the prominent data collected while separating the optional elements and (6) To allow a statistical method of the materials gathered. (Classification of Data: Meaning, Definition, Objectives, n.d.)

Whether data are primary or secondary they are classified into two groups qualitative and quantitative. Qualitative data: It is non-numerical data. For eg., the texture of the skin, the color of the eyes, etc.

Quantitative data: Quantitative data is given in numbers. Data in the form of questions such as "how much", "how many", gives the quantitative data.

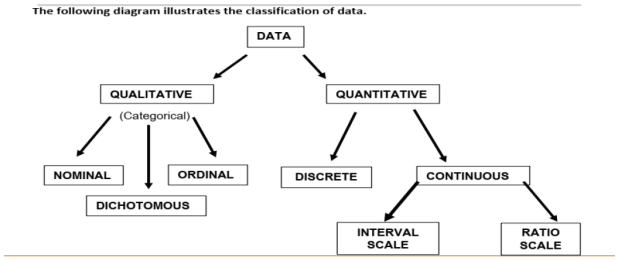


Figure 1: Classification of data

In the 1940s, Stanley Smith Stevens introduced four scales of measurement: nominal, ordinal, interval, and ratio. These are still widely used today as a way to describe the characteristics of a variable. Knowing the scale of measurement for a variable is an important aspect in choosing the right statistical analysis(What Is the Difference between Ordinal, Interval and Ratio Variables? Why Should I Care? - FAQ 1089 - GraphPad, n.d.)

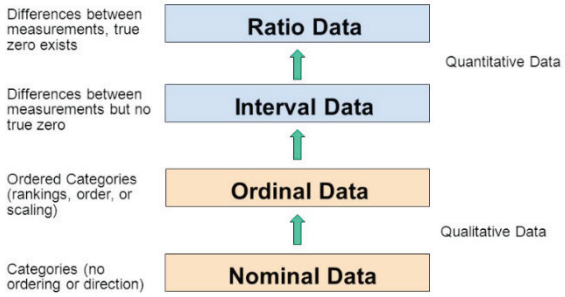


Figure 2 types of data use in research

Source:(What Is the Difference between Ordinal, Interval and Ratio Variables? Why Should I Care? - FAQ 1089 - GraphPad, n.d.)

Nominal data:

A nominal scale is a naming scale, where variables are simply "named" or labeled, with no specific order. Nominal Scale, also called the categorical variable scale, is defined as a scale used for labeling variables into distinct classifications and doesn't involve a quantitative value or order.

An example of nominal scale is given In Table 2:

Table 2: Nominal scale

What is your Gender?	What is your political preference?	Where do you live?
• M- Male • F- Female	• 1- Independent • 2- Democrat • 3- Republican	• 1- Suburbs • 2- City • 3- Town

Ordinal data:

Ordinal Scale is defined as a variable measurement scale used to simply depict the order of variables and not the difference between each of the variables. These scales are generally used to depict non-mathematical ideas such as frequency, satisfaction, happiness, a degree of pain, etc. It is quite straightforward to remember the implementation of this scale as 'Ordinal' sounds similar to 'Order', which is exactly the purpose of this scale. Its example is How satisfied are you with our services? The responses can be placed in an order of value as given in Table 3

Table 2: Example of ordinal data

Level	values
Very Unsatisfied –	1
Unsatisfied –	2
Neutral –	3
Satisfied –	4
Very Satisfied –	5

Interval data Interval Scale is defined as a numerical scale where the order of the variables is known as well as the difference between these variables. Variables that have familiar, constant, and computable differences are classified using the Interval scale. It is easy to remember the primary role of this scale too, 'Interval' indicates 'distance between two entities, which is what the Interval scale helps in achieving. The example is calendar years and time also fall under this category of measurement scales.

Ratio data

At a fundamental level, Ratio scale data is quantitative due to which all quantitative analysis techniques such as SWOT, TURF, Cross-tabulation, Conjoint, etc. can be used to calculate ratio data. While some techniques such as SWOT and TURF will analyze ratio data in such as manner that researchers can create roadmaps of how to improve products or services and Cross-tabulation will be useful in understanding whether new features will be helpful to the target market or not. An example of a ratio scale is the income of the daughter is double that of her father.

Table 3: Summary table of different types of scale

Offers:	Nominal	Ordinal	Interval	Ratio
The sequence of variables is established	–	Yes	Yes	Yes

Mode	Yes	Yes	Yes	Yes
Median	–	Yes	Yes	Yes
Mean	–	–	Yes	Yes
Differences between variables can be evaluated	–	–	Yes	Yes
Addition and Subtraction of variables	–	–	Yes	Yes
Multiplication and Division of variables	–	–	–	Yes
Absolute zero	–	–	–	Yes

Source: (What Is the Difference between Ordinal, Interval and Ratio Variables? Why Should I Care? - FAQ 1089 - GraphPad, n.d.)

Data Analysis based on the research objective

Data analysis is defined as a process of cleaning, transforming, and modeling data to discover useful information for increasing our knowledge level. The purpose of Data Analysis is to extract useful information from data to add to the common knowledge of the society. Data analysis provides information that can be of different levels as given in figure 2.

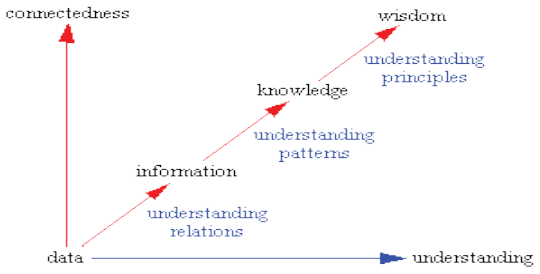


Figure 2: level of data analysis and use

Source: (Data, Information, Knowledge, & Wisdom, n.d.)

Data: While analyzing data the analyzer must think up to increasing wisdom in the society. The first level of data analysis is to find data, which can be in a different form. It can be a symbol, letter, color, and any attribute of an object and object itself. Data can be natural like a tree or a river, the mountain a person, etc and manmade like a motorbike, house, road, etc in the first level of research with the objective like exploring might be just to collect data and relate it with something like a place, person and system Here the objective is what is found in a certain human being like students, leader, in a certain place like Jumla, Humla, etc. For example, the income of the people living in Kathmandu is information. Because there is a connection between data like income, (data of income), people (another data), and a place (another data). When we put these together and associate them in our cognitive mind then it becomes information. The very first level of mental exercise starts here. As we know research is a cognitive process.

Ackoff indicates that the first four categories relate to the past; they deal with what has been or what is known. Only the fifth category, wisdom, deals with the future because it incorporates vision and design. With wisdom, people can create the future rather than just grasp the present and past. But achieving wisdom isn't easy; people must move successively through the other categories. (Data, Information, Knowledge, & Wisdom, n.d.)

Information: The relation of two or more data becomes information. It is a database on paper and computer. An example of a database is the list of the top 10 cities in Nepal based on their population. The research objective likes to identify the factors associated with any social, economic, or political system.

Knowledge: knowledge is the appropriate collection of information, such that it intends to be useful. Knowledge is a deterministic process. When someone "memorizes" information (as less-aspiring test-bound students often do), then they have amassed knowledge. This knowledge has useful meaning to them, but it does not provide for, in and of itself, an integration such as would infer further knowledge. The research objective to investigate what is the existing level of knowledge one has before training.

Understanding: Understanding is an interpolative and probabilistic process. It is cognitive and analytical. It is the process by which one can take knowledge and synthesize new knowledge from the previously held knowledge. The difference between understanding and knowledge is the difference between "learning" and "memorizing". People who have understanding can undertake useful actions because they can synthesize new knowledge, or in some cases, at least new information, from what is previously known (and understood). The research objective for understanding can be to predict the earth quack, demand of some products, etc. The task of understanding demands statistical analysis of data.

Wisdom: Wisdom is an extrapolative and non-deterministic, non-probabilistic process. It calls upon all the previous levels of consciousness, and specifically upon special types of human programming (moral,

ethical codes, etc.). It beckons to give us understanding about which there has previously been no understanding, and in doing so, goes far beyond understanding itself.

Data analysis process under qualitative research

There are two approaches often we say design: qualitative and quantitative. Under qualitative we try to understand the relation of data without statistical analysis. Some come methods of qualitative data analysis are: content analysis, narrative analysis, discourse analysis, thematic analysis, grounded theory, and Interpretive Phenomenological Analysis. (Qualitative Data Analysis Methods 101: Top 5 + Examples - Grad Coach, n.d.)

Content analysis : Content analysis is possibly the most common and straightforward QDA method. Content analysis refers to an evaluation of units of content like words, phrases, or images. It also includes the evaluation of sentences, words, and pictures of articles; and speeches given by leaders, managers, and journalists. For example, a collection of newspaper articles or political speeches.

Narrative Analysis: it is the process of hearing the stories and give meaning to the feeling of story teller. Narrative analyses the meaning what one wants to tell. Stories works like a mirro through which we see the socity and words about how bpople are living and starving.

Discourse Analysis: lots of conversations take place between and among the the parties of the societies. For instance how ruling parties react with the oppositions. Discourse analyses is used to evaluate the words used in the written or spoken language or debate. We understand the manner and gesture, and words used in the particular societies and group of societies through this.

Thematic Analysis: Thematic analysis try to find the them from the scrips and videos recrded during researches. What is the similarity of content of different speeches given by different people is called them. People speaks in different way but their them can be same. Theme is central meaning underlying in an article, speech, documentary and films. For example, many films are made with "lost and found theme" or we say " love tragedy theme".

Grounded Theory: Grounded Theory is a method of qualitative research where after knowing the data and information the researcher try to make a theory which can be used for further testing. Here the researcher develops a testable theories, which can be a subject of discussion. Grounded theory is based on logic of inductive method. But to what extent researchers of difffernet philosophical believer believ it, it can not be said.

Interpretive Phenomenological Analysis (IPA): IPA is method of using personal experience to understand the subject being studies concerning a major life event, an experience, or a situation. This event or experience is the "phenomenon" or phenomena that make up the "P" in IPA. An experience person can give his meaning to the different objects based on his experience, which can be further discussed and tested. for example, someone's personal experience in a refugee camp. So, IPA is a great choice if your research involves analyzing people's personal experiences of something that happened to them.

Right qualitative analysis method largely depends on your research aims, objectives, and questions. In other words, the best tool for the job depends on what you're trying to build. For example: if your research aims to analyze the use of words and what they reveal about the intention of the storyteller and the cultural context of the time then mnarative analysis is the best. If your research aims to develop an understanding of the unique personal experiences of people that have experienced a certain event then it is Interpretive Phenomenological Analysis (IPA), and if your research aims to develop insight regarding the influence of a certain culture on its members, then you use grounded theory.

Data analysis process under quantitative research

Statistical analysis allows you to use math to reach conclusions about various situations. This type of analysis can be performed in several ways, but you will typically find yourself using both descriptive and inferential statistics to make a full analysis of a set of data. There are key differences between these two types of analysis, and using them both can aid you in getting accurate conclusions about your test subjects. Descriptive and inferential statistical methods are used for quantitative data analysis. (Descriptive and Inferential Statistics: How to Analyze Your Data | Udemy Blog, n.d.)

Descriptive Statistics

Typically, descriptive statistics (also known as descriptive analysis) is the first level of analysis. It helps researchers summarize the data and find patterns. A few commonly used descriptive statistics are:

- Mean numerical average of a set of values.
- Median: midpoint of a set of numerical values.
- Mode: most common value among a set of values.
- Percentage: used to express how a value or group of respondents within the data relates to a larger

group of respondents.

- Frequency: the number of times a value is found.
- Range: the highest and lowest value in a set of values.
- Skewness and kurtiosis: the inclination of curve right, central or nomal.

Descriptive statistics provide absolute numbers. However, they do not explain the rationale or reasoning behind those numbers. Before applying descriptive statistics, it's important to think about which one is best suited for your research question and what you want to show. For example, a percentage is a good way to show the gender distribution of respondents.

Descriptive statistics are most helpful when the research is limited to the sample and does not need to be generalized to a larger population. For example, if you are comparing the percentage of children vaccinated in two different villages, then descriptive statistics are enough.

Inferential statistics

Inferential statistics takes data from a sample and makes inferences about the larger population from which the sample was drawn. Because the goal of inferential statistics is to draw conclusions from a sample and generalize them to a population, we need to have confidence that our sample accurately reflects the population. This requirement affects our process. At a broad level, we must do the following:

Table 4: The use of inferential statistics

You study	**You estimate**
You study sample mean	Guess the population mean
You study sample variance	Guess the population variance
Study the sampling error	Guess the rnge of population parameter
You study the histotical pattern of data	Guess the future patern of your data which is called forecasting.
You study series of the date of past several year in different condition	You find the influencing factor of some system

These are complex analysis which includes correlation, regression, and analysis of variance There are many statistical tools to use to predit the pattern of relation between dependent and indepemdet variables. These are:

Table 5: Some major inferential tools

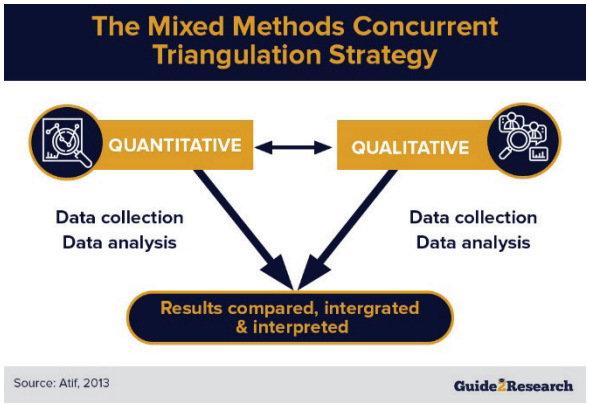
Major inferential tools	Uses
Correlation:	it is the descriptive relationship between two variables.
The T-Test	The t-test assesses whether the means of two groups are statistically different from each other. This analysis is appropriate whenever you want to compare the means of two groups,
Dummy Variables	A dummy variable is a numerical variable used in regression analysis to represent subgroups of the sample in your study. In research design, a dummy variable is often used to distinguish different treatment groups.
General Linear Model	The General Linear Model (GLM) underlies most of the statistical analyses that are used in applied and social research. It is the foundation for the t-test, Analysis of Variance (ANOVA), Analysis of Covariance (ANCOVA), regression analysis, and many of the multivariate methods including factor analysis, cluster analysis, multidimensional scaling, discriminant function analysis, canonical correlation, and others. Because of its generality, the model is important for students of social research
Posttest-Only Analysis	It is experimental method characterized by:has two groups, uses a post-only measure, has two distributions (measures), each with an average and variation, assess treatment effect = statistical (i.e., non-chance) difference between the groups.
Factorial Design Analysis	It is regression model statement for a simple 2 x 2 Factorial Design. In this design, we try to find effect of two factor At a time. Say productivity affected by one factor (1 hour/week versus 4 hours/week) and another factor (in-class or pull-out).
Randomized Block Analysis	The Randomized Block Design is research design's equivalent to stratified random sampling. Like stratified sampling, randomized block designs are constructed to reduce noise or variance in the data (see Classifying the Experimental Designs).

Analysis of Covariance	The basic Analysis of Covariance Design (ANCOVA or ANACOVA) is a just pretest-posttest randomized experimental design. The notation shown here suggests that the pre-program measure is the same one as the post-program measure (otherwise we would use subscripts to distinguish the two), and so we would call this a pretest
Nonequivalent Groups Analysis	Non-Equivalent Groups Design (NEGD) have two groups, a program and comparison group, and that each is measured pre and pos

Source: (Knowledge Base - Research Methods Knowledge Base, n.d.)

Data analysis process under mixed-method approach

By using either quantitative or qualitative research data alone, studies often fall short of providing findings with applicability to real-life situations. Instead, findings can be confusing, or at best, incomplete. Mixed methods research designs are proposed, since they have the potential to provide a more comprehensive picture of a phenomenon and can produce findings that answer a broader scope of questions, often with greater depth(Smith, n.d.).



Data analysis software

These days data analysis is not possible without computer software. Because computers can give the results quickly and reaserr must have the ability to operate the software correctly and interpret the result correctly. While doing this works losts of jargan and key terms even commands one has to understand.

Some of the softares are displayed in the table

Table 6: statistical software used for data analysis

Types of dta analysis	Software
Qualitative data	• HubSpot • MAXQDA • Quirkos • Qualtrics • Raven's Eye • Square Feedback • FreeQDA • QDA Miner Lite • ConnectedText • Visão
Quantitative	• SPSS • JMP • Stata • SAS • R • MATLAB

Source:(Which Statistical Software to Use? - Quantitative Analysis Guide - Research Guides at New York University, n.d.), (Fontanella, 2020)

Conclusion

No research can be completed without proper analysis of data. There are two approaches to analyzing data: qualitative approaches which do not use numerical values to describe a social phenomenon. Another is a quantitative approach which uses descriptive and inferential statistics to analyze and conclude the data. And the third approach is a mixed-method approach that tries to befit from both methods.

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An Analysis of Classification Algorithms for Nepali News

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Abstract

This study compared different classification algorithms namely SVM-RBF Kernel, SVM-Poly Kernel, NB Multinomial and Random Forest. Datasets were prepared using web crawler from various Nepali news portals as well as from online repository on kaggle.com. News classification task began with news collection. After that pre-processing was done using Natural Language Tool Kit (NLTK) in which special symbols and stop words were removed, tokenization of keywords was done. Word stemming was carried out with the help of Lovins Stemmer. Finally four different classification algorithms (SVM-RBF Kernel, SVM-Poly Kernel, NB Multinomial and Random Forest) were implemented and compared on the basis of evaluation metrics Accuracy, Precision, Recall and F-Measure. Among them SVM-Poly Kernel outperformed remaining three algorithms with Accuracy 82.76%, Precision 82.9%, Recall 82.8 % and F-Measure 82.7%.

