Initiation for Information...

The Agrineer 2019

Vol. 6

"Dedicated To All Our Respected Alumni"

An Annual Publication of

Nepal Agricultural Engineering Students' Society (NAESS)

IOE, Purwanchal Campus

Dharan, Nepal

In collaboration with Nepalese Society of Agricultural Engineers

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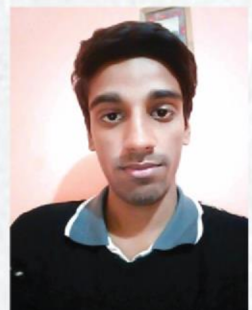

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EDITORAL....

It is the moment of great pride and happiness to come with the fifth volume of our technical journal entitle "The Agrineer". The idea of publishing a new volume of this journal was a real excitement and courage with small time bound. The Agrineer is not just complication of page it is the complication of meaningful pages which carries a knowledge about the different topics of agricultural engineering. It includes research articles and informative articles that benefit all of our agricultural engineering student and related professionals. We aim to correct the short coming of volume-6 in this new edition.

Agricultural engineering are swiftly evolving fields that Integrate the principles of biological and physical sciences and use them to solve agricultural and environmental problems. Engineers in these fields design systems and equipment that increase agricultural productivity and food safety. They also manage and conserve soil, water, air, energy, and other agricultural resources. As an agriculture engineering major, you will learn skills of engineering as they relate to agriculture, food production, and resource conservation.

Agricultural engineers apply their knowledge of biological and agricultural systems and engineering to equipment design and assure environmental compatibility of practices used by production agriculture. This includes all activities related to agriculture and horticulture for smooth functioning and efficient increase of food productivity, improvement in agriculture farm machinery, farm structure, rural electrification, biogas, new technology in the design and manufacture of agriculture products, conservation of soil and water are the major jobs handled by agriculture engineers.

We are thankful to all the seniors, Purwanchal Campus Department of Agricultural Engineering, student's union and campus administration who helped us in every steps of our journey for publishing the journal magazine.

Nepalese Society of Agricultural Engineers (NSAE)

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Message

I am pleased to know that Nepal Agricultural Engineering Students' Society (NAESS) of Institute of Engineering, Purwanchal Campus is publishing its Sixth Edition of Technical Journal, **'THE AGRINEER 2019'**.

Agriculture is the backbone of Nepalese economy where about two thirds of the total population depends on agriculture for livelihood. Likewise, Nepalese agriculture sector covers about one third of total GDP. However, our agriculture is not as modernized and diversified as we expected. In this context, promoting agricultural products through effective commercialization and modernization is main priority of the nation. Moreover, soil conservation, irrigation management, food processing, market management, food security and so on are even focused areas for overall development of agriculture.

Likewise, youths with diversified skills and capacity in agricultural field should be mobilized effectively to reduce brain drain, unemployment and poverty. The application of modern agricultural technologies, mechanization of agriculture and mobilization of related manpower is even required for this. In this scenario, the collaborative effort of NAESS and its team for the publication of technical journal including the information related to agriculture and its role in Nepalese economy is really respective. I hope the publication will further be the source of information for people who keep interest in this field.

Finally, I wish for the success of the publication and the society ahead.

Minister
Chakrapani Khanal 'Baldev'

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June 17, 2019

MESSAGE FROM THE VICE CHANCELLOR

I am happy to know that Nepal Agricultural Engineering Students' Society (NAESS), Purwanchal Campus, Institute of Engineering, Tribhuvan University has come out with its annual technical magazine **THE AGRINEER** (Vol. 6). I am delighted put a few words for the magazine. I feel proud to have such a Students' Society under the Institute of Engineering, TU.

The magazine is focusing on the modern technologies, research works, innovative ideas, and contemporary issues in the field of Agricultural Engineering. This magazine aims to develop a platform for integration of agricultural students, researchers, scientists, academicians, entrepreneurs, and other scientific societies and academic institutions of the country with international societies for promotion of interaction among research workers across the country and abroad. I am sure that this magazine will be a source of knowledge for the students of Agriculture and Agricultural Engineering throughout the nation.

I would like to congratulate the Editorial Board for maintaining the quality of the magazine with publishing high standard research articles and maintaining the regularity of the publication. Finally, I would like to express full support of the university to this society in its endeavors to achieve greater heights in the days to come.

T.R. Khaniya

Prof. Tirth Raj Khaniya, Ph.D.
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Message from the Dean

I am gratified to know that the 'Nepal Agricultural Engineering Students Society' of Institute of Engineering, Purbanchal Campus, Dharan is bringing out 6th Volume of their technical journal **"Agrineer"**.

The Institute of Engineering (IOE) being the centre of excellence for engineering education in Nepal; it has greater role to achieve its goal and provide excellent manpower to the nation. This can be possible only by setting a mission of quality engineering education in the frontier engineering areas relevant primarily to the nation thereby enhancing national development process. I believe this publication will be one of such steps to achieve the national development goal.

The most important aspect we could derive from this stupendous effort is that it brings out the various technical and analytical skills of the promising engineers. I also applaud the coordination and efforts behind the team to bring out this issue. I congratulate all the contributors and the editorial board for bringing out such a beautiful journal and glad to welcome students with more interest in bringing the article with more bright concepts and innovative ideas in the next issue. I wish them to experience victory in all of their future endeavors.