Keywords— Nepali News Classification, SVM-Poly Kernel, SVM-RBF Kernel, NB Multinomial, Random Forest

I. Introduction

In our daily life there are lots of data in different field. Whenever there is data we can have lots of information, patterns, meaning etc. The information can be stored in computer in the form file, database or data warehouse. Moreover, this information helps us to extract knowledge for decision making. Good decision making process helps us identifying, selecting, and implementing alternatives. The right information, in the right form, at the right time is needed to make good decisions. The process of Extracting or "mining" knowledge from large amount of data is called Data mining [1]. Data mining also can be defined as Exploration and analysis of large quantities of data to discover meaningful pattern from data and is also known as "Knowledge discovery from data (KDD)" [1].

In data mining [1] there are lots of techniques to mine the knowledge from data which are recently used widely in different fields such as Business, Scientific Research, Computer Science, Machine Learning, Information Science, Statistics, and Database Technology etc. Most commonly used data mining techniques are Classification, Regression, Clustering and Dependencies and Associations.

Online news portal and other media on the internet now produced the large amount of text, which is mostly unstructured in nature. When an individual wants to access or share particular news, it should be organized or classified in the proper class. Automatic classification of text is to assign a label or class to given text using a computer program [2].

Data mining applications has got rich focus due to its significance of classification algorithms. The comparison of classification algorithm is a complex and it is an open problem. First, the notion of the performance can be defined in many ways: accuracy, speed, cost, reliability, etc. Second, an appropriate tool is necessary to quantify this performance. Third, a consistent method must be selected to compare with the measured values.

At present, as like in all other parts of the world, the most of the news now flashed out from the online media in Nepal. The online news portals classify their news into different categories such as "Political News", "Sports News", "Entertainment News" and so on. This task of

manually labelling the news class becomes tedious when a large amount of news comes together from heterogeneous sources. It is almost impossible to make this classification manually if some application tries to feed the trending news to the reader in real time [2]. Hence the selection of the best classification algorithm for the development of an automatic tool that will be able to classify the Nepali news into relevant class is a measure problem.

This research compared the different classification algorithms (Random Forest, Naïve Bayes Multinomial, SVM-RBF Kernel and SVM-Poly Kernel) for classifying Nepali news so that the best algorithm can be implemented in the automatic tool.

II. Related Works

In research work [2] author had evaluated some most widely used machine learning techniques, mainly Naive Bayes, SVM and Neural Networks, for automatic Nepali news classification problem. To experiment the system, author used a self-created Nepali News Corpus with 20 different categories and total 4964 documents, collected by crawling different online national news portals. TF-IDF based features were extracted from the pre-processed documents to train and test the models. The average empirical results showed that the SVM with RBF kernel was outperforming the other three algorithms with the classification accuracy of 74.65%. Then followed the linear SVM with accuracy 74.62%, Multilayer Perceptron Neural Networks with accuracy 72.99% and the Naive Bayes with accuracy 68.31%.

In [14] the researcher intended to find the appropriate algorithm to automatically classify a news articles in Indonesia Language. They compared the TF-IDF and SVD algorithm for feature selection, while also compared the Multinomial Naïve Bayes, Multivariate Bernoulli Naïve Bayes, and Support Vector Machine for the Classifiers. Based on the test results, the combination of TF-IDF and Multinomial Naïve Bayes Classifier gave the highest result compared to the other algorithms, with precision 0.9841519 and recall 0.9840000.

In [15] task of classifying documents into predefined categories was carried out. This paper compared different text classification methods based on their effectiveness on the Nepali language. Results from 3 models, SVM with word2vec and cosine similarity with TF-IDF and LSI show that the word2vec model outperforms the TF-IDF only method by 1.6 percentage and cosine similarity with LSI method by 2.2 percentage.

In [16] authors have studied the impact of text pre-processing and different term weighting schemes on Arabic text classification. In addition, developed new combinations of term weighting schemes to be applied on Arabic text for classification purposes. The stemmed and root text were obtained using two different pre-processing tools. The results illustrated that using light stemmer combined with a good performing feature selection method enhanced the performance of Arabic Text Categorization especially for small threshold values.

In research [17] researcher deled with Bangla news classification. From pre-processing the news text, they tried to do all sorts of procedures to classify the news text using Machine Learning classifier, "Naive Bayes classifier" and developed a user interface to take the news text and showed the class of that news.

III. Research Methodology

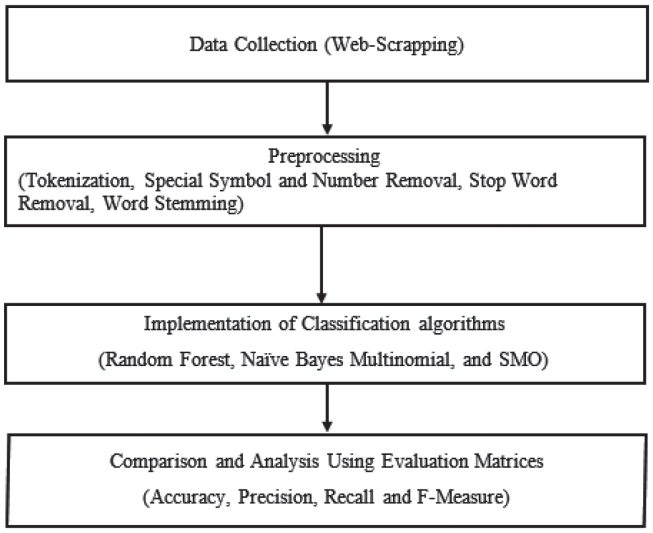

Fig 1. Implementation Model

A. Data Collection

Nepali news were collected from the various online news portals(onlinekhabar.com, Ratopati.com, setopati.com, Nagariknews.com, Ekantipur.com) by performing web-scrapping using the package available in the python library named BeautifulSoup. Some of the data were also obtained from the online repository (kaggle.com). Collected Nepali news corpus contained 1000 news in each 10 different classes of news.

B. Pre-processing

Pre-processing was done to change the data into format that can be feed into the algorithms. For pre-processing following steps were carried out. These all the steps were carried out using the NLTK package available in python

1) Tokenization: Collected news were tokenize i.e

separated into individual words.

2) Special Symbol and Number Removal: Special character like ? , ! | and the numbers like ०, १, २ were removed.

3) Stop Word Removal: Words which don't have special making and can be removed without altering the meaning of the sentence are stop words. In Nepali corpus stop words are छ, छैन, ल, म, मेरो, हामी. These were removed creating the list of the stop words for Nepali language.

4) Word Stemming: It is the process of obtaining the root word by removing the additional suffixes attached. For example the stemming of खेल्छ gives खेल. From among the number of available stemming algorithms LovinsStemmer was used.

C. Implementation of Classification Algorithms

There are many different classification algorithms available. For this research four classification algorithms that were chosen were Random Forest, Naïve Bayes Multinomial, SVM-RBF Kernel and SVM-Poly Kernel. SVMs were implemented using SMO algorithms by changing the kernel used.

All these algorithms were implemented using WEKA (Waikato Environment for Knowledge Analysis). WEKA [12] is a collection of machine learning algorithms for data mining tasks. The algorithms can either be applied directly to a dataset or called from own Java code. WEKA contains tools for data pre-processing, classification, regression, clustering, association rules, and visualization. It is also well-suited for developing new machine learning schemes [10]. It runs in almost any platform and has been tested under Linux, Windows and Macintosh operating systems- and even on a personal digital assistant [8]. WEKA's native data storage method is Attribute-Relation File Format (ARFF) [13]. So the data obtained after the preprocessing was changed to arff format before applying the following algorithms.

1) Random Forest: Random Forest [8, 9] constructs random forests by bagging ensembles of random trees. It combines more than one classifiers into one to improve the classifier's accuracy, therefore such classifiers are called ensemble method of classifier. It combines learning method for classification and regression. It is operated by using a collection of multiple decision trees at training time and individual trees gives its own output. This algorithm was developed by Leo Breiman and Adele Cutler. It combines Breiman's "bagging" idea and Tin Kam Ho random decision forest. In this algorithm, the individual decision trees are generated using a random selection of attributes at each node to determine the split. Each tree depends on the values of a random vector sampled independently and with the same distribution for all trees in the forest. Each tree votes and the most popular class are returned.

2) Naïve Bayes Multinomial: This classifier is based Bayes' theorem and computes probabilities to be able to perform Bayesian inference. The simplest Bayesian strategy, Naive Bayes, is called a special situation of algorithm that requires number adaptation to data streams. It is easy to train , and performs well when it comes to reliability and generalization, rendering it a great strategy for baseline comparison [7]. The NB-Multinomial classifier[18] is one NB classifier variant used for multinomially distributed data like the one in the text classification. It is often used due to its easiness in implementation and execution speed. Multinomial Naïve Bayes or multinomial NB model, is a probabilistic learning method. The probability of a document d being in class c is computed as

$$P(c|d) \propto P(c) \prod 1 \leq k \leq nd\ P(tk|c)$$

where P(tk |c) is the conditional probability of term tk occurring in a document of class c.[19]

3) SVM-RBF and SVM-Poly Kernel: Sequential Minimal Optimization (SMO) is a new algorithm for training support vector machines. Training a support vector machine requires the solution of a very large quadratic programming (QP) optimization problem. SMO breaks this large QP problem into a series of smallest possible QP problems. These small QP problems are solved analytically, which avoids using a time-consuming numerical QP optimization as an inner loop. The amount of memory required for SMO is linear in the training set size, which allows SMO to handle very large training sets. On real world sparse data sets, SMO can be more than 1000 times faster than the chunking algorithm [10].

D. Comparison and Analysis

For evaluating the algorithms I have used the 5-fold cross-validation. And the confusion matrix was used for analysing the output of the algorithms.

1) 5-fold Cross-validation: In 5-fold cross-validation, the initial data were randomly partitioned into 5 mutually exclusive subsets or "folds" i.e. D1, D2, D3, D4 and D5 each of approximately equal size. Training and testing was performed 5 times in the ratio of 4:1 means to say 4 fold as Training and 1 fold as Testing.

2) Confusion Matrix: A confusion matrix is a table for analyzing the result of the classifiers. It deals with how classifier can recognize tuples of different classes. In

order to develop the confusion matrix, the following terms are important.

True Positive (TP): Positive tuples that are correctively labeled by the classifier.

True Negative (TN): Negative tuples that are correctly labeled by the classifier.

False Positive (FP): Negative tuples that are incorrectly labeled as positive.

False Negative (FN): Positive tuples that are mislabeled as negative.

TABLE I

CONFUSION MATRIX

Predicted Class

		Predicted Class		
Actual Classes		Yes	No	Total
	Yes	TP	FN	P
	No	FP	TN	N
	Total	P'	N'	P+N

Accuracy Accuracy of a classifiers on a given test set is the percentage of test set tuples that are correctly classified by the classifiers. It also refers to the recognition rate of the classifier that means how the classifier recognizes tuples of the various classes.

$$Accuracy = \frac{TP + TN}{P + N}$$

Precision Precision refers to the measure of exactness that means what percentage of tuples labeled as positive are actually such.

$$Precision = \frac{TP}{TP + FP}$$

Recall Recall refers to the true positive rate that means the proportion of positive tuples that are correctly identified. It is also known as sensitivity of the classifier.

$$Recall = \frac{TP}{TP + FN} = \frac{TP}{P}$$

F-Measure The F-score or F-Measure also refers to F-measures combines the both the measures Precision and Recall as the harmonic mean

$$F - Measure = \frac{2 \text{ x Precision x Recall}}{\text{Precision} + \text{Recall}}$$

The confusion matrix and the classified instances of all the four algorithms are depicted in the figures below:

```
=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances        8036               80.36  %
Incorrectly Classified Instances      1964               19.64  %
Total Number of Instances            10000

=== Detailed Accuracy By Class ===

               TP Rate  FP Rate  Precision  Recall   F-Measure  Class
                 0.806    0.022    0.806      0.806    0.806      Viswa
                 0.817    0.018    0.835      0.817    0.826      SuchanaPrabidhi
                 0.733    0.020    0.805      0.733    0.767      ArthaBanijya
                 0.775    0.031    0.733      0.775    0.753      Desh
                 0.859    0.014    0.871      0.859    0.865      Bichar
                 0.784    0.039    0.693      0.784    0.735      Sahitya
                 0.660    0.022    0.766      0.660    0.709      Manoranjan
                 0.971    0.009    0.923      0.971    0.946      Khelkud
                 0.925    0.021    0.829      0.925    0.874      Swasthya
                 0.706    0.022    0.780      0.706    0.741      Prabas
Weighted Avg.    0.804    0.022    0.804      0.804    0.802
```

Fig 2. Classified Instances by Random Forest Algorithm

```
=== Confusion Matrix ===

   a   b   c   d   e   f   g   h   i   j   <-- classified as
 806  27  21  51   8   8  28   7  36   8 |   a = Viswa
  39 817  36  25  10  14   7   6  20  26 |   b = SuchanaPrabidhi
  19  73 733  81  15   5   1   6  13  54 |   c = ArthaBanijya
  35   9  52 775  12  11   7   4  57  38 |   d = Desh
  10   8  22  12 859  29  15   4  16  25 |   e = Bichar
   4   9   3  17  45 784 106   7  10  15 |   f = Sahitya
  17  12   6  16   0 241 660  15  16  17 |   g = Manoranjan
   2   0   4   5   1   1   2 971   5   9 |   h = Khelkud
   8   4  12  32   5   0   6   1 925   7 |   i = Swasthya
  60  19  22  44  31  39  30  31  18 706 |   j = Prabas
```

Fig 3. Confusion Matrix of Random Forest Algorithm

```
=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances        8127               81.27  %
Incorrectly Classified Instances      1873               18.73  %
Total Number of Instances            10000

=== Detailed Accuracy By Class ===

               TP Rate  FP Rate  Precision  Recall   F-Measure  Class
                 0.830    0.019    0.831      0.830    0.830      Viswa
                 0.842    0.009    0.908      0.842    0.874      SuchanaPrabidhi
                 0.804    0.022    0.804      0.804    0.804      ArthaBanijya
                 0.760    0.026    0.763      0.760    0.762      Desh
                 0.832    0.023    0.799      0.832    0.815      Bichar
                 0.756    0.036    0.702      0.756    0.728      Sahitya
                 0.751    0.032    0.724      0.751    0.737      Manoranjan
                 0.953    0.003    0.970      0.953    0.962      Khelkud
                 0.914    0.012    0.895      0.914    0.905      Swasthya
                 0.685    0.026    0.745      0.685    0.714      Prabas
Weighted Avg.    0.813    0.021    0.814      0.813    0.813
```

Fig 4. Classified Instances by Multinomial Naïve Bayes Algorithm

```
=== Confusion Matrix ===

   a   b   c   d   e   f   g   h   i   j   <-- classified as
 830  15  23  31  22   7  27   1  24  20 |   a = Viswa
  35 842  40   9  15   8  10   2  14  25 |   b = SuchanaPrabidhi
   2  41 804  80  11   3   2   1   3  53 |   c = ArthaBanijya
  24   5  54 760  53  11   9   5  45  34 |   d = Desh
  14   3  35  19 832  49  13   0   6  29 |   e = Bichar
   1   2   4  10  38 756 169   3   3  14 |   f = Sahitya
  16   5   4   5   6 187 751   0   4  22 |   g = Manoranjan
   2   0   7   3   3   3   3 953   0  26 |   h = Khelkud
  12   5   9  33   6   3   6   0 914  12 |   i = Swasthya
  63   9  20  46  55  50  47  17   8 685 |   j = Prabas
```

Fig 5. Confusion Matrix of Multinomial Naïve Bayes Algorithm

```
=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances        8004               80.04   %
Incorrectly Classified Instances      1996               19.96   %
Total Number of Instances            10000

=== Detailed Accuracy By Class ===

               TP Rate  FP Rate  Precision  Recall   F-Measure  Class
               0.853    0.031    0.752      0.853    0.799      Viswa
               0.778    0.008    0.911      0.778    0.839      SuchanaPrabidhi
               0.726    0.014    0.853      0.726    0.784      ArthaBanijya
               0.877    0.072    0.576      0.877    0.695      Desh
               0.875    0.012    0.893      0.875    0.884      Bichar
               0.749    0.034    0.708      0.749    0.728      Sahitya
               0.678    0.022    0.772      0.678    0.722      Manoranjan
               0.918    0.002    0.978      0.918    0.947      Khelkud
               0.850    0.006    0.942      0.850    0.894      Swasthya
               0.700    0.020    0.795      0.700    0.744      Prabas
Weighted Avg.  0.800    0.022    0.818      0.800    0.804
```

Fig 6. Classified Instances by SVM-RBF Kernel Algorithm

```
=== Confusion Matrix ===

   a   b   c   d   e   f   g   h   i   j   <-- classified as
 853  12   6  85   9   5  15   1   9   5 |   a = Viswa
  59 778  26  79   9  10   9   2   3  25 |   b = SuchanaPrabidhi
  21  48 726 144   6   3   3   0   3  46 |   c = ArthaBanijya
  23   3  35 877   8   9   4   0  23  18 |   d = Desh
   6   2  19  27 875  33   9   1   7  21 |   e = Bichar
   6   3   2  42  44 749 123   0   2  29 |   f = Sahitya
  37   1   7  46   2 208 678   3   2  16 |   g = Manoranjan
  12   0   4  43   1   4   3 918   0  15 |   h = Khelkud
  22   4  12  95   4   1   6   0 850   6 |   i = Swasthya
  95   3  14  85  22  36  28  14   3 700 |   j = Prabas
```

Fig 7. Confusion Matrix SVM-RBF Kernel Algorithm

```
=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances        8276               82.76   %
Incorrectly Classified Instances      1724               17.24   %
Total Number of Instances            10000

=== Detailed Accuracy By Class ===

               TP Rate  FP Rate  Precision  Recall   F-Measure  Class
               0.878    0.022    0.814      0.878    0.845      Viswa
               0.858    0.016    0.853      0.858    0.855      SuchanaPrabidhi
               0.805    0.020    0.817      0.805    0.811      ArthaBanijya
               0.817    0.030    0.749      0.817    0.781      Desh
               0.896    0.013    0.888      0.896    0.892      Bichar
               0.737    0.034    0.707      0.737    0.721      Sahitya
               0.702    0.023    0.772      0.702    0.735      Manoranjan
               0.957    0.002    0.978      0.957    0.967      Khelkud
               0.900    0.009    0.915      0.900    0.907      Swasthya
               0.726    0.021    0.793      0.726    0.758      Prabas
Weighted Avg.  0.828    0.019    0.829      0.828    0.827
```

Fig 8. Classified Instances by SVM-Poly Kernel Algorithm

```
=== Confusion Matrix ===

   a   b   c   d   e   f   g   h   i   j   <-- classified as
 878  21   7  31  10   5  13   0  19  16 |   a = Viswa
  36 858  34  19   8  12   5   2   8  18 |   b = SuchanaPrabidhi
  13  56 805  67   8   4   1   2   5  39 |   c = ArthaBanijya
  28   8  63 817  11  12   3   0  33  25 |   d = Desh
   7   6  14  14 896  31   9   0   5  18 |   e = Bichar
   8  11   4  17  48 737 143   1   3  28 |   f = Sahitya
  23  14   5  19   5 201 702   1   4  26 |   g = Manoranjan
   4   3   6  11   1   2   3 957   0  13 |   h = Khelkud
  12   8  12  48   5   1   7   1 900   6 |   i = Swasthya
  70  21  35  48  17  38  23  15   7 726 |   j = Prabas
```

Fig 9. Confusion Matrix SVM-Poly Kernel Algorithm

TABLE II

COMPARISON TABLE OF THE ALGORITHMS

S.N.	Algorithms	Accuracy (%)	Precision (%)	Recall (%)	F-Measure (%)
1	SVM-RBF Kernel	80.04	81.8	80	80.4
2	SVM-PolyKernel	82.76	82.9	82.8	82.7
3	NB Mutinomial	81.27	81.4	81.3	81.3
4	Random Forest	80.36	80.4	80.4	80.2

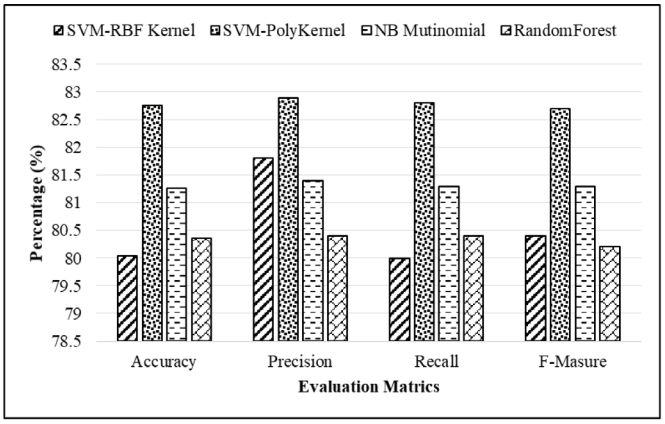

Fig 10. Graph for the table II

IV. Conclusions

The comparison of classification algorithm is a complex task and it is an open problem. First, the notion of the performance can be defined in many ways: accuracy, speed, cost, reliability, etc. Second, an appropriate tool is necessary to quantify this performance. Third, a consistent method must be selected to compare with the measured values. The selection of the best classification algorithm for a given dataset is a very widespread problem. In this sense it requires to make several methodological choices. This research was focused in the analysis of classification algorithm for Nepali news classification where analysis was done among four classification algorithms (SVM-RBF Kernel, SVM-PolyKernel, NB Mutinomial and RandomForest).

It was found that SVM-PolyKernel was able to classify 82.76% of the data correctly which was the best among all the algorithms under comparison. In a nut shell, the result showed that SVM-PolyKernel had got about 2.72% better accuracy than SVM-RBF Kernel, 2.4% better accuracy than RandomForest and 1.49% better accuracy than NB Mutinomial for Nepali News Classification. SVM-Poly Kernel also outperformed others in term of precision, recall and F-measure.

The accuracy of the algorithms was not high enough. This accuracy can be increased by using the deep learning models and also by increasing the dataset size.

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Decentralized Approach to Wastewater Treatment and Management Using Constructed Wetland in Nepal

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Abstract

One of the common environmental problems in Nepal is water pollution caused by direct disposal of untreated wastewater. The main objective of study is to investigate the effectiveness of decentralized CW technology for wastewater treatment and to compare the decentralized CW technology with the currently utilized centralized conventional wastewater treatment systems in terms of cost, technology, environmental friendliness and sustainability. For the centralized wastewater treatment plant, the Guheswori sewage treatment plant at Guheswori was selected and for the decentralized wastewater treatment plant, some of the constructed wetland of Kathmandu and its surrounding was selected. It was observed that the efficiency of the decentralized CWs was better than the efficiency of centralized system. The average removal efficiency on COD, Ammonia and TSS were 78%, 19% and 69% respectively in the centralized system while the maximum removal efficiency on COD, BOD, TSS and NH4 were 88%, 97%, 97% and 88% respectively in decentralized system. The average reaction rate constant for COD removal in the horizontal flow bed was found 1.4 per day. It was found that the decentralized system is not only a long-term solution for small and scattered communities but is more reliable and cost effective. For the almost same or even less Internal Rate of Return (IRR) and Cost Benefit Ratio (BCR), people who are using the centralized system have to pay more revenue than people who are using the decentralized system of treatment. Finally, the decentralized system of waste water treatment proved to be most appropriate technology as it was the economically affordable, environmentally sustainable and socially acceptable.

1.0 Introduction

The availability of freshwater resources on the earth is decreasing rapidly due to less constant water supply and increasing world's population. Some of the developing countries are facing acute scarcity of water due to rapid and unplanned urbanization (Karn and Harada, 2001; Kivaisi, 2001; Stikker, 1998). In many developing countries, sewage wastewaters, industrial effluents and municipal wastewaters are discharged directly into the aquatic environments, and such indiscriminate discharge of polluted effluents further intensifies the shortage of water supply by deteriorating the quality of available freshwater. Surface water bodies are under serious threat as a result of haphazard discharge of polluted effluents from industrial, agricultural, and domestic/sewage activities. Water pollution is the most serious environmental issue due to disposal of solid and liquid

waste on land and surface water.

In Nepal, more than 80% of the population lives in the rural areas but the rate of urbanization in the cities like in Kathmandu is high as compared to other cities of South Asian countries (NPC, 2010; WaterAid, 2008). The rate of urbanization in Kathmandu valley is increasing without any planning and haphazardly. The problem of wastewater management is critical in Kathmandu, the capital city of Nepal. Kathmandu Valley is situated at an altitude of about 1,300 m above the sea level and has an area of approximately 899 square kilometer including three districts namely Kathmandu, Lalitpur and Bhaktapur. The Valley is densely populated with its population about 25 million and population density about 2793 per square KM which has five municipalities and constitutes the country's largest urban economy.

The conventional treatment plant requires high cost for the operation and maintenance of the system. Out of these plants, only one plant i.e. Guheswori sewage treatment plant is operating. In general, centralized wastewater treatment plants are cost intensive and rely on sophisticated technologies and highly skilled manpower. These plants consume more energy and also are not environmentally friendly.

Since the conventional treatment system have a lot of disadvantages, it is necessary to adopt simple, efficient and cost-effective treatment technology for least developing countries like Nepal. Constructed Wetlands have been used successfully worldwide for the treatment of municipal, industrial, landfill leachate, storm water and agricultural wastewater.

Constructed Wetlands (CWs) are a natural, low-cost, eco-technological biological wastewater treatment technology designed to mimic processes found in natural wetland ecosystems, which is now standing as the potential alternative or supplementary systems for the treatment of wastewater.

The Advantages of the constructed wetlands are (Gurung, 2004; Bradley et al., 2002; Cooper et al., 1996)

- Wetlands can be less expensive to build than other treatment options.
- Utilization of natural processes,
- Simple construction (can be constructed with local materials),
- Simple operation and maintenance,
- Cost effectiveness (low construction and operation costs)
- System is more Energy efficient, no environmental reduction that occurs due to extraction of nonrenewable resources.
- More life than conventional treatment plants (25- 30 years)
- No Odor and Nuisance produced

The Limitations of constructed wetlands are:

- Large area requirement
- Wetland treatment may be economical relative to other options only where land is available and affordable.
- Design criteria have yet to be developed for different types of wastewater and climates.

The removal of pollutant in a subsurface flow constructed wetland is believed to be in the following ways: (Subedi, 2007; Conley et al., 1991)

- Filtering of large particles through root and root masses
- Wetland detention time allowing for natural die-off of pathogens.
- UV radiation and excretion of antibiotics by plant to remove pathogens.
- Direct uptake of pollutants by the plants
- Plants providing large surface area on which microbial degradation occurs.
- Adsorption of nutrients (such as nitrates and phosphates) by soil and substrate media

Basically, the design models are characterized by BOD or COD removal of biodegradable organic matters for both FWS and SF system constructed Wetlands (USEPA, 1993).

The model are designed as an attached growth biological reactor using the plug flow equation

$$\frac{C_e}{C_o} = e^{(-K_t T}$$

Where,

C_e is effluent BOD or COD concentration

C_o is the influent BOD or COD concentration

K_t is the temperature dependent first order rate constant

T is the hydraulic retention time

The temperature dependence of the rate constant in above equation can be defined as

$$K_t = K_{20} (\Theta)^{T-20}$$

Where,

K_{20} is the rate constant at 20°C. USEPA proposed 1.104 per day value for the rate constant. Θ is the temperature constant. USEPA proposed 1.06 values for the temperature constant.

According to USEPA (1993) the surface area of the bed (A_s) required to achieve the necessary level of BOD5 or COD removal could be get by the following equation

$$A_s = (L)(W) = \frac{Q\left\{In(\frac{C_o}{C_e})\right\}}{K_t\, dn} \frac{Q\left\{In(\frac{C_o}{C_e})\right\}}{K_t\, dn}$$

Where,

As is the bed surface area, m^2 or ft^2

L is the length of bed, m or ft

W is the width of bed, m or ft

Q-Average flow through the bed, m^3/d or ft^3/d

d- Average depth of liquid in bed, m (ft)

η- Effective porosity of media

2.0 Methodology

This study was carried out on existing full scale treatment units of wastewater treatment plant. For the centralized wastewater treatment plant, the Guheswori Sewage Treatment Plant was selected at Guheswori, Kathmandu and for the decentralized wastewater treatment plant, the following constructed wetland of Nepal.

- Dhulikhel Hospital at Dhulikhel, Nepal
- Kathmandu University at Dhulikhel, Nepal
- Malpi International School at Panauti, Kavre, Nepal
- Susma Koirala Memorial Plastic Surgery Hospital at Sankhu, Kathmandu, Nepal
- Ama-Ghar at Godavari. Lalitpur, Nepal
- Sunga Community at Sunga, Madhyapur Thimi, Nepal
- Guheswori CWs at Guheswori, Kathmandu, Nepal
- Srikhandapur Community at Srikhandapur, Dhulikhel, Nepal

Centralized Wastewater treatment units (Guheswori WTP)

Kathmandu valley currently has five municipal wastewater treatment plants, among which Guheswori Wastewater Treatment Plant (GWWTP) is, the only wastewater treatment plant in operation. The treatment system involve is the activated sludge system at Guheswori. Guheswori wastewater treatment plant is located at the bank of the Bagmati River on the northeastern part of Kathmandu City (Figure 1). It is constructed at the initiative of the government to clean up the Bagmati River. The treatment plant site covers an area of 5 hectares.

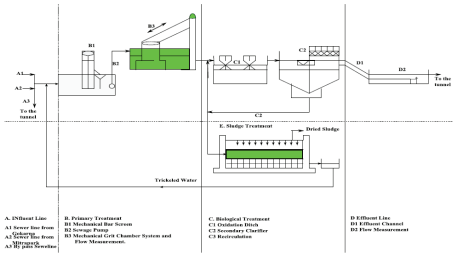

Fig .2 Schematic diagram Guheswori Wastewater Tratment Plant.

Figure 1: Schematic Diagram of Guheswori WTP (Shahi 2012)

Decentralized wastewater treatment units (Constructed wetlands)

This study was carried out on following constructed wetlands.

2.1 Dhulikhel Hospital at Dhulikhel, Nepal

Dhulikhel Hospital is a Kathmandu University Teaching Hospital located at Dhulikhel, Kavrepalanchowk District Nepal. The original hospital wastewater treatment system, constructed in 1997, was the first constructed wetlands for wastewater treatment in Nepal (Fig 2). The purpose of this CWs is to treat the wastewater generated from the hospital and staff quarters to minimize the environment impact and hygiene of local waterways and another purpose is to collect and reuse the wastewater from the entire hospital for irrigation, gardening, etc.

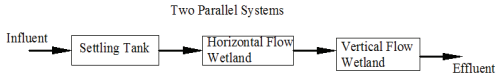

Figure 2: Schematic Diagram of Constructed wetland of Dhulikhel Hospital

2.2 Kathmandu University at Dhulikhel, Nepal

It is located in Dhulikhel Municipality about 30 Km east of Kathmandu, The site is both a demonstration of CWs in institutions and educational tool for environmental and engineering students. The plant consists of three modules including settling, horizontal flow wetland and two intermittently fed vertical flow wetlands that operate in parallel (Figure 3).

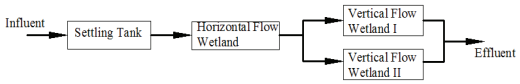

Figure 3: Schematic Diagram of Constructed wetland of Kathmandu University

2.3 Malpi International School at Panauti, Kavre, Nepal

It is a residential school around 30 Km southeast of Kathmandu. The constructed wetland at Malpi treats wastewater from about 380 students and other teachers and administration staffs. The purpose of construction of CWs was to observe restrictions on local discharge of wastewater into the river and to treat the wastewater generated from the school to minimize the environmental impact on local waterways. The system comprises of a septic tank, anaerobic baffled reactor, horizontal flow bed followed by a vertical flow bed and a collection tank.

2.4 Susma Koirala Memorial Plastic Surgery Hospital at Sankhu, Kathmandu, Nepal

The hospital is a non-government hospital located in Sankhu within the Kathmandu Valley. The hospital constructed a wastewater treatment plant in 2002 to improve the environmental and hygienic quality of the wastewater discharge. Due to the hospital expansion the treatment plant was also expanded in 2007. The treatment plant is well maintained and operated, setting an example of DEWATS in institutional setting and protecting the downstream communities from potentially dangerous hospital waste.

2.5 Ama-Ghar at Godavari. Lalitpur, Nepal

Ama Ghar is a nonprofit, small medium enterprise children's orphanage home. It is located in Godavari, with in the Bishankhu Narayan VDC, Lalitpur. The purpose of this wetland is to treat and reuse the wastewater from the student hostel and to establish an example of proper solid waste management. Now the treated water is used for the gardening purpose.

2.6 Sunga community at Sunga, Madhyapur Thimi, Nepal

The community of sunga village is located in the Madhyapur Thimi Municipality in the Kathmandu Valley. The waste water treatment plant was constructed in 2005 to treat the sewage generated from the community which was previously discharging directly in to the Siddhikali River, one of the holiest rivers of the municipality (Figure 4). About 82 households are connected with the extended design

up to 200 households in the future.

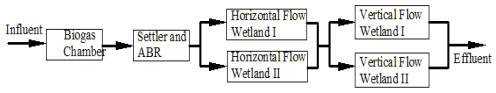

Figure 4: Schematic Diagram of Constructed wetland of Sunga, Thimi

2.7 Srikhandapur community at Srikhandapur, Dhulikhel, Nepal

The Srikhandapur wastewater treatment plant was constructed in 2008 to treat the sewage generated from ward number 8 and 9 of the Dhulikhel Municipality. Approximately 2000 people are connected to the existing sewer which is diverted into the DEWATS system for treatment prior to discharge into the river. Five households are currently using the biogas produced by the treatment plant. The system consists of a medium scale treatment system to generate biogas from municipal wastewater and treat with horizontal flow wetlands prior to discharge.

3.0 Results and Discussion

3.1 Overall Performance of the Wastewater Treatment Plant

The overall performance of the wastewater treatment plant, both centralized and decentralized system was observed during the study.

3.2 Performance of centralized Wastewater Treatment Plant

Guheswori Wastewater Treatment plant is one of the biggest plants operating in Nepal and taken as an example of Centralized Wastewater Treatment Plant system. In this plant, the urban wastewater is treated using activated sludge digestion process. Digested sludge is then piped to drying beds and effluent from secondary treatment process is feed into Bagmati River at Tilganga downstream of Pashupati Nath Temple through tunnel. The performance of this system can be measured by taking the water samples from the upstream of Tilganga and another from the downstream of the Tilganga after the point of discharging treated effluent of the Guheswori Plant. Pullutants involved are Chemical Oxygen Demand (COD), Ammonia and Total Suspended Solids (TSS) (Figure 5). These results have shown that the quality of water in Bagmati River has improved with the Guheswori Wastewater Treatment System but that also not enough required for washing and cleaning purpose.

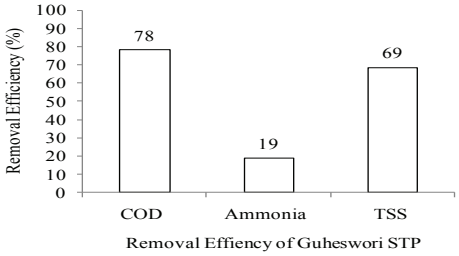

Figure 5: The average removal Efficiency of the GWTS

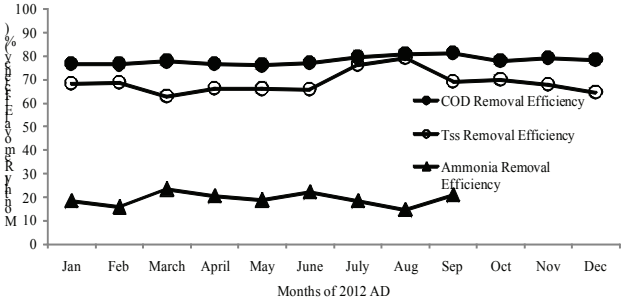

Figure 6: Monthly treads of removal Efficiency of the GWTS

The removal efficiency of the COD is highest of other two parameters which is 78%, followed by TSS and Ammonia of 69% and 19% respectively. Similarly, the figure 4.2 shows the monthly removal efficiency of COD, TSS and Ammonia for the whole 12 months of 2012 AD (Figure 6).