RSapkota
(रामचन्द्र सापकोटा)
सहायक डीन

Institute of Engineering
Office of the Dean

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पू.क्या.फा.नं. ( ) च.नं. 1546/075/076

मिति : २०७६।०३।०३

Message from the Campus Chief

Welcome to Agricultural Engineering Students Society's (NAESS) 'Agrineer Vol-6' a technical magazine published yearly by dedicated expert faculties, and excellent students of Department of Agriculture Engineering of TU, IOE, Purwanchal Campus, Dharan. It's the only campus running bachelor's and master's program of Agriculture Engineering in the country Nepal.

The NAESS publishes technical magazine papers yearly concerned with the advance of agricultural science and the use of land resources. It publishes original scientific work related to strategic and applied studies in all aspects of agriculture science and exploited species.

I wish to express my sincere thanks to the Department of Agriculture Engineering faculties members and the students who took interest in R&D in the fields of agricultural science, and other allied areas.

My biggest appreciation goes to the editorial boards of NAESS. It meets the demand of the engineering in agriculture assisting the students to explore the frontiers of agriculture technology and methods. NAESS is the right platform for fulfilling the scientific agriculture temper and ignite the innovative agriculture methods to achieve excellence in the concern fields.

Finally, and significantly to 'Agrineer Vol-6', is my regards and thoughtful congratulations to the publishers, advertiser, entrepreneurs, and involved organization or industries in this regard.

Campus Chief:

Er. Om Prakash Dhakal

......Dhakal.........

TU, IOE, Purwanchal Campus

Dharan

क्याम्पस प्रमुख
पूर्वाञ्चल क्याम्पस
धरान-८

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प.क्या.फा.नं. । च.नं. 1557/075/076

मिति : 2076/03/04

Message from the Head of TheDepartment

It is my immense pleasure to know the students of Department of Agricultural Engineering are going to publish the"The Agrineer Vol-6", a technical journal under the leadership of Nepal Agricultural Engineering Students Society (NAESS).It is my core belief that this journal helps to disseminate technical knowledge and upgrade the understanding & skills of students in the area of agricultural engineering. Besides this, the journal will be useful to the academia, planner and policy makers in context of Nepal.

I would like to thanks specially the business organizations, entrepreneurs, industrialists who have helped to publish this journal with their financial support. I hope this kind of assistance will be continuing in the future.

Finally, I would like to express my thanks and congratulate to the members of NAESS for their hard work to publishing the journal. I wish the success for the journal and hope the continuation in coming future.

....

(Yam Kumar Rai)
Head of The Department
Department of Agricultural Engineering
Purwanchal Campus, Dharan

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पू.क्या.फा.नं. (   ) च.नं.   मिति :

Dated: 1st Ashad, 2076

MESSAGE FROM DEPUTY Head of Department

It is indeed a great pleasure to express my word in the sixth edition of Agricultural Engineering Students Society's (NAESS) scholarly publication of AGRINEER.I would like to express mine gratitude to the team and functionaries for the positive effort in bringing out the constructive work in the sector of Agricultural Engineering.

The fact of fragmented small land holding capacity and food insecurity in the country, development of Agricultural Engineering plays a vital role towards the contribution towards GDP of country. Focusing on the goal to achieve double digit GDP, Department of Agricultural Engineering concentrates on high crop productivity, farm mechanization, farmshed management, entrepreneurship and advanced water and soil management. The constructive support and encouragement of the team plays a great role for the development and growth of significant role in the sector of Agricultural Engineering.

To overcome the necessity of country: Sustainable Agricultural Mechanization, Paradigm shifts toward Robotics and UAVs, and Socio-Economic transformation is to be focused to overcome the coming days need.

Finally, I would like to congratulate all the positive effort of The AGRINEER team for the commendable scholarly efforts for the contribution to the society.

Sameer Shakya
Deputy Head of Department
Department of Agricultural Engineering.

त्रिभुवन विश्वविद्यालय इन्जिनियरिङ अध्ययन संस्थान पूर्वाञ्चल क्याम्पस, धरान

Regd No. 29/046/047

नेपाल कृषि इन्जिनियर्स सोसाइटी

Nepalese Society of Agricultural Engineers

Message from Chairperson

First academic journal was published in the 17th century, beginning with the Journal des Scavans in 1665 and followed by the Philosophical Transactions of the Royal Society of London, a year later. The importance of a journal as a means of wider disseminating knowledge has grown considerably since then. Journal articles are generally given greater prestige and merit within the scientific community, relative to other forms of disseminating research findings because published journal articles generally have gone through a rigorous screening process known as peer review. Articles published in peer reviewed journals are likely to remain a very important means of distributing research findings for the foreseeable future.

The most advantage of publishing a paper in a journal is an additional point you can provide on your Curriculum Vitae — actually a very important point. The more of these points there are on your CV, the more attractive it will appear to prospective employers, particularly, if those employers are academic institutions who keep their eyes on the ranking in the research arena. Other benefits of publishing article in the journal are that it brings your name out in your professional field, and heightens your academic reputation. Publishing your findings in the journal is particularly important career step but, like all things that are worthwhile, it takes time; it also gets easier with practice. So don't wait any longer. Start writing the journal paper now. This is the message I would like to convey to all my prospective Agricultural Engineers Colleagues.

I am very much pleased to know that Nepal Agricultural Engineering Student's Society Of Purwanchal Campus is publishing a journal "Agrineer" covering wide range of topics of technical, social, economic and environmental importance and related to Agricultural Engineering. I wish all the best!

Devaraj Niraula
Chairperson
Nepalese Society of Agricultural Engineers

Reg. No 1002/964

NEPAL AGRICULTURAL ENGINEERING STUDENTS' SOCIETY
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MESSAGE FROM PRESIDENT

It is a matter of great pride and honour to all of us agricultural engineers to bear witness to the publication of the sixth volume of 'The Agrineer', the flagship journal of agricultural engineering in Nepal.