3.3 Performance of decentralized Wastewater Treatment Plant

The data were collected from the site office and the different organization of the following horizontal flow bed (HFB).

- Dhulikhel Hospital (DH)
- Kathmandu University (KU)
- Malpi International School (Malphi)
- Susma Koirala Memorial Plastic Surgery Hospital (SKM)
- Ama-Ghar (AG)
- Sunga Community of Thimi (ST)
- Guheswori CWs (Guh)
- Srikhandapur Community of Dhulikhel (SD)

The influent and effluent of the above CWS were collected and the percentage removals of the different parameters were calculated. Pollutants involved are Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS) and Nitrogen compound (NH_4).

The influent of COD concentration was found to vary from 180.5 mg/L in Guheswori CWs to 2700 mg/L in Sunga CWs and the effluent concentration of the same were found to vary from 36 mg/L to 699.45 mg/L in the same respective CWs. The influent of BOD concentration was found to vary from 82.12 mg/L in Dhulikhel Hospital CWs to 1489 mg/L in Sunga CWs and the effluent concentration were found to vary from 9.98 mg/L in Kathmandu University CWs to 179 mg/L in Sunga CWs. Similarly, it can be observed that the highest influent concentration of the TSS was 1800 mg/L in Sunga CWs to lowest 101.01 mg/L in Dhulikhel Hospital CWs and the effluent concentration was found to be 90 mg/L in SKM CWs to 10 mg/L in Srikhandapur CWs. For the NH_4, the average influent concentration was 104.92 mg/L in SKM CWs to 40 mg/l in Guheswori and effluent concentration was 30.35 mg/L in Srikhandapur CWs to 7 mg/l in Kathmandu hospital CWs.

3.4 Removal efficiency of different constructed wetlands of Nepal

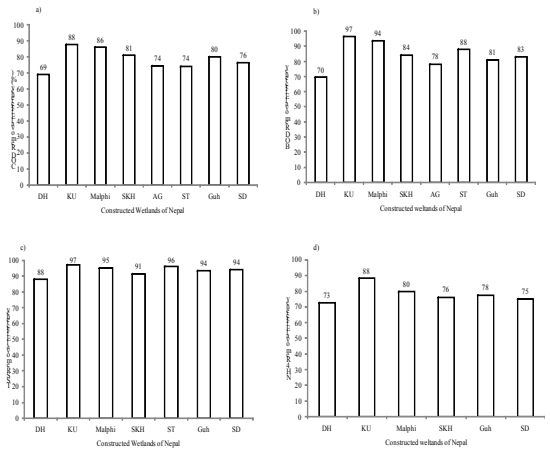

Figure 7: The removal efficiency of different CWs. of Nepal; a) COD removal. b) TSS removal. c) BOD removal. c) NH_4 removal

It was observed that the COD removal efficiency of the CWs of Nepal varying from 69% to 88% while the BOD removal efficiency varying from 70% to 97%. Similarly the TSS removal efficiency is even higher and observed to be varies from 88% to 97%. The minimum NH_4 removal efficiency is 73% and highest of the same is observed to be 88% (Figure 7). It was seen from the centralized wastewater treatment system has removal efficiency of COD, TSS and Ammonia was observed to be 78%, 69% and 19% respectively. Which is less than the decentralized wastewater treatment system ie constructed wetlands.

3.5 Relationship between HLR and removal efficiency

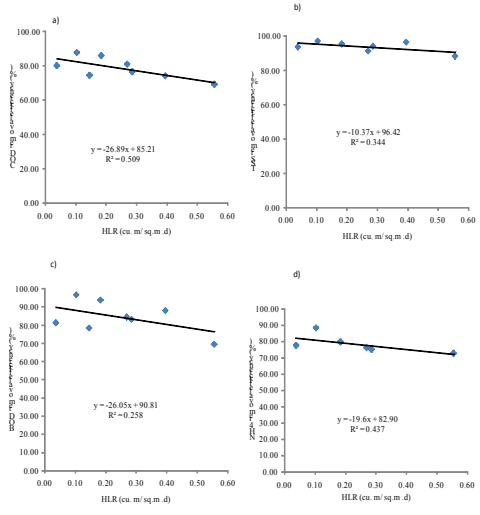

Figure 8: The relation between the removal efficiency and HLR. a) COD. b) TSS, c) BOD, d) NH_4

From the Figure 8, it was observed that as removal efficiency (COD, TSS, BOD and $NH_{4)}$ decreases with increase in HLR. The maximum removal efficiency of BOD and COD was observed in HLR 0.1 cum/sq m. day. The minimum removal efficiency of BOD and COD was observed in HLR 0.56 cum/sq m. day. The highest COD removal efficiency at lower HLR may be due to longer HRT (contact time) of treatment bed during the time more oxygen is supplied into the treatment bed for both aerobic and anaerobic degradation (Garcia, et al. 2004; Grau, 1996). In this study change in removal efficiency at different hydraulic loading rate was expressed by the linear equation (y=ax+b). The fitted line exhibits gradually decreases of HLR with increase in removal efficiency.

3.6 Relationship between surface area of CWs and removal efficiency

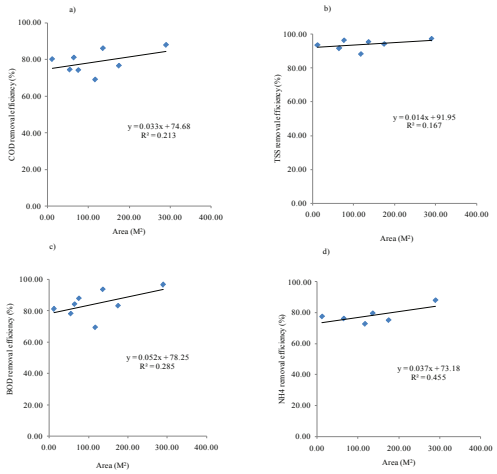

Figure 9: The relation between the removal efficiency and Surface area of CWs.

a) COD, b) TSS, c) BOD, d) NH_4

From the Figure 9, it was observed that as removal efficiency of the pollutants like COD, TSS, BOD and NH_4 increases with increase in surface area of the constructed wetlands. The maximum removal efficiency of BOD and COD was observed with area 290 m^2 and the minimum removal efficiency of the same was with area 80.06 m^2. In this study, change in removal efficiency at different surface area expressed by the linear equation (y=ax+b). The fitted line exhibits gradually increases of surface area with increase in removal efficiency.

3.7 Economic analysis

Per capita cost of construction

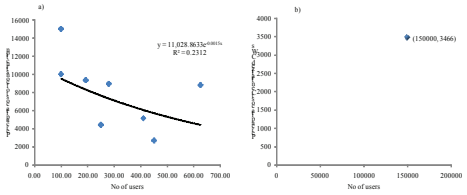

Figure 10: Per capita cost of construction and numbers of users. a) For Decentralized Wastewater Treatment plant system. b) For Centralized Wastewater Treatment plant system.

3.8 IRR and BCR analysis

Internal rate of return (IRR) is the discount rate that makes the Net Present Value (NPV) of the investment zero. The result of the centralized wastewater treatment system shows that huge money is required to invest for the IRR of 10.21% and the decentralized wastewater treatment system shows that small amount of money can be invested for the IRR of 10.90%. Similarly the BCR of the centralized wastewater treatment system is 1.4 whereas it is in the case of decentralized system is 1.43. The revenue taken from the people is also very high in the case of centralized wastewater treatment system as compared to decentralized system. Due to the high initial investment and large land requirement, the centralized system may not be suitable for the country like Nepal.

3.9 Net Present Value (NPV) analysis

The NPV is the difference between the present value of cash inflows and the present value of cash outflows. NPV is used in capital budgeting to analyze the profitability of an investment in project. The general rule of NPV is that if NPV is equal or greater than zero then the project is accept otherwise the project is rejected. The NPV analysis of Guheswori Wastewater Treatment Plant and Gunga Community constructed wetland shows the both systems are acceptable.

3.10 Cost distribution and major cost contribution component analysis

One of the main demerits of using the constructed wetlands system in place of centralized system is, CWs requires more land than centralized system. Conley et al has presented the certain distribution of cost. He has placed the rock media represents about 53 percentage of the total construction costs. If the rock media is found locally, its cost can be decreased. The cost of construction is about 32 percentage, clearing is about 6 percentage, land of cost is about 3 percentage and miscellaneous cost is around 11 percentage.

The major cost distribution of typical CWs design in this research is taken as following (Figure 11). The major cost of land in not consider during this study. The land used in such types of CWs are assumed to be built in the government unused land. The clearing means cutting the trees, bushes and leveling the land.

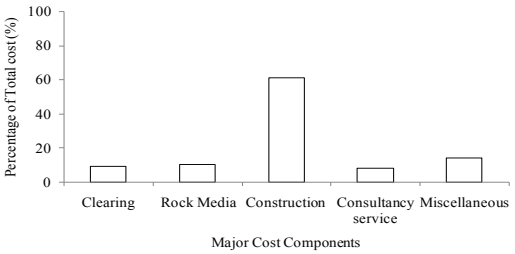

Figure 11: Distribution of Major Cost Components of typical CWs.

Here the cost of clearing is about 9 percent and for rock media is about 10 percentage of the total construction cost. The cost of construction of the civil work is about 60 percent while the consultancy service bears 8 percent. About 13 percent of the total cost is for miscellaneous purposes.

3.11 Other factors

Some of the factors that supports in the decentralized wastewater treatment system rather than the centralized system are as followings:

- The wastewater as from the treatment system can be reuse for irrigation purposes and others as required.
- Use of local resources and local manpower.
- It is the natural process system
- The system can be developed as the research for the university students.
- It creates beautiful landscape and pleasing environment
- CWs can attract local birds and others animal.

3.12 Operating and maintenance cost

The process of evaluating and selecting appropriate wastewater treatment technology should consider the life cycle cost of such a system including design, construction, operation, maintenance, repair and replacement. Over the operational lifetime of the system the operation and maintenance costs are equally important to construction costs. Cost estimates on a national basis for wastewater treatment systems are difficult to develop, primarily due to varying conditions of each community such as population density, land costs, and local performance requirements. The USEPA developed cost estimates of centralized and decentralized approaches to wastewater management for a hypothetical rural community. The study revealed that decentralized systems (cluster or on-site) are generally more cost effective for managing wastewater in rural areas than the centralized systems (Table 1).

Table 1; Summary of hypothetical EPA rural community technology costs (1995 US$) (Massoud, 2008)

Technology	Total capital cost	Annual operation and maintenance cost	Total annual cost
Centralized system	2,321,840–3,750,530	29,740–40,260	216,850–342,500
Alternative small-diameter gravity sewers	598,100	7290	55,500
Collection and small cluster systems On-site systems	510,000	13,400	54,500

Assumptions:

All technology options presented are assumed to have a 30-year life span.

All of the options considered are capable of achieving the secondary treatment level.

The rural community consists of 450 people in 135 homes.

The huge amount of operating and maintenance cost of the centralized system (Rs 130 million in the case of Guheswori WTP) is also discouraging the use of such system than the decentralized system (Rs 65,000 in case of Sunga CWs)

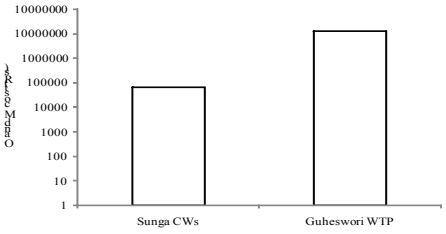

Figure 12: Comparison of operation and maintenance cost of centralized and decentralized waste water treatment.

3.13 Management of decentralized Wastewater Treatment System

Before, the house owners had to manage the operation and maintenance of onsite systems. Due to the lack of knowledge many problems were arises and many systems were due to improper maintenance. It is essential to develop policies, programs, guidelines, and institutions to ensure the proper design, construction as well as operation and maintenance of decentralized wastewater treatment systems. With rapidly increasing population and decreasing water resources, wastewater is becoming a significant resource. An integrated management approach ensures that all the perspectives of effective management that include economic, social, technical and environmental dimensions are taken into consideration. It is important to note that the needs and conditions of wastewater management vary from country to country and sometimes within the same country.

The questionnaires were asked to civil engineers of the concerned NGO/ INGO, Secretary of the VDC and different stakeholders related to the wastewater treatment system about the management of the decentralized wastewater treatment system. The result is presented in figure 13.

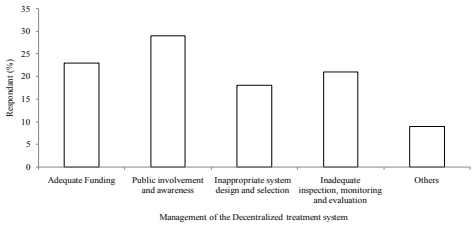

Figure 13: Parameters for management of the decentralized treatment system

Properly managing a system helps in protecting public health and local water sources, increasing the property value and avoiding expensive repairs. Such management systems should address the major problems related to wastewater treatment approaches primarily in developing countries like Nepal. Some of these are:

i. Funding

ii. Public involvement and awareness

iii. Inappropriate system design and selection

iv. Inadequate inspection, monitoring and evaluation.

Adequate funding and clear environmental and public health goals are vital for developing, implementing and sustaining a management program. In addition, good knowledge of the political, social and economic context of the community as well as the institutional structure and available technologies are necessities for successful long-term operation. Wastewater management decisions often generate controversy and public concern as a result of negative attitudes and incomplete knowledge. Public awareness and participation programs lead to more acceptable decisions to all parties involved. Given that the capacity of the community to manage the selected technology was factored into the decision-making process and that the appropriate technology was selected, the chances of system failure are minimal. An effective management program can reduce the potential risks to public health and the receiving environment during the installation, operation and maintenance phases of the decentral-

ized wastewater treatment system. Throughout the installation phase it is crucial to choose the appropriate site and the proper design and construction. Periodic monitoring and strong regulatory enforcement are essential during the operational phase. During the maintenance phase systematic inspection is fundamental to detect any system that fails to function properly. Because impaired and failing systems are costly to a community, proper maintenance of a decentralized wastewater treatment system is essential. Similar to centralized wastewater systems, decentralized systems require effective operation and maintenance that should not be underestimated. While precise management strategies are suitable for high-risk areas, simple homeowner awareness and education programs suit the non-sensitive areas. An integrated risk assessment should be regularly conducted in order to manage and mitigate any emerging problem. The selection of a management organization primarily depends on local needs and preferences. It is very crucial to account for the needs, constraints and practices of local people in order to define problems, set priorities, select technologies and policies and monitor and evaluate impacts.

4.0 Conclusion

Based on the observation of the sites, discussion with different people and experimental results, following conclusions have been drawn.

- The decentralized wastewater treatment system was found to be more economical then centralized wastewater treatment plant system.
- The decentralized system was found to be most appropriate technology i.e. economically affordable, environmentally sustainable and socially acceptable.
- The removal efficiency of the different pollutants is higher in decentralized plant system.
- The decentralized system is more environmentally friendly and socially acceptable.
- Centralized system requires huge amount of operational and maintenance cost and also required highly skilled manpower but in the case of decentralized, small amount of rupees is enough for the operational and maintenance cost and even local people without any skill can operate this system.
- The removal efficiency increased with the decrease in hydraulic loading rate.
- The average removal efficiency of COD, NH_4 and TSS were 78%, 19% and 69% respectively in the centralized system. However, the maximum removal efficiency from decentralized CW system were 88%, 97%, 97% and 88% for COD, BOD, TSS and NH4, respectively.
- The average reaction rate constant for COD removal in the horizontal flow bed CW for Nepal was found 1.4 per day
- In almost the entire site of constructed wetland, Narkat *(Phragmite Karka)* was used and found the most effective in treatment process.
- Decentralized system of treatment is found discharging the poorly treated effluents in the river containing the higher contents of pollutants.
- For the almost same or even less Internal Rate of Return (IRR) and Cost Benefit Ratio (BCR), people who are using the centralized system have to pay more revenue than people who are using the decentralized system of treatment.

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Role of ICT in Crisis and Emergency Management: A Case of Nepalese Education Perspective

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Abstract

The COVID-19,a pandemic caused by acute respiratory syndrome Coronavirus 2, was first identified in December 2019 in Wuhan, China. It spread across the world leading the World Health Organization to declare it a pandemic on 11 March 2020. As WHO confirmed human to human transmission of COVID-19 and given the high rate of international movement that happens on a daily basis from and to all countries, Nepal has not remained unaffected by the pandemic. The objectives of this paper is to highlight major impacts of COVID-19 in education sectors in Nepal and use of ICT to cope with this pandemic. Different cases and impacts of COVID-19 were taken in this study and significance of ICT have been highlighted to minimize international pandemic.

Keywords: crisis management, COVID-19, education, ICT

1. Introduction

The coronavirus disease caused by acute respiratory syndrome was first identified in Wuhan, China. It spread across the world leading the World Health Organization to declare it a pandemic on 11 March 2020.The Government of Nepal on 27 March 2020 announced nationwide lockdown to contain the spread and protect its citizens. The lockdown has affected all spheres of Nepali life including in the education sector where all students, faculties and staff have had to stay at home. Face to face classes at academic institutions were also closed, and examinations could not take place. Immediately assessing the emerging emergency situation Kathmandu University (KU)decided to run classes using available online educational platforms. In the beginning, some of the Schools of the University were able to run most of their classes online effectively with Learning Management Systems (LMS) as they were also practicing online pedagogy before the COVID-19 situation. Some other faculties in other Schools have started running live classes using Skype, Google Meet, Zoom, etc.

COVID-19 has not only physical but also psychosocial influences. Any of the psychosocial effects are more awful than the physical effects of the transient rage and pandemic situation. The behavior of the peopleis likely have an important bearing on the

course of the COVID-19. Human behavior is effected by public information and perceptions (NHRC, 2020; (Azzi-Huck &Shmis, 2020). All stakeholders in education in organizations, educators, publishers, and parents have worked together to create digital resources so that they can be delivered through virtual classrooms.

The response to the crisis showed that the University appeared to have already developed a minimum basic infrastructure for online classes but did not seem fully prepared the crisis. Except some faculties in certain Schools, faculties were not trained and accustomed to online mode of teaching as the usual required mode of teaching is face-to-face. Moreover, the hardware and connectivity required for hosting online learning software platforms is very weak at the faculties' end.

In this context, KU is now bound to act to develop a complete plan to prepare its faculties, staff, and students capable in technical aspects as well as be willing to adopt and practice new technology with adequate and robust infrastructure in all its academic. In addition to the technological provisions, the University needs to plan and adopt/implement a new pedagogical approach that fits the online teaching and learning. The courses, their delivery, modes of interactions and assessments are to be adjusted to suit the online mode. In addition, given the recent developments in Information and Communication Technology (ICT), the online system of learning is now more user-friendly, effective, trustworthy, interactive, and creative in many ways.

The purpose of this paper is to elborate major impacts of COVID-19 in education sectors in Nepal and use of ICT to deal with this pandemic. The Nepal Preparedness and Response Plan lays out the preparedness actions and key activities to be taken in Nepal, based on the developments and trends of the global COVID-19 pandemic. The plan covers two major levels of interventions: one that is the preparedness that should take place at the earliest possible and that constitutes an investment in Nepal's health systems that will benefit the Nepalese people, irrespective of the extent of the COVID-19 pandemic. The second level is the effective response to an estimated case of 1500 infected people and 150,000 affected people. This can be increased in case there is a high case of number of infected and affected people, beyond the original scenario of 1500 patients.

2. Impact of COVID-19 on education in Nepal

Except human casualties every single sector has been hardly affected by COVID-19. Socio-economic implications have already initiated to be observed across the countries. The share market has gone down, industries have been closed, private health institutions reduced its services and small-medium enterprises has been closed worldwide. Usually in epidemic the cases of small to big disaster, education sector is the one to be affected initially. As the COVID-19 transfers from person-person, almost all education institutions across the globe has temporarily closed its classes with no confirmation regarding re-opening dates. As per the UNESCO report, the closure of academic institutions affected 1576021818 young learners constituting 91.3% of the total enrolled learners (pre-primary to tertiary education levels). In Nepal alone, 8796624 students (Pre-Primary: 958127, Primary: 3970016, Secondary: 3463763 and Tertiary: 404718) are affected (COVID-19, 2020).

All seven provinces in Nepal and 77 districts are now affected. Clusters of cases are occurring in five provinces and infrequent cases in the remaining two. 85 % of cases are reported from Province 2, Province 5, Sudurpaschim and Karnali province combined. Sudurpaschim province has witnessed a three-fold increase in the number of COVID-19 cases.A total of 22 designated COVID-19 testing labs are now functional in the country, including the National Public Health Laboratory. The latest addition to the list of designated COVID-19 labs was the Provincial Tuberculosis Control Center, Pokhara. The Ministry of Health and Population has published a notice regarding the operation of the COVID-19 RT-PCR testing laboratories.

The present scenarios indicate that students in Nepal are affected by the pandemic. For example, a few schools and colleges in urban areas have started to run online classes to alleviate the impact on learn-

ing. However, running online classes does not seem to be feasible for most rural schools in Nepal. It is estimated that only 56% people in Nepal have access to internet. According to Pandit (2020), only 13 % schools might be able to run online classes (though 35% schools have access to internet). The existing ICT infrastructure and the distribution of access in the urban and rural areas have created two-tier of inequalities in the Nepalese citizens. Considering such divide, the Human Right Commission in Nepal has requested the Ministry of Education and private schools not to pressurize children in online education (Kantipur News 2020). Education during COVID-19 and beyond must be reimagined as a community embedded practice. While teachers in community-embedded education provide resources and help set goals and pathways that students can take, it must be noted that the actual realization of the educational practice will depend on the facilities, resources, skills and expertise of those involved in the process (Mahboob 2020).

All kinds of external assessments have been postponed and almost all the internal assessments have been cancelled. The cancellation of assessments has negative impact on students' learning. Internal assessments are very important as they indicate students' learning needs and then support learning (Black &Wiliam 2018). For instance, Andersen and Nielsen's (2019) study, which explored the impacts of a major IT crash in the testing system in Denmark, indicated that participating in the test had positive impacts on students' learning. The score in a reading test was increased by 9% of a standard deviation, similar effects were observed in mathematics. Dawadi (2018) highlights that assessment motivates students for learning. Regarding the external assessments, their postponement has a direct impact on students as the educational and occupational future of students depends on their outcomes.

The Nepalese government has recently started to run a few classes on radio and television, but all students cannot get access to such lessons as 20% people in Nepal have no access to radio and television as well (Poudel 2020). It is also worth mentioning that many families from the third and fourth groups primarily use the internet for personal communication and for social media. Most of them need awareness about the existence of the digital content, and training to use digital resources for their children's education. To motivate those parents, setting up a Viber group, Facebook group or WhatsApp group could be a better option. Learning materials can also be sent directly to parents through the groups and the parents can help their children to access the learning materials from their phones. Phuyal (2020) argues that most people in Nepal cannot spend on data to broaden their mind; they must give first priority to their food to sustain their lives in such a crisis.

3. Problems and challenges created by COVID-19 in Nepali education

In Nepal, COVID-19 has started to impact education and create problems from its initial stage. In the early stages of the COVID-19, majority of the school level exams from grade 1-9 in Nepal were completed. Although the schedule for the School Ending Examination (SEE) was published on March 19, 2020, the exams were postponed due to fear of COVID-19 spread. Likewise, examinations at various levels of the university, which were supposed to start the same day, had to be postponed. The statement issued by the Secretary of the Ministry of Education, Science, and Technology mentioned that no significant effort was initiated by any sector for the reopening of education in Nepal till October 20, 2020. It is also clear from this statement that the model of school reopening has not been identified in the crisis of COVID-19. The authorities are looking at new approaches that ensure students continue to learn and at the same time ensure their wellbeing. The education will be a priority sector in the upcoming budget given the COVID-19 pandemic and will look at means to expedite programs and coordinate amongst all levels of government and stakeholders on a national framework that guides safe reopening of academic institutions (WorldBank, 2020).

The major problems faced by Nepali education institutions are that the physical academic activities were halted almost for one year. In addition, online evaluation systems was not efficient as such fair evaluation of students in terms of subject knowledge could not make effective. In order to know the im-

pacts of long duration school closures due to crisis, and resultant alternative education, it is crucial to understand the major differences between normal education and virtual education. Distance and virtual or online learning provides various channels such as mail, online chat, and video conferences, through which students and instructors can interact with each other. In classroom learning, there is only one channel to communicate with each other (HindustanTimes, 2020). Remote and virtual or online education is useful for regular education. Besides this, the education is especially useful in times of various crises and disasters because in such cases, a long time classroom will be disrupted. The concept of crisis management and ICT requires a details understanding of the socio-technical systems that could contribute for risk management (Mendonça and Bouwman, 2008). The need for coordination raises significant public governance challenges, as crisis management functions are usually exercised at sub-national levels. The face makes coordination capacity of crisis management a fundamental element of good governance. This also tests governments' capacity to provide the appropriate responses at the right time, in order to protect their citizens and mitigate the impact of disasters, thus ensuring that the national authorities have the right tools and institutional framework for coordinated action (Charles, 2013).

4. Preparedness and response

4.1 Initiation taken by Government of Nepal (GoN) and Ministry of Health and Population (MoHP)

The MoHP has provided information on risk categorization of districts based on available epidemiological and health systems information to aid in the management of the lock-down process.

As per the decision of Government of Nepal (Council of Ministers), the suspension period of all domestic and international commercial passenger flights were extended till 21 July 2020. Special permission from Civil Aviation Authority of Nepal (CAAN) is required for Rescue flights, freighter flights and flights related to the medical and other essential supplies.

MoHP is engaged in assisting the provincial and local governments in case investigation and contact tracing, monitoring and management of quarantine, isolation and treatment sites.

National Health Training Center, Kathmandu has prepared training package on Case Investigation and Contact Tracing (CICT) of COVID-19 and the training has commenced at all the levels (Federal, Provincial and Local level) from 25 June 2020.

The Government of Nepal has formed a committee to coordinate the preparedness and response efforts, including the Ministry of Health Ministry of Home Affairs, Ministry of Foreign Affairs, Ministry of Finance, Ministry of Culture, Tourism and Civil Aviation, Ministry of Urban Development, Nepal Army, Nepal Police and Armed Police Force. The Humanitarian Country Team (HCT) includes the Red Cross Movement, civil society organisations. Under the joint leadership of the Resident Coordinator's Office and the WHO, the HCT initiated the emergency planning and preparedness interventions, including dissemination of communications materials to raise community-level awareness across the country (COVID-19, Nepal, 2020). The Clusters led by the Government of Nepal and co-led by the Inter-Agency Standing Committee (IASC) are working on finalizing contingency plans which will be consolidated into an overall joint approach with the Government and its international partners. The UN has activated the Provincial Focal Point Agency System to support coordination between the international community and the Government of Nepal at provincial level.

4.2. Strategic objectives for Covid-19 response

The overarching goal is to control the pandemic by slowing down the transmission and reducing mortality associated with COVID-19. The global strategic objectives are as follows (MOHP, 2020):

Mobilize all sectors and communities to ensure that every sector of government and society takes own-

ership and participates in the response and in preventing cases through hand hygiene, respiratory etiquette and individual-level physical distancing.

Control irregular cases as well as clusters and prevent community transmission by rapidly finding and isolating all cases, providing them with appropriate care, and tracing, quarantining, and supporting all contacts.

Suppress community transmission through context-appropriate infection prevention and control measures, population level physical distancing measures, and appropriate and proportionate restrictions on non-essential domestic and international travel.

Reduce mortality by providing appropriate clinical care for those affected by COVID-19, ensuring continuity of essential health and social services, protecting frontline workers and vulnerable populations.

Develop safe and effective vaccines and therapeutics that can be delivered at scale and that are accessible based on need.

4.3 Current preparedness interventions

Coordination with Ministry of Women, Children and Senior Citizen and Department of Women and Children.

Help desks around quarantine sites

Coordination with protection cluster members and relevant organizations.

Updating and mapping of protection cluster partners stockpiling, list of psychosocial counsellor and other preparedness activities.

5. Inclusion of Information, Communication and Technology in Education Sector

For a developing country like Nepal, though use of technology is not at advanced stage like that in countries such as China, Korea, USA, UK, Australia or other European nations. However, strategies have been already adopted through inclusion of Information Communication and Technology (ICT) in education sector in Government implemented programs such as Education for All program (2000-2015), School Safety Reform Plan (2009-2016) and School Safety Development Plan (2016/17-2022/23). Academic Institutions such as Kathmandu University, Ace Institute of Management, King's College, etc. has already adopted distance education and e-learning. Government has been producing and broadcasting the teaching class for the students of Grade IX and X through Television. Similarly, Open and Distance Education of Tribhuvan University (TU) has been running virtual classes in Master in English, Math and Public Administration since 2015. In the meantime, Ministry of Education, Science and Technology (MOEST) and university authorities also have started discussions and consultations with stakeholders for initiation of e-learning in coming days, if the situation still is same or become worse. Government of Nepal has already formed the committee to look after the research and recommendon the possibility of management of online material and other virtual medium as an alternative to respond the COVID-19 impact on education(COVID-19, 2020). Majority of academic institutions in Nepal were not prepared to initiate online courses in preliminary phase of pandemics due to lack of IT infrastructure, lack of IT awareness among students as well as faculties and lack of online teaching/learning guidelines.It was gradually solved as per the support received from various sectors.

The COVID-19 pandemic has consequence in the disruption of education services throughout the country carrying with it not only the immediate risk of loss of learning for every individual student and young person, the negative effect on Nepal's development particularly in the most vulnerable communities, long after the COVID-19 pandemic. In this perspective, continuity of learning is essential to avoid a permanent setback to the education of Nepal's 7.5 million school children, to help re-establish routines and support children's mental health, and to use education as a tool to prevent disgrace, counter discrimination and support public health measures

by keeping children and their communities informed on handwashing and other hygiene practices.

5.1. Initiation of distance learning by academic Institutions

For countries from developed and developing countries, continuation of learning has been the challenging and prioritized task. As an alternative to closure of academic institutions, online approach has been adopted by institutions from countries such as Nepal, Argentina, Portugal, Republic of Korea, USA, Australia, etc. Observing at current situation, teachers and school administrators were encouraged to use applications to deliver education session i.e. application of tools such as zoom, moodle, google meet, skype, slack, canvas, etc. The virtual classes that KU have been organizing are very helpful. As we can support the regular classes and keep up with the semester schedule, the interactions with the professors are also regular.

5.2. Moving to digital infrastructure

The COVID-19 has made to think an alternative way to teach students. Though few schools and universities have started to run online classes during this pandemic, majority of students in Nepal are out of schools/universities now. Therefore, the government should support academic institutions to strengthen their capacity to run online classes. Students also need support to get access to internet and technology as a number of students cannot afford them. During this pandemic, our focus should be more on virtual learning including television, radio and online education.

It is assumed that pandemic of this scale happens in waves and is cyclical. WHO has recently pointed out that the COVID-19 may never be eradicated, people will have to live and adjust with it. As a response to such an event, countries now plan to introduce distance learning even in normal education. This facilitates to cope once the crisis hits and minimize negative impacts. The approaches may include adjustments to the academic calendar, prioritizing students in grades preparing for examinations, and continuing with distance learning. It is important to jointly work building on the experience of previous outbreaks (SARS, Ebola, etc.) in support of governments in understanding the options available and e-pedagogy need to be considered as an alternative and innovative learning in education.

6. Key issues need to be focused

Cyber safety awareness need to be conducted through online/virtual awareness activities through social media and video conferencing sessions.

Video conferencing workshops on ‘Parenting in the Digital Age’ can help to equip parents with knowledge and skills to keep children and young people safe online.

Educate children, young people and parents on the positive use of the internet

Develop simple and easy cyber safety resources in Nepali and local languages for dissemination through online media.

Operate a dedicated online helpline to provide tips, advice and support to people who experience online harms or at risk.

Strengthen law enforcement to report online abuses and make reporting accessible throughout the country.

7. Conclusion

The COVID-19 pandemic has created educational disorderin academic institutions worldwide. If proper actions are not taken on time, the entire education system will be immobile. A taskforce on education in each province needs to be set up under the leadership of the relevant ministry to explore possibilities, suggest immediate and short-term measures and enable teachers to compensate for the loss. Since the majority of students have almost no access to technology, the new measures must formilate on low-

tech approaches, and also provide some e-learning platforms to those students who have access to technology. It seems appropriate to advance education accordingly by preparing a platform for conducting education based on geographically remoteness, economic status of families as well as the basis for following things which students do have or not access: availability of electricity, access to internet and data, availability of devices like computers, and laptops, and availability of electronic media. Every academic institutions should be prepared to continue online academic as well as research activities even if the pandemic arises in the future considering above mentioned facts.

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A Comparative Study of Autoclaved Aerated Concrete Block and Conventional Brick for Buildings

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Abstract

The main objective of the study is to emphasize the importance of building materials in the construction in terms of strength, cost, safety, environment friendly and sustainability. The study was carried out to evaluate the comparisons of light weight AAC block for the building construction with conventional brick on the basis of the strength. Economy, safety and sustainability. From the result, it was observed that the seismic weight of the structure with AAC block was found less than conventional brick. As the density of block is less (1/3rd of brick) as compared to brick, the dead load of the structure was reduced in AAC block. So, it is better to use light weight blocks in seismic prone zones. The base shear is case of AAC block was also less in all buildings compared to brick. This is because of light weight of AAC blocks. Less base shear results in lesser lateral forces and due to reduced base shear, member forces are also reduced which results in decrease in reinforcement and thus leads to economical construction with AAC blocks. The use of AAC blocks reduce the wall load and reduces overall loading of the structure which reduces the cost of the building. The study shows that the construction of structural wall and plaster with AAC block also reduces the cost.

Keywords: Light weight, Conventional brick, safety and sustainability, safety.

1. Introduction

People have constructed building and others structures since ancient time and construction industry is one of the large industries in every country of the world whether it is a developed, developing or under developed country. In Nepal 60% of the National budget is spent through construction industry as development works. That means Ministry of physical planning and building construction is the ministry which covers largest amount of the national budget. 11 % of GDP is covered by construction industry after agriculture sector.[1] So construction industry is considered as major industry in Nepal as well as world. In Nepal, urbanization development in the capital city is growing on fast rate. And also due to high inflation rate, construction cost is also gone very high. The demand for housing is increasing as there is a heavy backlog of houses to be constructed in Nepal. According to the projections made by the National Shelter Policy in 2012, around 1,364,000 residential housing units would be needed in the urban areas, with around 900,000 new units needed by 2023.[2]

Bricks were developed in the Malla Period ranging from 1200 onwards to 1768 B.S. The bricks that make up the temples were divided into two main kinds, the dachi appa, or veneer bricks, known in Nepali as teliya ita, and the ma appa, or structural bricks.

The dachi appa bricks were especially fired at very high temperature, were darker red in colour, and had a glossy finish that made them perfect as veneer bricks, those used for the seemingly “polished” side or facade of the tiered Newar temples and palaces. They also had a special shape, the front of the brick were a perfect rectangle while the sides taper with the width. [3]

In the Kathmandu valley, various types of brick making technologies were practiced. In the early 1950's the simplest technology was introduced which replaced the traditional clamp kilns. In 1970, the Nepal Government with the assistance of the People's Republic of china made the modern technology for the production of bricks. And in 1991 under a GATE-GTZ program, brick with Ceramics were introduced in Kathmandu valley and in the Terai region.[4]

Brick has been a primary technique used in building structures and one of the oldest construction technologies in common uses mostly in developing nations. Its legacy in existing architecture still makes it a desirable, architectural choice in many locations. Bricks remain one of the most important building materials but it directly or indirectly cause a series of environmental problems and loss of fertile land due to use of clay soil excavation for making of bricks. Bricks cannot be used in high seismic zones for load bearing structures and it is heavy in weight so that the structure needs to withstand greater weight.[5]

So, new substitutes for conventional brick started to come in practice in developed nations and the same trend was started in Nepal. Various types of substitute for conventional brick can be used to reduce environmental pollution and global warming, preserve fertile land, reduce the time and cost of construction and ensure better thermal insulation, acoustic quality. CLC, fly ash and Light weight AAC (autoclaved aerated concrete) blocks may be one of the solutions for replacement of conventional brick.[6] AAC is now commercially available and is being used in Nepal.