Agricultural engineering also known as rural engineering, basically deals with design of farm machinery, farmstead, soil and water conservation practices, food processing, smart agriculture, management of water supply and irrigation and design of farm drainage. Though we agricultural engineers have knowledge on these various fields, opportunities are scarce for us. Through this journal the readers would get idea about research activities and related works of us. I hope this journal will be able to change the mindset of policy makers and other relevant stake holders about the importance of agricultural engineers for the advancement of agro-based economy of the country.

I would like to extend my congratulations to the entire team behind the publication of The Agrineer Volume 6 for successful publication of the journal. I am thankful to the team for the efforts shown during the publication of the journal.

I am also indebted to Purwanchal Campus, Department of Agricultural Engineering and Free Students' Union Purwanchal Campus for supporting in the publication of the journal. Lastly, I would like to thank the sponsors and everyone who offered the helping hand during the publication of the journal.

President
Pralad Phuyal

Tribhuvan University
Institute of Engineering
Nepal Agricultural Engineering Students Society
Purwanchal Campus
Dharan-8, Sunsari

Message From The Co-ordinator

It feels immense pride and honored to work as a coordinator of entire family of "The Agrineer volume-6" publishing through NAESS Nepal, Purwanchal Campus.

The journal has tried its almost best to share the researches and knowledge of several engineering experts of Nepal. I believe this journal will provide us the benchmark for continued improvement in overall development of agricultural engineering.

As well know about the country's high dependency on agriculture, this type of document will help not only in transferring the new knowledge and development that are being made in a wider context for the betterment and upgrading the existing technologies and skill. As agriculture is one of the most important sectors of country's development in which agricultural engineering is a very supporting part so the Agrineer, collection of agriculture related research papers, is helpful for all agricultural related persons as I hope.

At last but not least, I would like to express my sincere gratitude and respect to Er. Jawed Alam, Er. Samir Shakya and Er. Sagar Kafle for their advice, suggestions and encouragement. I am heartily thankful to all the advisors, teachers, staffs, professionals, students and everyone who provided their helping hands for this publication. We are indebted by your support and cooperation and expect the same in the future too.

Rupesh Acharya
Co-ordinator, Agrineer Vol. 6

CONTENTS

Acrylamide in Foods & Its Effects on Human Health

Er. Atu1Anand Mishra* Er. KC.Yadav* and Er. R.N. Shukla*

**Assistant Professor, Department of Food Process Engineering, Vaugh School of Agricultural Engineering & Technology, SHIATS, Allahabad Uttar Pradesh, India*

Eating potato chips may seem harmless. However, recent studies have shown that subjecting foods to high temperatures during cooking processes such asfrying could give rise to theformation ofacrylamide, a chemical that causes cancer in ratsand may cause cancer in humans.Several factorsincluding product composition and processingconditions may affect the rate of formation of thischemical in starch rich foods. Low reducing sugarand the amino acid asparagine content is desiredwhen cooking, since the formation of acrylamide isattributed to the Maillardreaction that occursbetween these food components. Scientist's areinvestigating ways ofreducing the formation ofacrylamide in foods without giving up flavor andquality. However, notmany alternatives have beeninvestigated.

Researchers in Europe and the United States havefound acrylamide in certain foods that were heatedto a temperature above 120 degrees Celsius(248degrees Fahrenheit), but not in foods preparedbelow this temperature. Potato chips and Frenchfries were found to contain higher levels ofacrylamide compared with other foods. The WorldHealth Organization and the Food and AgricultureOrganization of the United Nationsstated that thelevels of acrylamide in foods pose a "majorconcern" and that more research is needed todetermine the risk of dietary acrylamide exposure.

Acrylamide is a naturally occurring by-product ofthe cooking process that forms naturally in a widevariety' of foods when they are heated or cooked,including coffee, chocolate, almonds,French-fries,crackers, potato chips, cereal, bread and even somefruits and vegetables. When heated to hightemperatures in the presence of certain sugars,asparagine can form acrylamide. High-temperaturecooking methods, such as frying, baking, orbroiling, have been found to produce acrylamide, while boiling and microwaving appear less likely todo so. Longer cookingtimes can also increaseacrylamide production when the cookingtemperature is above 120 degrees Celsius.

While acrylamide has been present in the humandiet ever since we began cooking withfire, it wasnot known to be in food until 2002 when a group ofSwedish scientists presentedresearch that detectedit in some baked and fried foods. Prior to theSwedish study, food was not analyzed foracrylamide because it was not an added ingredient nor was it known to be a component of food.

No Acrylamideformsnaturally whencarbohydrate-rich foods are fried, toasted or roasted at high temperatures. Acrylamideforms when foods are cooked at home andrestaurants as well as when they are madecommercially. The primary way that acrylamideforms in foods is throughthe reaction of reducingsugars (such as glucose) with free asparagine, anamino acid found in many foods, during thebrowning process. Reducing sugars, asparagine, and other amino acids are all naturally present inmany plant-based foods.

At doses much higher than what is in foods, acrylamide has been found to cause cancer in `laboratory animals. Currently, the U.S. Food and Drug Administration, the World Health Organization and most other health regulatory bodies have not determined that the presence of acrylamide in food presents a health risk to humans and do not recommend that consumers change their diets for the of avoiding acrylamide. Studies are ongoing on this subject. Acrylamide has been around since mankind began cooking with fire and is present in approximately40% of the American diet. As such, there is no single product that has been identified as the main contributor.