AAC was first introduced commercially over 50 years ago. AAC was perfected in the mid-1920s by the Swedish architect named Dr. Johan Axel Eriksson. AAC is manufactured by a process that involves slurry preparation, foaming /rising, cutting, and steam curing (autoclaving)[7]. In 1987, AAC was produced in 35 countries. AAC is a construction material that is factory-made and available to the user in blocks and precast units for walls, floors, and roofs. Blocks for laying in mortar or glue are produced without any reinforcement. It has gained widespread use in many areas of the world including Europe, South America, the Middle East, and the Far East. Autoclaved aerated concrete a porous lightweight concrete whose cellular structure is generally obtained through an in situ gas-producing chemical reaction of a sand and cement slurry.[8]

AAC is a thermally insulating concrete-based material used for both internal and external construction. Besides AAC's insulating capability, one of its advantages in construction is its quick and easy installation, because the material can be routed or cut to size on site using standard carbon steel power tools. AAC is well suited for urban areas with high rise buildings and those with high temperature variations. Due to its lower density, high rise buildings constructed using AAC require less steel and concrete for structural members. The requirement of mortar for laying of AAC blocks is reduced due to the lower number of joints. The material required for rendering is also lower due to the dimensional accuracy of AAC. The increased thermal efficiency of AAC makes it suitable for use in areas with extreme temperatures, as it eliminates the need for separate materials for construction and insulation, leading to faster construction and cost savings.[5]

So, this study aims to find the merits of AAC over conventional brick available in Nepal and encourage Nepalese people for use of AAC as alternative to conventional brick for construction purposes.

2. Objectives of the Study

1.To compare the autoclaved aerated concrete blocks and conventional brick under Seismic weight, base shear, required rebar area and gravity load.

2.To compare the autoclaved aerated concrete blocks and conventional brick in terms of cost effectiveness.

3.To compare the compressive strength between aerated concrete blocks and conventional brick.

3.Methodology

3.1Sampling Technique and Sample Size

Most of the residential building that are constructed or under construction in and around the Kathmandu valley ranges from four and half storey to two and half storey buildings. So, in this thesis the model that was analyzed and studied were between the four and half to two and half storey residential buildings. The building size that has been structurally studied in this paper will represent the present field and construction scenario practice in a Kathmandu valley.

Below Fig. showes the flow chart of research methodology use to achieve the objectives that has been set.

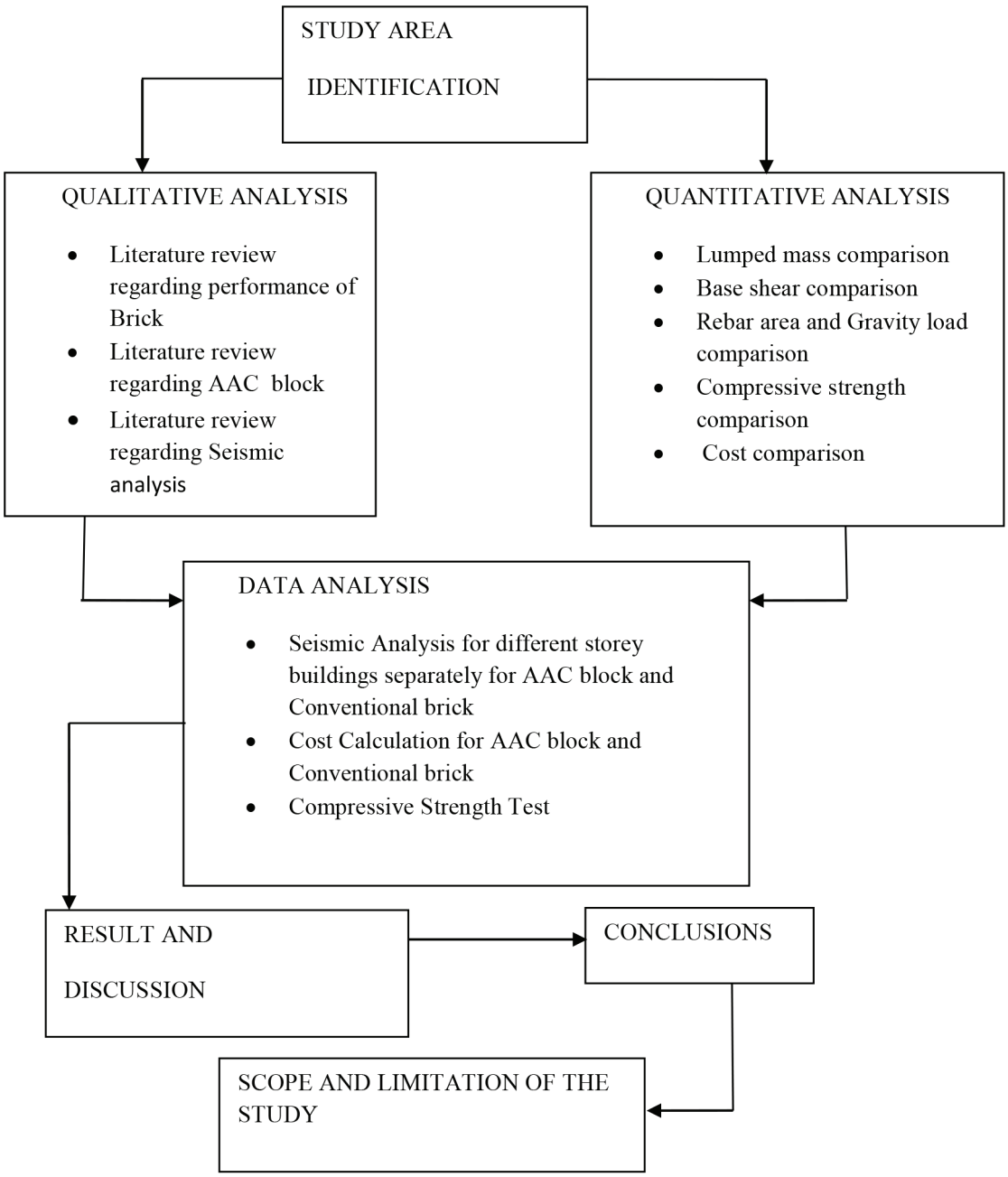

Figure 1: Flow Chart of Research Methodology

4.Result and discussion

The seismic analysis for all three different storey residential buildings has been done with two different materials i.e. Brick wall and AAC block wall by using seismic coefficient method under consideration in ETABS and the results are presented below. The parameters which are to be studied are Seismic Weight, Base Shear, Rebar Required Area and Gravity Loads on wall by changing the material i.e. Conventional Brick and AAC block.

In the Comparison of seismic weight between conventional brick and AAC block, various observations are obtained from the analysis. In terms of four and half storey building, the seismic weight of structure using brick gave the higher value 5038.87 KN and the structure using AAC block gave the lower value 3938.91 KN. In terms of three and half storey building, the seismic weight of

structure using brick gave the higher value 3053.54 KN and the structure using AAC block gave the lower value 2191.32 KN. In terms of two and half storey building, the seismic weight of structure using brick gave the higher value 1447 KN and the structure using AAC block gave the lower value 1090 KN. Result shows the variation of seismic weight with different materials. So, light weight brick is better to use in seismic prone zones which gives lesser seismic force. Also using the light weight brick infill, seismic design is more conservative as compared with brick.

In the comparison of base shear using two materials, four and half storey building gave the value 453.50 KN with the use of bricks and the structure using AAC block gave the value 354.50 KN. In terms of three and half storey building, the base shear of structure using brick gave the value 274.82 KN and the structure using AAC block gave the value 197.22 KN. In terms of two and half storey building, the base shear using brick gave the value 130.23 KN and the structure using AAC block gave the value 98.1 KN. Result shows the variation of base shear. The base shear is less in all the buildings using AAC block and less base shear results lesser lateral forces. The less base shear also reduces the member forces which results in decrease in the amount of area of steel in various members.

In terms of rebar required area, all these three buildings with using two different materials were structurally analyzed using IS-456:2000. Effect of building materials and their behavior in structures were analyzed and from the observation it has been found that the rebar required area with the use of AAC block in all three buildings was found less than that in Conventional brick. So, the reduced reinforcement indicates economy in the construction of a buildings using AAC Block.

The study of Conventional Brick and AAC Block under gravity loading for all building shows that the AAC blocks reduces the wall load because the density of AAC block is less than brick and it helps to reduce the overall load of the structure which reduces the cost of a building.

In this study, comparison on the cost of construction of structural walls with brick and AAC block has been done and the cost is calculated including the cost of materials, cement, sand, and water. Result shows that the 230mm thick brickwork wall in 1:6 ratio cost Rs. 16,462.61 per 1m3 and 200mm thick AAC block wall in 1:6 ratio cost Rs. 14167.70 per 1m3. The lower cost with AAC block wall is due to the fact that the requirement of mortar is lesser in AAC block wall due to its bigger size and less number of joints.

Similarly, comparing the plaster on brick wall surface and AAC block wall, the cost is calculated including cement, sand and water. Result shows that the 12mm thick brick wall plaster work cost Rs. 453.85 per 1m2 and 12mm thick AAC block wall plaster work cost Rs. 369.33 per 1m2. The lower plaster cost with AAC block is due to the uniform shape and texture of AAC block that gives even surface to the walls and when it is built it has both faces as fair faces unlike brick work, which has only one face as a fair face. So, the thickness of Plaster for AAC block is much less compared to conventional brickwork.

In a comparative analysis chart, we found that in almost all the parameters, the AAC blocks have a superior edge over Conventional bricks. The use of AAC blocks leads to savings in overall project cost, enables to speed up the construction process, reduced environmental and social impact.

The compressive strength test is carried out in the laboratory for both conventional brick and AAC block. The result shows that the average compressive strength of first class brick is 15.54 N/mm2 and second class brick is 6.31 N/mm2 while that of AAC block is 1.76 N/mm2. So, due to less strength of AAC block, it cannot withstand in load bearing structure, while it can be used in a frame structure.

5.Conclusion

The results of the study lead to the following conclusions.

1.The impact of earthquake is directly proportional to the weight of the building and from the analysis it was found that larger the mass of the structure, larger will be the seismic force acting on the structure. The AAC block building gives the lesser seismic force as compared with conventional brick due to its light weight properties. The AAC block shows excellent resistance to earthquake force. So it is better to use light weight bricks in seismic prone zones and it is more conservative to construct the structure with AAC block.

2.Base shear in case of AAC block masonry was also found to be less in all the three buildings compared to brick masonry because of light weight of AAC blocks.

The less base shear in AAC block building results lesser lateral forces. And due to the reduced base shear, member forces are also reduced and this helps to decrease in reinforcement requirements. So it leads to economical construction using AAC blocks as compared to conventional brick.

3.The study of AAC block and conventional brick under gravity loading for buildings shows that the AAC blocks reduce the wall load because the density of AAC block is less than brick and it helps to reduce the overall load of the structure which reduces the cost of a building.

4.AAC blocks are highly cost effective in nature. Cost reduce is attained due to the reduced reinforcement requirement, reduced the size of structural members and the indirect factors likely reduced plastering width and less mortar required for wall work.

5.The AAC blocks have a superior edge over Conventional bricks. The use of AAC blocks leads to savings in overall project cost, enables to speed up the construction process, reduced environmental and social impact.

6.This study encourages the use of AAC block over Conventional brick in a frame structure which will be safer and reliable.

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Damage Study of Buildings at Kathmandu Valley Due to Gorkha Earthquake 2015

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Abstract

This paper outlines the common observed failure patterns in the buildings of Nepal after the Gorkha earthquake. Several types of damage patterns were observed for reinforced concrete buildings, as well as for unreinforced masonry and adobe houses during the reconnaissance survey performed after the earthquake. This paper also covers damage patterns in non-engineered buildings, middle and high-rise buildings and commercial complexes from Kathmandu valley. The construction and structural deficiencies were identified as the major causes of failure, however local soil amplification, foundation problems, liquefaction associated damages and local settlement related damages are also significantly observed during this earthquake and reported in this paper. At the end, the lessons learned from the field survey are resumed in order to give some guidelines for future construction practices.

Keywords: Epicenter, Aftershock, Liquefaction, reinforced concrete building, construction.

1.0 Introduction

1.1 Background

An earthquake with a magnitude of M7.8 occurred at 11:56 A.M. (local time) on 25 April 2015 in the central part of Nepal (Gorkha). The epicenter was at Gorkha, 77 km southwest of Kathmandu, at 28.15°N, 84.71°E, and at a depth of 15 km (USGS) [1]. According to Nepal Police statistics, the number of deaths, as of 22 June, was 8,660 with 21,952 injured in the main shock and 172 deaths with 3,470 injured in the aftershocks. It was also reported that more than 5 million buildings were damaged, with about half of them experiencing collapse. The mortality rate mainly resulted from the collapse of buildings, the areas near the earthquake source had low rates, while the rate exceeded 1% (extremely severe damage) in Sindhupalchowk and Rasuwa districts north of the Kathmandu Valley and distant from the earthquake source. In the Kathmandu Valley having high population, the rate was low at 0.1% or less. This earthquake is officially referred to as the 2015 Gorkha Nepal earthquake because the hypocenter was located in the Gorkha region [2].

A major aftershock with a moment magnitude of M7.3 occurred at 12:51 P.M. (local time) on 12th May 2015. The epicenter was 75 km northeast of Kathmandu, near the Chinese border, at 27.82°N, 86.08°E, and at a depth of 19 km (USGS) [2] .

Kathmandu valley consists of Kathmandu, Lalitpur and Bhaktapur district. There is one famous city called Kirtipur which is also located in Kathmandu valley. In this research, I have considered these four cities as the study area.

1.2 Risk of earthquake in Nepal

About 700000 earthquakes occur daily in the world. About 6000 earthquake occurs daily having magnitude of 5 Richter scale, 800 earthquakes occurs with magnitude of 6 Richter scale, 120 earthquakes occur with magnitude of 7 Richter scale and 20 earthquakes occur with magnitude of 8 Richter scale. But, all of these effects will not come to the earth's surface and we cannot feel at all. The biggest earthquake recorded ever took place in Chile in 1960 having 9.5 on Richter scale [3].

There is no availability of record and data about the earthquake that happened in Himalayas before 1800 A.D. But, in some religious book it is found that in different time the earthquake claimed huge damage. According to the history, in Kathmandu, huge damage due to earthquake occurred in the year 1255, 1408 and 1681 A.D. But, still it is unknown about the magnitude and epicenter. After 1800 A.D., in Nepal and India, eight numbers of earthquake occurred. Department of Geology and Metrology of Nepal published a statistical data mentioning about earthquake lesser then 4 Richter scale occurs daily in Himalayan region. 4000 earthquake occurred in Nepal in between 1985 to 1992 year. Earthquake with magnitude 7 or greater hit the Himalayas time to time but, magnitude 8 Richter scale or higher usually occurs in about 100 years of interval [3].

From 1985 A.D. till now, earthquake with magnitude 4 or higher occurred in the border of higher Himalayas and Middle hilly region in Nepal. From this, it is clear that there is a high risk of earthquake in the border of higher Himalayas and Middle hilly region of Nepal. Although the epicenter lies anywhere in Nepal, there is high risk of damage due to earthquake throughout the country [3].

In Himalayas, according to the risk due to earthquake, Nepal lies in 11th position and Kathmandu lies in 3rd position in the world [4].

1.3Liquefaction of Soil in Kathmandu Valley from the 2015 Gorkha, Nepal, Earthquake

1.3.1 Liquefaction

Liquefaction can occur in moderate to major earthquakes resulting in severe damages to infrastructure. Loss of shear stress of granular material due to increased pore pressure due to earthquake shaking behaving as a liquid is generally called liquefaction. When this happens, the sand grains loose its effective shear strength and will behave more like a fluid.

Liquefaction potential is commonly associated with saturated sand and silty soil having low plasticity and density. However, Liquefaction potential is attributed to characteristics of earthquake event (e.g. duration of earthquake, amplitude and frequency of shaking, distance from epicenter), particle size distribution of soil, cohesion and permeability of soil, location of water table, and relative density etc [5].

The deposition in the Kathmandu Valley is lacustrine and fluvial in origin with thickness up to 500 m. The deposited sediments are made up of clay, silt, sand and gravel. Areas with loose sand deposits have a greater chance of liquefaction after the earthquake. After the devastating *Mw* 8.0 Bihar-Nepal earthquake in 1934, occurrence of liquefaction at many places in Kathmandu Valley was reported [6]. Studies of previous major earthquake and characteristics of soil in Kathmandu Valley give evidence that significant damage to buildings and infrastructures occurred in Kathmandu valley as a result of widespread liquefaction [5]. Liquefaction susceptibility was judged "high" and"medium" in a large area along the major rivers.

1.3.2 Liquefaction During 2015 Gorkha Earthquake

The deposition in the Kathmandu Valley is lacustrine and fluvial in origin with thickness up to 500 m. The deposited sediments are made up of clay, silt, sand and gravel. Areas with loose sand deposits have a greater chance of liquefaction after the earthquake [7]. and

many other researchers concluded that a large area in Kathmandu Valley is susceptible to liquefaction in this region. However, unlike in previous major earthquakes, the liquefaction triggered by the 2015 Gorkha earthquake appears to be fairly limited and localized. The localised areas where liquefaction was observed are Manamaiju, Ramkot, Bungmati, Jharuwarasi, Hattiwan, Imadol, Mulpani and Duwakot (Figs. 21, 22). Typically, these are sand boils formed by freshly ejected sand forced out of over-pressurized sub-strata. At most site, sand was ejected to agricultural fields forming deposits that varied from thin veneers to sheets, a few centimeters thick. Liquefaction-induced damage to structures in these areas was not found except buildings on some places tilted slightly. All these eight locations were indicated as the moderate to high liquefaction susceptibility zone by both UNDP/MOHPP (1994) and Piya (2004) with the exception of Jharuwarasi area. In contrast to UNDP/MOHPP (1994), JICA (2002) and Subedi et al (2012) identified most of these locations as a non-liquefiable area even though the estimated ground motions in their research is higher than the observed ground motion in Kathmandu Valley during the 2015 Gorkha earthquake. JICA (2002) and Subedi et al (2012) considered magnitude of earthquake as 8.0 and the corresponding peak ground acceleration as 0.3g. While the observed peak ground acceleration in Kathmandu Valley during 2015 Gorkha earthquake was about 0.18 g. Brief descriptions of reported liquefied locations are presented here. Some studies have shown that Kathmandu bears non homogenous soil strata even within small area which suggest that liquefaction potential of small area may differ [8]. Past studies have limited information on site specific liquefaction potential. Most of these researches were based on SPT value and bore hole data. Extensive dynamic and/or cyclic field test and/or laboratory test are very important to predict the liquefaction potential accurately. Site specific liquefaction potential of even small area of the Kathmandu Valley is necessary in order to implement the reconstruction planning properly and also to prevent and minimize the probable damage that might occur during large earthquake in the valley.