More importantly, the World Health Organization concluded that removing my one or two foods from the diet would not have a significant impact on overall exposure to acrylamide. That's why regulatory guidance to consumers regarding acrylamide has focused on recommending that people eat a balanced diet, choosing a variety of foods that are low in trans-fatand saturated fat, and rich in high-fiber grains, fruits, and vegetables. Furthermore, the amount of acrylamide in aparticular food varies based on the natural components of raw materials and cooking conditions. Therefore, removing one food from the diet is unlikely to change overall consumption.

A wide range of carbohydrate-rich products subjected to heating and consequently the “browning Maillard reaction" when flavors, colors, and textures are - generally contain acrylamide. Among the foods that develop acrylamide during the cooking process are coffee, chocolate, almonds, French fries, potato chips, cereal, crackers, bread, and even some fruits and vegetables.

Although the formation of acrylamide in cooked foods are still being studied, a number of leading government food safety authorities around the world advise that consumers eat a healthy and balanced diet, rather than eliminate certain foods. For example, the U.S. Food and Drug Administration (FDA) recommends that the public cat a balanced diet, choosing a variety of foodsthat are low in trans-fat and saturated fat, and rich in high-fiber grains, fruits, and vegetables. Similarly, the World Health Organization (WHO) reinforces general advice on healthy eating, including moderating consumption of fried and fatty foods. The WHO concludes that there is not enough evidence about the amounts of acrylamide in different types of food torecommend avoiding any particular food product.

FDA and other health and scientific organizations are continuing to study acrylamide in food — how it is formed during cooking its effect on health, and how its formation during cooking can be reduced. This research may form the basis for more specific dietary advice and/or federal regulation of specific food products in the future. FDA has explicitly stated, however, thatwarnings about acrylamide in food is not in the public interest at this time. The industry’s acrylamide mitigation efforts are truly global in scope.

The industry has developed a special process using the enzyme, asparaginase, to mitigate acrylamide's natural formation in dough-based foods. This process has been implemented worldwide in every country that has approvedthe process.

Beginning shortly after the announcement in Sweden, there have been extensive studies devoted -to the reduction of acrylamide in foods where possible without changing consumer acceptability of the resulting food product or increasing food safety concerns. Much of this work has been done in the food industries, but also has involved academic and government scientists/technologists. Members of the European food industry freely shared the results of their studies through a collaboration coordinated by the Confederation of the Food and Drink Industry of the EU (CIAA) (now known as Food Drink Europe). Education/mitigation of acrylamide in foods can be approached through (a) removing reactants (fructose, glucose, and asparagine) before the heating process, (b) disrupting the reaction (addition of amino acids, food grade acids, and changing reaction conditions) and (c) removing acrylamide after its formation during heat processing.
The latter approach has not proved to be viable. Efforts, ranging from laboratory through industrial scale, have focused on (a) changing ingredients (decreasing glucose, fructose, asparagine), (b) altering processing conditions (lower heating temperatures, decreased heating time, blanching, use of the enzyme asparaginase), (c) changes in equipment, and (d) agronomic practices (for example storage practices, breeding of cultivars with lower glucose, fructose and/or asparagine content, selection of current cultivars with lower glucose, fructose and/or asparagine contents). Some approaches that have

been used to reduce acrylamide formation in the laboratory or. pilot plant has not yet been successfully scaled to industrial production yet. A relatively recent development has been the use of the enzyme asparaginase, which converts asparagine to aspartic acid. The latter cannot form acrylamide. Asparaginase is commercially produced from *Aspergillusniger* (DSM'sPreventase) or *Aspergillusoryzae* (Novozyme'sAcrylaway).

Both have been approved in several counties for use in reducing acrylamide in selected food products. They are particularly effective in dough products (e.g., cereal products or fabricated chips), but can be applied in soaking (blanching) (e.g., potato strips) where they canreduce asparagine concentrations on the surface. Reduction of acrylamide contents in selected products made from doughs has ranged up to over 90%.

The use of asparaginase is now included in the CIAA Acrylamide "Toolbox". After several years of cooperative research and testing, the results were compiled into the CIAA Acrylamide 'Toolbox," first released in 2005 not a prescriptive manual but giving brief descriptions of intervention steps that have been tried,evaluated, and have been successful in reducing acrylamide formation in specific classes of products. It warns where intervention steps have the potential for producing decreased product quality or acceptance. The Toolbox is meant for individual manufacturers including small and medium size industries. It can also provide useful leads for catering, retail, restaurants, and domestic cooking to aid in the reduction of acrylamide. It allows potential users to access assess and evaluate which reduction measures are appropriate for their product(s).

Currently, there does not appear to be a practical and effective method for completely eliminatingacrylamide from many kinds of products. There is not a single solution that can be applied to all foods. Nevertheless, through research and innovation, the industry is discovering ways to reduce levels of acrylamide in many foods and continues to develop innovative ways to reduce levels even further.

References:

- Food and Agriculture Organization of the United Nations. World Health Organization. *Summary reportof the sixty-fourth meeting of the Joint FAO/WHO Committee on Food Additives (JECFA). 24, 2008, July*
  Retrieved from*http://www.who.int/entity/ipcs/food/jecfa/summaries/sumaryreport 64final.pdf*
- Gertz C, Klostermann S. Analysis of acrylamide and mechanisms of its formation in deep-fried products. *European Journal of Lipid Science and Technology*2002; 104(11):762-771.
- IARC. (1994). Monographs on the evaluation of carcinogenic risks to humans. International Agency for Research on Cancer.Lyon 60, 389.
- Mottram DS, WedzichaBL, Dodson AT. Acrylamide is formed in the Maillard reaction. Nature2002; 419(6906):448-449.
- Rydberg P, Erikson St Tareke E, et al. Investigations offactors that the acrylamide content of heated foodstuffs. *Journal of Apicultural and Food Chemistry* 2003;51(24):7012-7018
- Stadler RH, Blank I, Varga N, et al. Acrylamide from Maillard reaction products. *Nature* 2002;419(6906):449-450
- Zyzak, D., Sanders, R., Stojanovic, M. Tallmadge, D., Eberhart, L., Ewald, D., Gruber, D., Morsch, T., Strothers M., Rizzi, G., &Villagran, M. (2003). Acrylamide formation mechanism in heated foods. Journal of Agricultural and Food Chemistry, 51(16), 47824787.