The Manamaiju area is located on the north-west edge of Kathmandu Valley (Fig. 1). Some sand boils and traces were found in paddy fields on the right bank of the Bishnumati River (Fig. 1a). Other geotechnical problems were observed in the surrounding area but were not associated with liquefaction. Structural damage was significant in Manamaiju but not associated with liquefaction. Ramkot is located on the western edge of the Kathmandu Valley (Fig. 1b). Liquefaction of very fine sand was observed on slope (Fig. 1a and b). Both Geotechnical and structural failures were observed in Ramkot but not associated with liquefaction. Extensive liquefaction was found in the flood area of the Bagmati River in Bungamati, located on the south edge of Kathmandu Valley. The ground water table was at shallow depth (~1.5 m) as the flood plain is 200 m far from Bagmati River. Sand boiling and fissures were seen on a flat plain along the river channel. Jharuwarashi is located on the southeast edge of Kathmandu Valley. Ground fissuring of about 100 m long and 10 cm wide, parallel to the Karmanasa River, was found (Okamura et al., 2015). Sand boils were ejected through the fissures.

Numerous sand boils were found in Hattiban, Lalitpur (Fig. 2a). Unlike other liquefaction sites that this site is not located on the river bank and not a borrow pit for sand. Some sand boils and traces were also found in the field of Nepal Agriculture Research Council, Khumaltar. Small scale liquefaction is found in Imadol area, southern part of Kathmandu (Fig. 2b) as shown in Fig. 2b. The white spots in the field are the trace of sand boiling. There is no any significant damage in this surrounding area except tilting of a house.

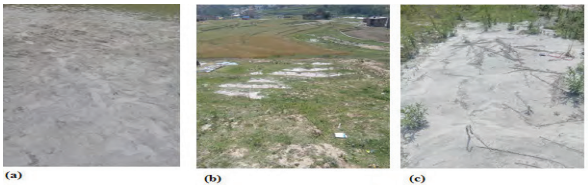

Fig. 1 (a) Boiled sand at Manamaiju, (b) overview of liquefied area at Ramkot, and (c) boiled sand at Ramkot

Fig. 2 (a) Boiled sand at Hattiwan, (b) boiled sand at Imadole, and (c) boiled sand at Duwakot

Duwakot is located on the east edge of Kathmandu Valley (Fig. 2c). This is another site with clear liquefaction as indicated by sand boils. It is also famous for sand mining. Extensive liquefaction was found in Duwakot near Nepal Engineering College on the left bank of Manohara River (Fig.2c). Sand boiling and fissures were seen on a flat plain along the river channel. As liquefied site is about few hundreds meter from Manohara river, the water table at shallow depth may lead to liquefaction during the earthquake. No significant damage due to liquefaction was found. However, college building was subsided slightly as reprted by [9]., 2015. Small scale liquefaction was also reported in Mulpani which is located on the same flood plain as Duwakot [10].

The low liquefaction occurrence at the valley may be attributed to low amplitude of high-frequency shaking of the main shock. Peak ground motion observed in Kathmandu Valley (about 0.17g) was lower than the estimated peak ground motion (about 0.3g) [7] for these studies. Additionally, water levels were likely at their lowest levels because of dry season at the time of earthquake and/or rapidly sinking water table as a result of uncontrolled ground water withdrawal in Kathmandu Valley may decrease the liquefaction potential. The lacustrine sediment might be insusceptible to liquefaction because of the fine grain-size distribution [10].

Very interestingly, most of liquefied sites are either within or on the edges of the Kathmandu Valley, regions likely to be more vulnerable to liquefaction due to basin edge effect. The basin edge effect can be defined as the amplification of seismic energy at the margins of sedimentary deposits. When such sediments are laterally confined by a more rigid basement rock as in the Kathmandu Valley, the seismic behaviour becomes multi-dimensional and lead to severe damages [11]

2.0 Data Collection

To meet the objectives of the study, primary and secondary data was collected and the collected data was analyzed and interpreted. Survey of the damaged buildings in various areas of Kathmandu valley was done and primary data was collected through the field visit interviews. Random selection of the house was adopted for the study. House Owners and Tenants of the damaged house gave the required information and helped in showing the damaged parts of their houses. Secondary data sources include previous research report, Literature review, Nepal building codes and websites of different organization like United States Geological Survey (USGS), United Nation Development Program (UNDP/UNCHS), Japan International Cooperation Agency (JICA), Asian Development Bank (ADB), World Bank etc.

2.1Building Assessment Methods

The Rapid Visual Assessment (RVA) was done to investigate the damaged buildings. RVA helped to identify the key spots where damages are very severe to no damages at all. It helped to declare whether the building is ready for re-occupancy or need some treatments and/or requires demolishing.

Observations were primarily made in Beam Column joints, Columns, Beams, Slab and walls. Each observation was note along with its photographs.

3.0 Results and Discussions

There are several types of failure of RC frame structure, such as failure of foundation, beam, column, beam column joint, slab, staircase, infill wall and so on. This type of failure caused building to collapse or tilt. Some of the building failed due to soft storey effect shown in Fig. 3.

Fig. 3: At Gongabu, RC frame buildings were tilted (a, b). A shear crack in the first floor (c)

3.1 Tilting of Building

There are certain buildings which did not collapse, nor damaged but tilted (Fig. 4). It is due to soil settlement. These buildings are not damaged but it was not habitable due to massive amount of tilting. Soft soil of foundation and slender buildings are other causes of tilting of the building. Some of these buildings can be made habitable with certain rectification after consulting the expert. Some buildings were tilted due to unequal settlement and very weak soil of foundation. These buildings are not in a habitable state thus cannot be used and needs complete dismantling.

Fig. 4: Tilted building at Kalanki

3.2 Fully Collapsed Building

Improper design or having poor quality of building materials led to the collapse of the building during earthquake (Fig.5). Section of beam and column are smaller than required. Transverse and longitudinal reinforcements seem less than needed. It was seen that there was less Rebar used in footing, beam, column, slab and staircase as required.

Depending upon the soil condition, required footing size must be designed. But, due to people's negligence and lack of knowledge in most of the cases isolated footings with identical dimensions were built.

Fig. 5: Fully collapse building at Gongabu

3.3 Sandwich Type Failure of Buildings

This type of failure was seen in most of the places in Kathmandu valley. Weak column was built to support the strong beams. This disproportionality of the columns and beams led to the sandwich type failure in Reinforced Concrete buildings (Fig. 6). It was seen that in most of the RC buildings which failed was due to lack of infill walls. Load in roof was increased due to gardening. Some building had less infill walls and was used for shopping area in ground floor and first floor, bank or office in second floor and residence for top floor, which in fact was designed for residential building.

Fig. 6: Sandwich type failure at Sitapaila

3.4 Soft Storey Failure of Buildings

This type of failure occurred when ground floor was

weak in stiffness with respect to lateral stiffness of above stories. Buildings are classified as having a "soft storey" if that level is less than 70% as stiff as the floor immediately above it, or less than 80% as stiff as the average stiffness of the three floor above it. This type of failure occurs where ground floor is being used for parking, shopping and open hall without considerable shear walls and infill walls. At sitapaila, near Paropkar building and at Gongabu this type of failure was seen (Fig.7).

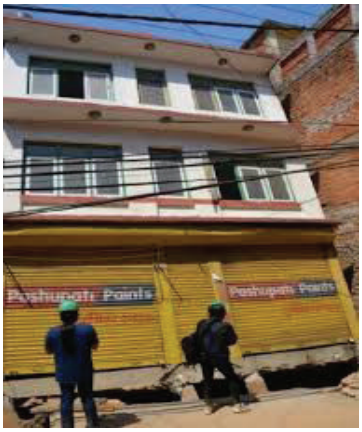

Fig.7: Soft storey failure at Gongabu

3.5 Crushing of Concrete Failure of Column

Crushing of concrete of column occurs when column is subjected to heavy dynamic axial load as well as lateral loads. It might happen due to weakness of column in terms of concrete grades or they do not have enough reinforcements. Column failure of four storey residential building in Gangabu was observed. This type of failure was observed in residential building at Kalanki. Due to heavy load of above storey corner column failed as shown in figure below. (Fig.8).

Fig.8: Crushing of concrete in column at Kalanki

3.6 Shear and Bending Failure of Columns

Most of the building columns did not have enough resistance for shear. Due to this, shear failure of column occurred (Fig. 9). It was seen that column cracked due to shear and bending in bottom. Shear failure at mid height of column near the place of opening was observed.

Fig.9: Shear and bending failure at Balaju

3.7 Shear Failure of Beams and Beam Column Joint Failure

Shear failure of beam happens when either concrete section is not enough or shear reinforcements are not suffi-

cient. The beam column joint failure was observed due to either poor quality of concrete or improper detailing of reinforcement in beam column joints (Fig. 10).

Fig.10: failure of beam column joint at Gongabu

3.8 Failure Due to Reinforcement Deficiency

Improper design of buildings consists deficiency of longitudinal and transverse rebar. Detailing of rebar was not correct. The spacing of transverse rebar was more than 150 mm which is one of the main cause of column failure (Fig. 11).

Fig.11: Failure due to Reinforcement deficiency at Gongabu

3.9 Poor Quality of Concrete

Most of the buildings which were damaged are not only because of design problem and reinforcing detailing but also due to inferior quality of concrete. Concrete strength was not good enough and vibration of concrete was not done properly **(**Fig 12).

Fig.12: Honeycomb seen in RCC at Dhumbarahi

3.10 Infill Wall Failure

In general practices of building construction, there were no provision of connecting masonry infill wall with concrete bands and connection with columns, so the problems was found on infill wall cracks. It was observed that infill wall failed in most of the RC buildings (Fig.13).

Fig.13: Damage on infill wall at Kavresthali

3.11 Others

Others reasons of failure of buildings also exist, irregular shape leads to failure of the building. It is due to Architectural planning problem. Some buildings failed due to construction in slope ground area. In the sloppy land, foundations are laid in different level and some of them are infill soil, so due to unequal settlement of building, it damaged. In most of the cases, soil explorations are not done. Staircases of some of the buildings are damaged it was observed that the length of the staircase is too long and thickness of slabs was not enough for staircase.

Dense and haphazard urbanization is another cause of damage due to earthquake. Kathmandu valley is potentially prone to damaging earthquakes, as it is located in an active seismic zone as well as due to haphazard urbanization and increase in population in the Kathmandu valley. Very rapid increase in population has put pressure on land, housing and urban facilities [12]. It has become very essential to carry out studies on different aspects of the earthquake hazard leading to long term earthquake vulnerability reduction program.

3.12 Monuments

According to UNESCO, more than 30 monuments in the Kathmandu Valley collapsed in the quakes, and another 120 incurred partial damage. The destruction is concen-

trated in the Kathmandu Valley. During this survey, one old masonry building was found having wall thickness of 1 meter. It was one of the Rana's Durbar situated at Dhoka tole, near Basantapur, Kathmandu. It was constructed using mud mortar with bricks. Despite of old age of this building, it did not collapse but damaged, mostly at lintel level and joints between infill walls (fig.14 and 15).

Fig.14: Damage on joint at Dhoka tole

Fig.15: Damage on wall at the opening

Damage of buildings in the Kathmandu valley was heterogeneous, but overall, the percentage of the totally collapsed buildings was less than 5 % in the Kathmandu valley

3.13 Types of Failure of Bulidings

Table 1: Types of failure of buildings

S. No.	Types of failure	Percentage
1	Structural	4
2	Non-structural	96

The above table describes types of failure of buildings in percentage. Here, structural members refer to beam, column, slab, footing and staircase. Whereas non-structural members refers to PCC, walls, plaster. In this study only 4% of structural and 96 % of non structural failure was seen. Very less structural failure was found as compare to non-structural failure.

3.14 Location of Failure in Buildings

Table 2: Location of failure of buildings

S. N.	Location of Failure in buildings	Percentage
1	Periphery of building at plinth	16
2	PCC	2
3	Sill	14
4	Lintel	19
5	Wall	11
6	Plaster	33
7	Parapet wall	5

The above table describes about location of failure of buildings in percentage. Damages seen in the different parts of the buildings were not identical. The periphery of the building at plinth showed 16 % of the damage as seen in Fig.16. The gaps were easily seen in such location. Very less damages was noted in PCC which is only about 2 %. Damages in sill level were 14% as seen in Fig.17. It was due to lack of sill band. Buildings having sill band did not damage after the earthquake. 19% of damages on lintel level were seen (Fig.18). To avoid such damages lintel band and sill band should be provided. The damage in wall occurred in abour 11% of the buildings as seen in fig.19. It is due to poor workmanship while lying brick masonry and poor quality of material. In most of the building hairline cracks are noted in the plaster, it occurred in about 33% of the buildings (Fig.20). It is due to improper mixing of mortar, poor workmanship and inappropriate cement-sand ratio. This study showed highest percentage of damage in the plaster and lowest was seen in PCC. 5% of the damages in the parapet wall were noted in the buildings (Fig.21). It is due to improper strengthening at the joint between parapet wall with infill wall or column.

Fig.16: Damage on periphery at plinth at Mulpani

Fig.17: Damage at sill at Kirtipur

Fig.18: Damage at lintel at Goldhunga

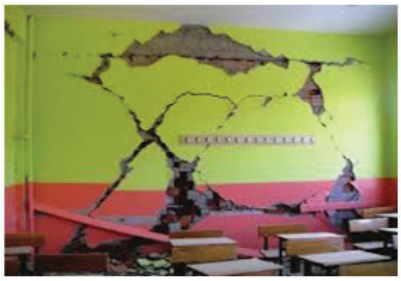

Fig.19: Damage on wall at Kavresthali

Fig.20: Damage on plaster at Balkot

Fig.21: Damage on parapet wall at Katunje

4.0 Conclusions and Recommendations

The conclusions of the entire study are based on the results and discussions. Damage survey of buildings were done and carried out visual rapid assessment in and around the Kathmandu valley to estimate distribution of damage due to 2015 Gorkha earthquake. Damage of the building depends on the soil condition, loading condition, design of building, quality of material etc. All these factors were taken into consideration in this study. The conclusions and recommendations from the study and analysis are as follows.

Out of 116 building surveyed, 5 buildings were in extremely inhabitable condition, so the owners of the buildings were immediately suggested to vacate their building. Remaining 111 buildings had minor non-structural damage, so the owners of the buildings were given the required knowledge about mitigating the problem. Preventive measures suggested were, repair or retrofit under supervision of engineer, owner should use good quality of building materials. From now onwards, do not neglect to assign and follow the advice of an engineer from designing till the construction ends.

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Performance Evaluation of Carbon Based Nano Antenna

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Abstract

Graphene-enabled wireless communications constitute a novel paradigm which enables wireless communications at the nano scale. There is the problem of limited capability of nano-scale antennas fabricated from traditional metallic components. With antennas made from conventional materials like copper, communication between low-power nano machines would be virtually impossible. But by taking advantage of the unique electronic properties of graphene, nano devices can be connected forming a network of nano devices. This research work carry out performance analysis of carbon-based nano patch antenna. Use of graphene and graphite as a patch material of nano patch antenna shows a better performance compared to copper patch nano antenna. Dependency of operating frequency of graphene patch nano antenna on its patch length is modeled and validated with simulation results.Also the effects slots in the patch of graphene patch nano antenna is observed and increment in the bandwidth of antenna is achieved.

Keywords

Graphene, Nano patch antenna, Operating frequency, Slots

1. Introduction

Nanotechnology is enabling the development of devices in a scale ranging from one to a few hundred nanome-ters. Coordination and information sharing among these nano-devices will lead towards the development of fu-ture nanonetworks, boosting the range of applications of nanotechnology in the biomedical,´ environmental and military fields. Despite the major progress in nano-device design and fabrication, it is still not clear how these atomically precise machines will communicate. Recently, the advancements in graphene-based electron-ics have opened the door to electromagnetic communi-cations in the nano-scale[1] [2].It would be unfeasible to simply reduce traditional metallic antennas to nano sizes, because they would require tremendously high frequencies to operate. Consequently, it would require a lot of power to operate them. Furthermore, electrons in these traditional metals are not very mobile at nano sizes and the necessary electromagnetic waves would not form. However, these limitations would not be an issue with graphene's unique capabilities. A flake of graphene has the potential to hold a series of metal elec-trodes. Consequently, it would be possible to develop an antenna from this material[3]. Graphene has a unique structure, wherein, electrons are able to move with min-imal resistance[4]. This enables electricity to move at a much faster speed than in metal, which is used for current antennas. Furthermore, as the electrons oscillate, they create an electromagnetic wave atop the graphene layer, referred to as the surface plasmon polariton wave. This would enable the antenna to operate at the lower end of the terahertz frequency, which would be more ef-ficient than the current copper based antennas.Based on the honeycomb lattice of carbon atoms, graphene-based nano-antennas can radiate electromagnetic wave, which is also referred to as the Surface Plasmon Polariton wave (SPP) at the terahertz band[5].