Building insulation materials based on agricultural wastes

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Abstract

Ecological insulation materials of vegetable raw materials are increasingly widespread. The agricultural wastes can have an interesting role because their use allows the revaluation of agricultural wastes, whose disposal is a serious issue.

This chapter will give an overview about the use of agricultural wastes on building insulating materials. The characteristics and opportunity of common agricultural residues in Nepal has been described. An overview has been given about the properties of bio insulation materials, including thermal conductibility, density, mechanical strength, hygroscopic behavior, fire performance and biodegradation of these materials. The goal is to report a state of the art of building insulation products made of agricultural wastes and residues that are not commercialized.

Keywords: building materials, agricultural wastes, insulating materials

1. Introduction

The current popular insulating materials make use of inorganic insulating materials. These materials have negative side effects from the early stage of production until the end of their useful lifetime. They may be harmful to human health and body and causes environmental pollution (Liang & Chin, 2007). Thermal insulating materials in addition to the properties such as low thermal conductivity, moisture protection, sound insulation, mould and fire resistance, should be environmental friendly. Therefore, there is the need of alternative insulating material with same or better properties as the conventional materials (Asdrubali et.al 2015).

The production of conventional building insulating materials not only consumes large amount of thermal and electrical energy but are also polluting the environment and emptying our natural resources (Panyakaew & Fotios, 2008). On the other hand, the waste generated from agriculture and agro based industries are generally burned or dumped into landfills, the management of these wastes has become a serious challenge and needs attention for the sake our environment and resources.

The major wastes generated from agro based industries are sugarcane bagasse, rice husks, palm shell or leaves, corn cob or stalk, cotton stalks, straw from cereal crops, coconut husk and others (Figure 1) which are creating environment pollution as well as increasing the expenditure of the industries in disposing these wastes. The reuse of such agricultural wastes in building material not only reduces the high cost of production but also promotes the green construction and provides a viable solution to environmental problems (Bjegovic & Roskovic, 2005). These agricultural wastes have high degree of fibrous content (lingo-cellulosic compounds), which serves as a main ingredient for composite materials, making them suitable for manufacturing boards or panels (Kyauta & Justin, 2014). The insulating material made from bio based material are comparable to conventional insulating materials and presents the advantage of being renewable and recyclable with a low embodied energy in the fabric of buildings (M Palumbo et.al., 2018). They are CO_2 neutral or negative and are able to reduce the in-use energy consumption of buildings in more ways than by simply reducing energy transmission. They have the characteristics to buffer heat and moisture, which is most evident in dynamic situations (Wilde & Lawrence, 2013).

Many research have been made on the application of hemp, straw, flax, wood, corn, sunflower and others (Liu et.al., 2017). The large availability of such biomass residues requires through investigation and can be a sustainable approach to address the aforementioned issues.

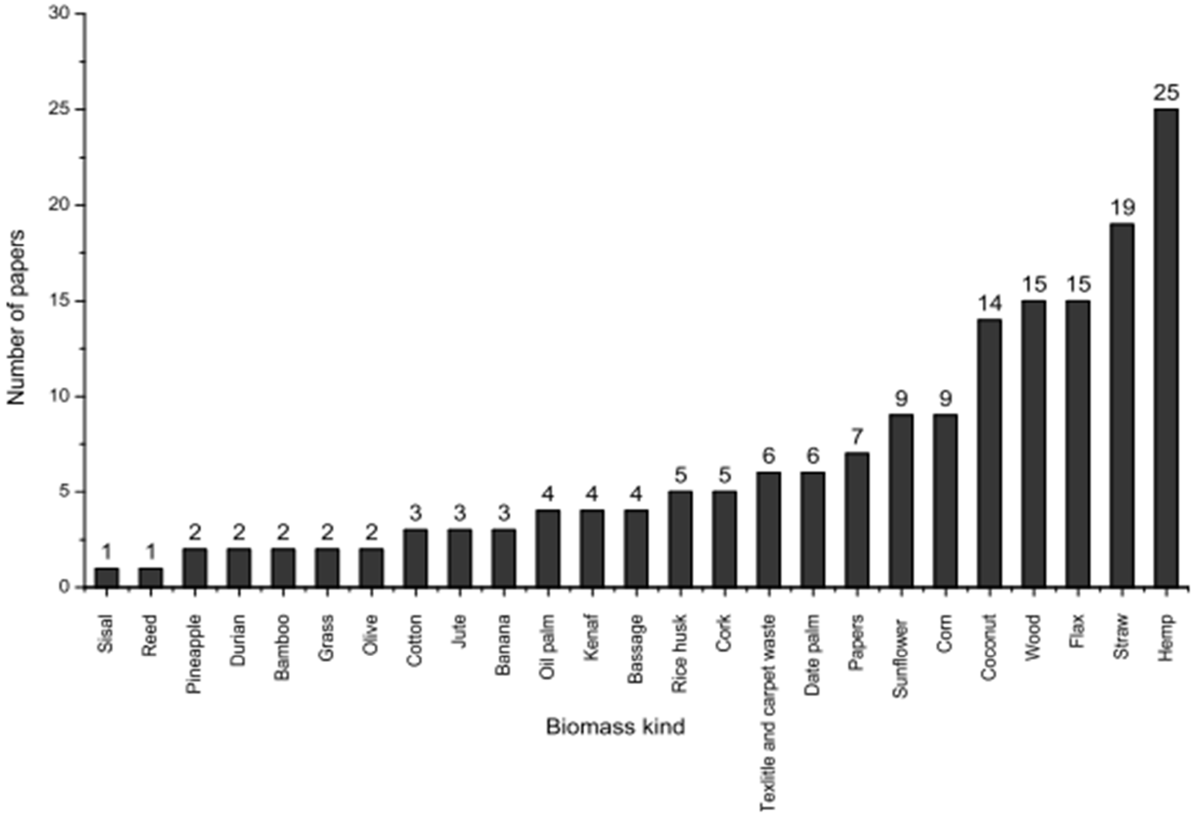

Figure1: Popular biomass under research for the development of building insulating materials. (Liu et al., 2017)

1. Potential Agriculture Biomass for insulating material

The various kinds of biomass are under research. The research depends on the availability of biomass in each country, including forest and agricultural wastes. The most researched and favorable biomasses arestraw, sunflower, hemp and flax. There are several biomasses which need to be recognized and investigated for the development of bio insulations(Liu et al. 2017). Also, there is a need to characterize the properties and structure of raw material, technological features that make influence on thermal conductivity of the material(Vejeliene et.al., 2011).

2.1 Straw bale

Different kinds of agricultural straws such as wheat, corn, barley and rice straws have been considered as building insulating materials since long time due to their hollow structure, low cost, low density and low thermal conductivity. The straw can be used in bulk, loose ground, pressed, tied up, as component in other building material or incorporated into the panels. Straws are widely distributed, cheap and easily available and has the advantage of their use in raw/natural form directly and do not need extra treatments to obtain the final product. Straw stalks are disposed by the farmers after harvesting the edible grains, or are generally burned. Various researches have evaluated the use of straw as straw bale as thermal insulators. Transforming them into straw bales gives them a new life and reduces the pollution resulting from burning. They are 100% bio degradable and can easily recycled back with little or no impact, if they are no longer required.

Building with straw bales are energy efficient, durable and even fire resistant (Ashour et.al., 2011).The density and fire resistance of straw bales is directly proportional. An ideal density of 120 $kg/m^3$was proposed. Thus, with the increase of density of straw bale blocks, the better resistance to fire can be achieved (Bozsaky, 2016). Similarly, Johnsson & Yang, (2008)examined the fire safety of the rendered straw bales, which are used to construct house in rural areas. They performed experiment on the combustion behavior of compacted straw bale with a render layer of about 45 mm on all sides exposed to two radiant heat flux regimes, a) 30 kWm^{-2} for 30 min and b) 50 kWm^{-2} for 40 min. The render materials were earth based and lime based. The straw bale survived an externally imposed heat flux of 30 $kWm^{-2}$for 30 minute with little damage to render layer and no ignition of the straw within the bale. The 50 $kWm^{-2}$for 40 minute initiated ignition of the straw, 24 hour after the end of the exposure regime, consuming the entire straw bale over 11 days. Hence, the render contributes to fire safety of straw bale construction by providing an insulating barrier between heat source and the straw and also providing a barrier to oxygen transfer from the atmosphere into the straw(Ashour et al. 2011).

The straw fiber aids in decreasing the thermal conductivity. In an experiment with three types of fibers, wheat straw, barley straw and wood shavings, the thermal conductivity of all material decreased with increasing straw fiber content. The straw fiber has greater effect on the change of thermal conductivity. Also, the barley straw fibers have the highest thermal conductivity (Ashour et.al., 2010). Vejeliene et al. (2011) studied the influence of macro and micro structural analysis of the straw bales on thermal conductivity. The macro – structure has the greatest effect on thermal conductivity of materials which is determined by the formation of the bale. Chaussinand et.al., (2015) analyzed the thermal behavior and energy performance of a straw bale building to mitigate overheating risks due to low heat capacity of straw. From the thermal dynamic results and LCA, it was concluded that the straw bale can be a sustainable alternative in the energy evolution of building construction due to its low embodied energy and excellent thermal performance.

2.2 Corn stalk

(Bozsaky, 2016)investigated the density, dimensional stability, water absorption, compressive, tensile and flexural strength, thermal conductivity and dynamic stiffness of chopped corn stalks and synthetic resin. It was shown that the thermal conductivity and sound insulation quality is inversely proportional to density, raise of temperature and water content. The change in thermal conductivity was twice intensive as change in water content under 10° C and three times intensive under 30°C when the limit of natural water was exceeded to 6-14% m/m. The dimensional stability of corn stalk insulating board was comparable with the standards for thermal insulating materials; however under extreme conditions, the dimensional stability result were not good enough but was better than the requirements of plastic foams. Corn stalks are sensitive to moisture. The water absorption with 24 hours particular dipping is high, 4.82 kg/m^2.

(Bozsaky, 2016)in the study of corn stalk demonstrated the compressive strength better than the compressive strength of rock wool and fiberglass and very similar to the same parameters of natural materials like cork, fiberboard and wood. The tensile strength of corn stalk is equal or much better than the natural materials and is very close to the tensile strength of artificial materials.