2. Methodology

2.1 Design of of Carbon-based Nano Antenna

Nano patch antennas with different patch material is designed using High Frequency Structure Simulator soft-ware. Various carbon allotropes are used for patch ma-

terial of the antenna. The carbon allotropes used are graphene and graphite. Design Specification of the Nano Antenna: Length of Patch (L): 120nm Width of Patch (W):160nm Thickness of Patch (t):5nm Thickness of Substrate (h):10nm Permittivity of Substrate Material: 3.58 Operating Frequency of the Antenna (fr):600THz Design Procedure of Nano Antenna using HFSS:

1. Draw patch, ground plane and substrate with the specified dimensions and properties.
2. Assign materials for patch and substrate with spec-ified value of conductivity, relative permittivity and relative permeability.
3. Assigning Boundaries
   (a) Select the bottom face of the substrate and assign the perfect electric boundary to it.
   (b) Assign the Radiation boundary to the top and bottom air boxes.
   (c) Assign perfect electric boundary to the rect-angular patch.
4. Assigning Excitation: Assign wave port excitation to the rectangle on the XZ plane.
5. Set-up a Solution.
   (a) Set up an Adaptive solution at 600 THz, with 20 passes and delta as .001
   (b) Set up a Sweep solution from 200-900 THz with a step size of 0.25.

2.2 Performance Comparison of Carbon-based Nano Antenna

After designing nano patch antenna of different patch ma-terials (graphene,graphite and copper), its performance measure is carried out using High Frequency Structural Simulator (HFSS). The major parameters for the perfor-mance measure of the antennas are antenna gain, VSWR, S parameter. Finally, the performance comparison of the nano patch antenna is carried out based on the parame-ters measured.

3. Result and Discussion

3.1 Graphene Patch Nano Antenna

Graphene was used as patch of the nano antenna. The carrier mobility measured in graphene devices is ex-tremely high, which leads it to be feasible candidates for nano patch antenna. Simulation of graphene patch nano antenna gives various results e.g. gain, VSWR, S11 parameter.

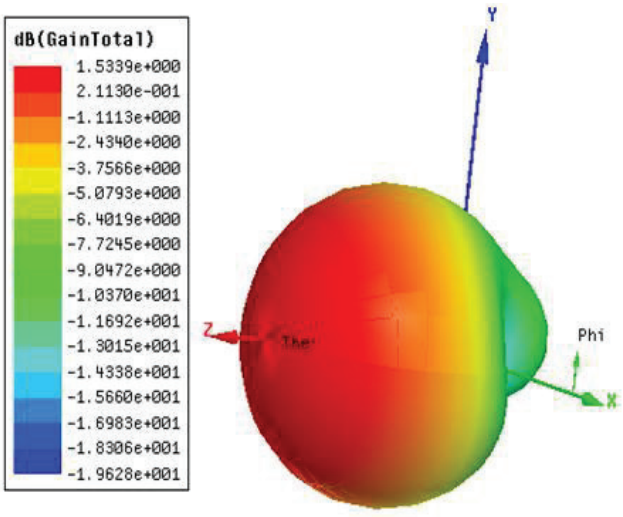

Figure 1: Radiation Pattern of Graphene Patch Nano Antenna

The figure 2 shows radiation pattern of graphene patch nano antenna. It gives the graphical representation of the radiation property i.e. gain of the antenna as a function of space. The maximum gain of the antenna is observed to be 1.5339 dB. In case of microstrip patch antenna, antenna gain is generally found upto 7dB. Due to an-tenna dimension of nano size, the antenna gain of the nano antenna is also dereased. So the result observed is acceptable.

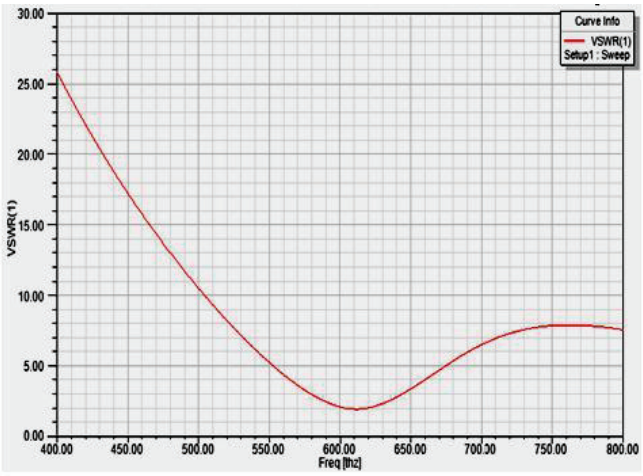

Figure 2: VSWR curve for Graphene Patch Nano Antenna

As shown in the graph the value of voltage standing wave ratio (VSWR) for graphene patch nano antenna is found to be 1.8. The resonant frequency of the antenna is cal-culated from an S-parameter measurement of the graph, which gives the S11 value of -9.5 dB . The minimum return loss (equivalent to maximum power delivered) occurs at 610 THz. So the frequency of operation of the antenna is 610 THz.

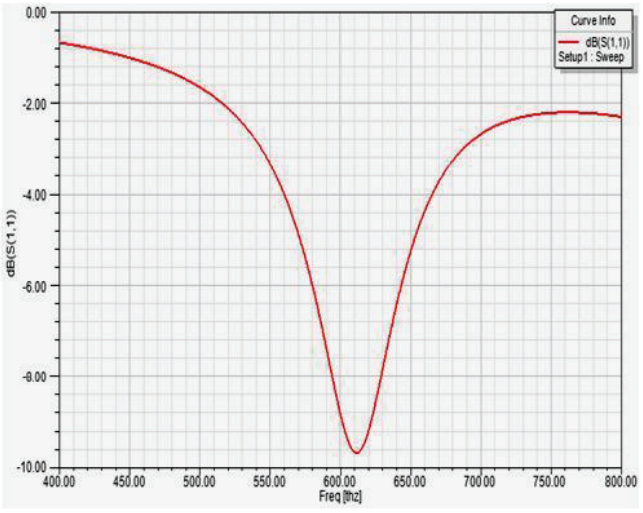

Figure 3: S11 Parameter for Graphene Patch Nano Antenna

3.2 Graphite Patch Nano Antenna

The figure 5 shows radiation pattern of graphite patch nano antenna. It gives the graphical representation of the radiation property i.e. gain of the antenna as a function of space. The maximum gain of the antenna is observed to be 1.5218 dB, which is comparable to that of graphene patch nano antenna.

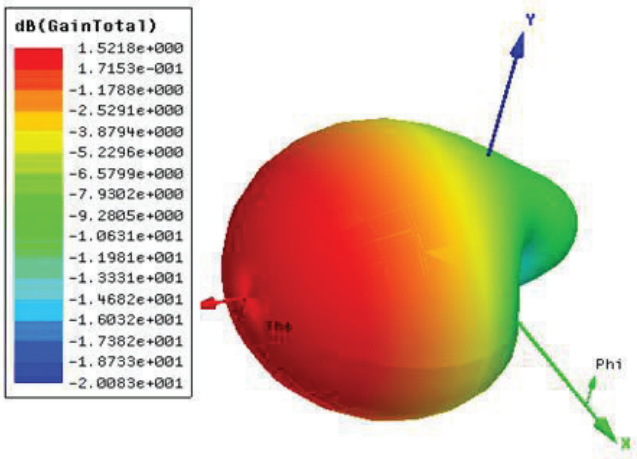

Figure 4: Radiation Pattern of Graphite Patch Nano Antenna

As shown in the graph the value of VSWR for graphite patch nano antenna is found to be 1.9. The resonant fre-quency of the antenna is calculated from an S-parameter measurement of the graph, which gives the S11 value of -9.4 dB . The minimum return loss (equivalent to maximum power delivered) occurs at 610 THz. So the frequency of operation of the antenna is 610 THz again.

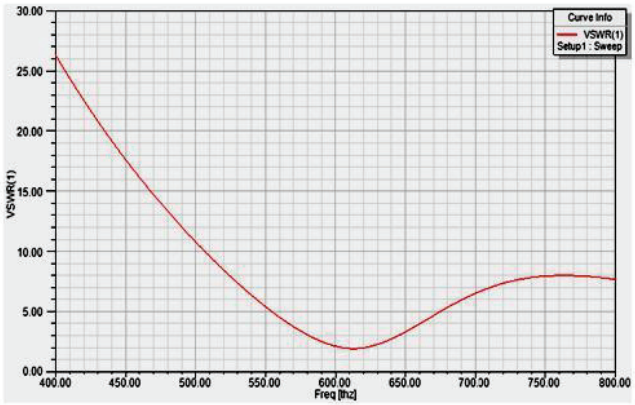

Figure 5: VSWR Curve for Graphite Patch Nano Antenna

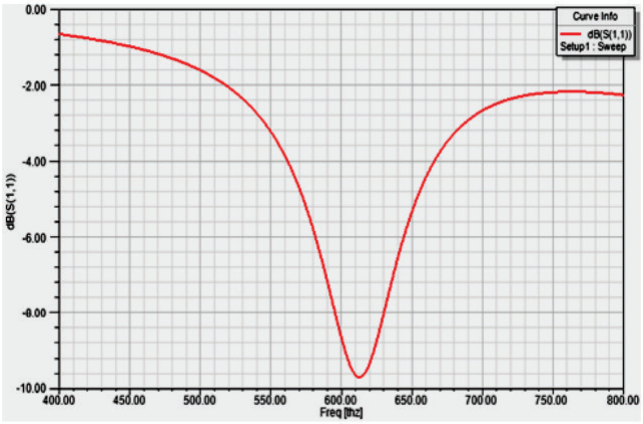

Figure 6: S11 Parameter of Graphite Patch Nano Antenna

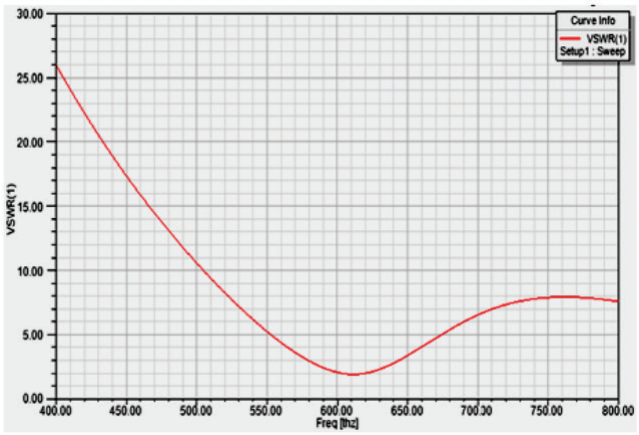

Figure 8: VSWR Curve of Copper Patch Nano Antenna

3.3 Copper Patch Nano Antenna

The figure 8 shows radiation pattern of copper patch nano antenna. The maximum gain of the antenna is observed to be 1.4807 dB, which is lower than that of graphene and graphite patch nano antenna.

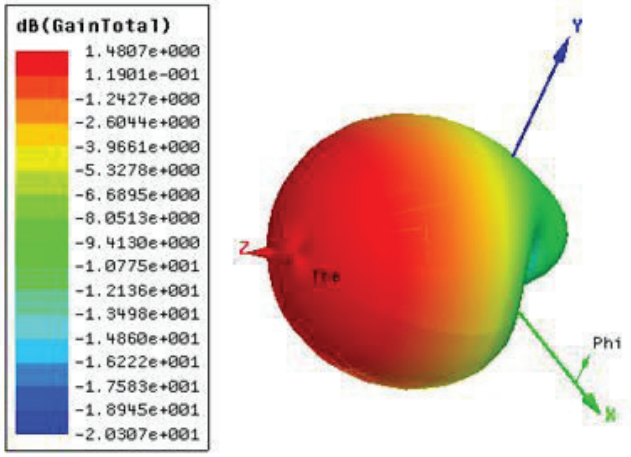

Figure 7: Radiation Pattern of Copper Patch Nano Antenna

As shown in the graph the value of VSWR for copper patch nano antenna is found to be 2. The resonant fre-quency of the antenna is calculated from an S-parameter measurement of the graph, which gives the S11 value of -9.6 dB . The minimum return loss (equivalent to maximum power delivered) occurs at 610 THz. So the frequency of operation of the antenna is 612 THz.

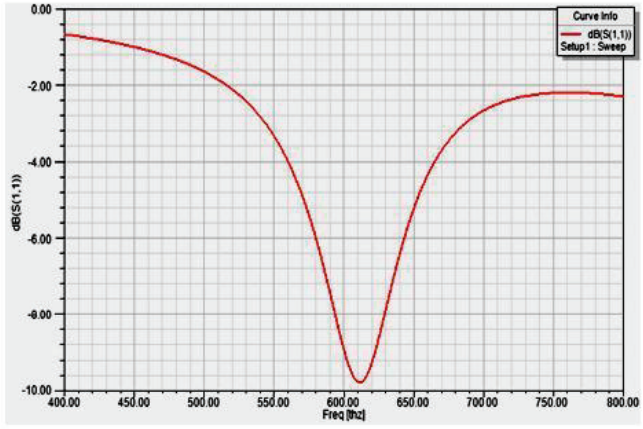

Figure 9: S11 Parameter of Copper Patch Nano Antenna

3.4 Dependency of Operating Frequency on Patch Length

The operating frequency of a nano patch antenna can be adjusted by an appropriate choice of resonator length of patch. The dependency of operating frequency for

a graphene patch nano antenna on resonator length of

patch (keeping width and thickness of patch constant) at room temperature can be given by the equation:

$$f_r = \frac{0{:}44}{(L + d\,L)\sqrt{\mu_{m0}\,\varepsilon_0\,\varepsilon_{eff}}}$$

Where,

L = length of patch

d L = Increment in patch length

e_0 = Permittivity of free space

e_{eff} = Effective Permittivity of substrate m_0 = Permeability of free space

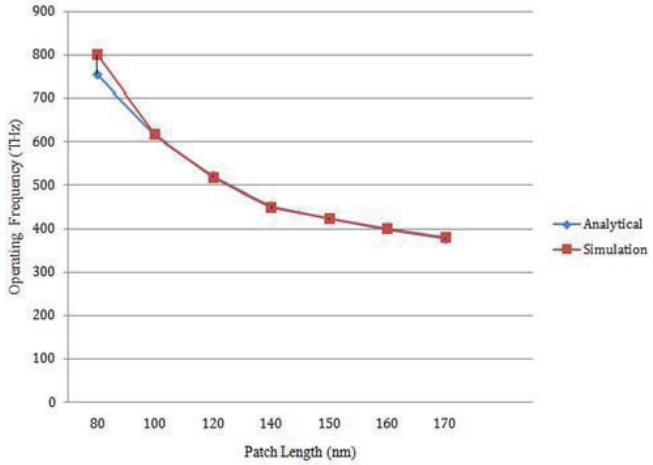

Figure 10: Dependency of Operating Frequency on Patch Length

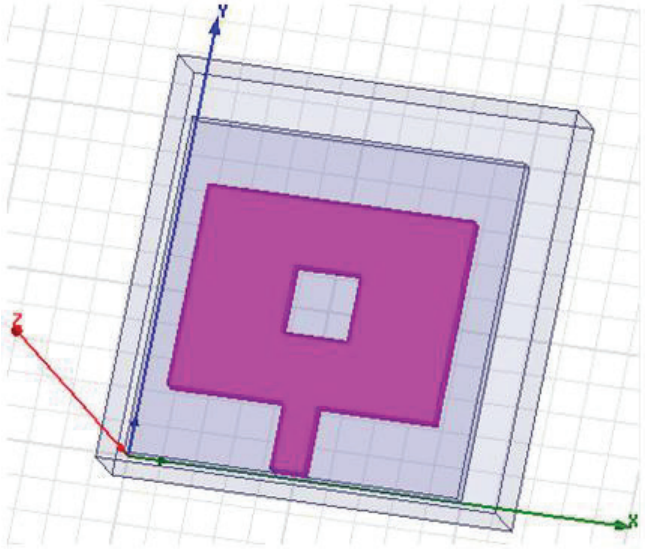

Figure 11: Graphene Patch Nano Antenna with Rectangular Slot in Center

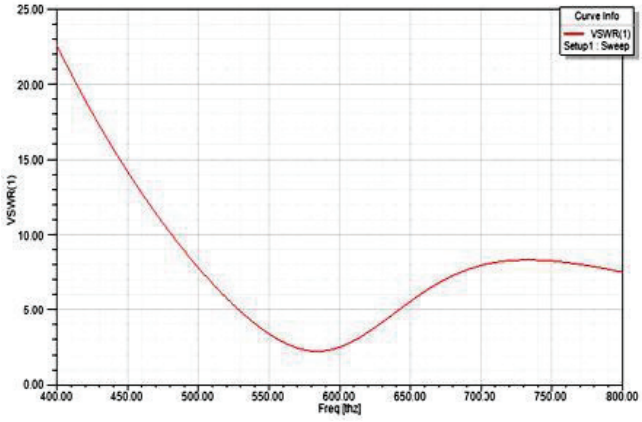

Figure 12: VSWR of Graphene Patch Nano Antenna with Rectangular Slot in Center

3.5 Effect of Slots on Antenna Performance

The effect of the slots on the antenna characteristics such as gain, return loss, VSWR is observed. Use of a slot on the patch's surface affects the radiation characteristics of patch antenna. The operating frequency of the an-tenna is shifted to its lower value due to the presense of slot in the center. The operating frequency is decreased from 610 THz to 590 THz.Operating frequency can be adjusted by incorporating slot of various size. By using slot on rectangular patch a wide bandwidth is achieved. Broadening of antenna bandwidth is achieved because of using slots on patch's surface. But the gain of the antenna is decreased from the maximum gain of 1.53 dB to 1.07 dB due to the presense of slot.

4. Conclusion

Performance analysis of carbon-based nano patch an-tenna is carried out in this research work. Antenna prop-erties of graphene, graphite and copper patch nano an-tenna are compared and the best performance is given by graphene patch nano antenna. Antenna gain of graphene, graphite and copper patch nano antenna is found to be 1.5339 dB, 1.5218 dB and 1.4807 dB respectively. De-pendancy of operating frequency of graphene patch nano antenna on its patch length is modeled and validated with simulation results. Also, performance of graphene sloted patch nano antenna is carried out and broadening

of antenna bandwidth is observed.

5. Acknowledgments

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