2.3 Rice Hull/ Rice hull ash / Rice straw

The world is producing more than 780 million metric tons of rice. China and India are producing more than 210 and 166 million metric tons of rice respectively. And nearly 482 million metric tons of rice husk were produced in 2017 worldwide (FAO, 2018).Rice hulls are solid waste materials with potential for use as building thermal insulation. The apparent thermal conductivity measured according to the procedures of ASTM as conducted by was between 0.046-0.057 W/m K at 24°C at an average density of 149 kg/m^3(Yarbrough et.al 2005).Panyakaew & Fotios, (2008) demonstrated that the rice husk can be made into hard, high density board without the use of chemicals binders.

The growing abundance of rice hull is a continuing environmental concern. The rice husk after refining is generally burnt. The effort to convert this waste into useful products such as building insulating materials would be an appropriate initiative (Kumar et.al. 2012). The rice hull ash contents 60 to 80% silica. This ash can be used as thermal insulating materials and a substitute for asbestos and organic polymer materials, as it reflects acceptable mechanical strength (145-196 $N.cm^{-2}$) and thermal conductivity (0.103-0.128 $Wm^{-1}K^{-1}$) respectively(Kalapathyet.al.2003).

1. Properties of building insulating material

Use of thermal insulation material developed from vegetable fibres offer a reduction in resource use, promotes recycle of wastes and reduces the dependency on toxic chemical types in wood/cellulose based insulators (Kyauta & Justin, 2014).

3.1 Thermal Conductivity

The ability of the material to store and transfer heat is defined by thermal conductivity, thermal diffusivity and specific heat capacity of the material. Accurate values of these properties areessential for modelling of insulating materials(Toman & Erný, 2001). If a thermal insulating material has a low thermal conductivity (K), it is possible to design a relatively thin building envelopes with a high thermal resistance R- value and a low thermal transmittance U – value (Petter, 2011).Thermal conductivity is a function of material mean temperature and moisture content(Al-homoud, 2005). The value of K for any material will become higher with the increase in temperature, however the increase in temperature should be significant for this to occur and the temperature variants in most buildings are generally within the tolerances that would render any change in the K value negligible (Mark Wilson, 2013). Knowledge of the thermal conductivity values allows quantitative comparison to be made between the effectiveness of different thermal insulation materials(Al-homoud, 2005). A material is usually considered as a thermal insulator if its conductivity is lower than 0.07 W/mK (Asdrubali et al. 2015).

Low thermal conductivityof insulation material plays an important role in the design of energy efficient houses and guarantees a high level of thermal insulation and low consumption of energy, to maintain the internal temperature(Toman & Erný, 2001). The thermal conductivity values of building insulation materials are generally given at 24°C according to ASTM standards. However, the realistic thermal values can differ from the reference values and the overall thermal behaviour of the building can differ from the designed conditions as the building envelope is exposed to significant and continuous temperature change due to changes in outdoor temperature and solar radiation(Khoukhi & Tahat, 2015).

(Bozsaky, 2015)analysed the relationship between thermal conductivity and water content during his laboratory test with liquid nano-ceramic thermal insulation coating according to European Standards (EN) and came to a conclusion that the difference between conductivity in dry condition and with a water content of 12% m/m is unnoticeable. Above this limit, they observed the linear relationship between thermal conductivity and moisture content. Hence, it was proved that the thermal conductivity is directly proportional to moisture content after a limit of 12% m/m. The moisture content of 12% was termed as natural water content which has no effect on thermal conductivity. The similar results have been presented in the experiment performed by(Abdou & Budaiwi, 2005).

(Kyauta & Justin, 2014) investigated the agricultural waste such as rice husk, bagasse and corncob in varying composition to determine their use as insulators; they proposed the best mix with 60% rice husk, 20% corncob and 20% bagasse with thermal conductivity 0.231 $Wm^{-1}k^{-1}$. Further, M & Justin (2014) concluded that the increase in thermal resistivity of a material will lower thermal conductivity thereby making a suitable insulation material. The thermal resistance of rice husk is 0.59 m^2K/W, in the same order of magnitude to recycled materials such as cork scarps, coffee chaff, waste paper, and textile fiber mats (Buratti et.al.2018). The thermal conductivity is also influenced by the orientation and size. Gailius & Vaitkus, (2011) in the experiment with straw stalks, observed minimum thermal conductivity when the straw stalks areoriented perpendicular to heat flow, and highest conductivity, when oriented parallel to heat flow. However, the thermal conductivity of chopped straw remains same or declines slightly.

3.2 Density

A high density material maximises the overall weight and is an aspect of low thermal diffusivity and high thermal mass (Saulles, 2009). The density of the insulation material is characterized as an important property of the material as it has direct influence on thermal conductivity. The solid state thermal conductivity (K_{solid})and radiation thermal conductivity (K_{rad}) of insulation materials are influenced by density. The higher is the density, higher is the $K_{solid}$and lower K_{rad}(Papadopoulos, 2005).Gailius & Vaitkus, (2011) mentions the densification of the straw by pressing which increases the thermal conductivity.

As the stem wall of the straw is porous, pressing of the straw, improves the contact between the individual straws. With the increase of density by 2 times, the thermal conductivity increases by approximately 2.5 times.When straws are chopped to 2 to 4 cm long,density has no effect on thermal conductivity. They demonstrated lower thermal conductivity for chopped straw than with the entire stalk.Wang & Sun, (2002) in the experiment of low density particle boards made from a mixture of wheat straw and corn pith showed that the equilibrium moisture content is not affected by the density of the sample.

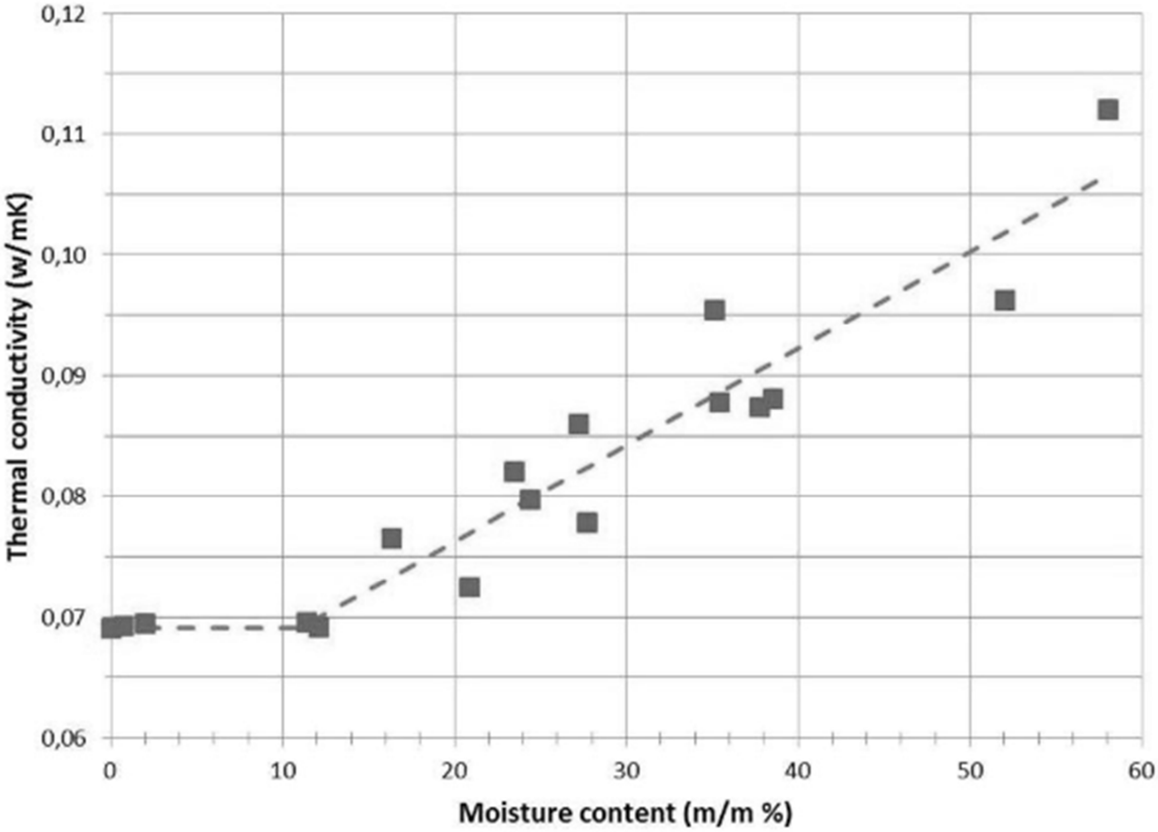

Figure 3: Relationship between thermal conductivity and moisture content(Bozsaky, 2015)

3.3 Fire Performance

Zach et.al.(2013)mentions poor resistance to fire as a drawback of using agricultural wastes for thermal insulation. The natural fibres are prone to biological attacks such as fungi and parasites, which is a major drawback in their flammability. Hence, insulating materials based on natural fibres shows reaction of fire within fire "F class". The fire resistance can be effectively improved by fire retardants and by building these natural materials into structures with fireproof finishing such as plaster or facing(Korjenic & Petránek, 2011).

The flammable insulating fibres require treatment before installation to achieveacceptable levels of combustion and smouldering resistance. The flammable substance for instance volatile compounds should be removed from bio insulation so as to increase the critical combustion temperature (Liu et. al. 2017).The additives such as aluminium sulphate, aluminium trihydrate, ammonium phosphate and ammonium sulphate are used(Lopez et. al., 2016).Day and Wiles (1978) studied the influence of borax and boric acid on the resistance of cellulose insulation to flaming and smouldering combustion. Several researches had proved that toxic flume is one of the most important reason in fire deaths, thus, while selecting a building insulation, both the ignition temperature and the production of smoke should be considered (Schiavoni et.al., 2016).

3.4 Hygroscopic behaviour

Bio based material have the capacity of adsorbing and desorbing of water vapour, contributing to moderate extremes of humidity in indoor environments (Osanyintola & Simonson, 2006). Thermal conductivity, equilibrium moisture content and water vapour permeability are the three main characteristics that need to be evaluated as an input data for simulation programs(Korjenic & Petránek, 2011). (Zach et al. 2013) mentions water absorption as a drawback of using natural materials for thermal insulation. The application of hydrophobic treatment can be helpful in reduction of absorbability; however, this requires further research.

Palumbo et al. (2016)determined the hygrothermal properties of six bio based insulation materials based on hemp, wool, wood, barley straw, corn pith. Their analysis revealed remarkable differences in the hygrothermal properties. They demonstrated the influence of relative humidity on thermal conductivity, thermal diffusivity and water vapour permeability of different material. The experimental moisture buffer values obtained werecompared with numerical simulations obtained from dynamical model. The thermal conductivity coefficient generally increases with higher humidity. Similarly,(Korjenic & Petránek, 2011)with an experiment on technical hemp fibres, flax and jute, demonstrated the high rise in measured thermal conductivity with the increasing moisture content of samples. The measured values are 2-3.5 times higher compared to normalised value.

The natural materials mostly exhibit higher moisture sensitivity, which is problematic if the material is exposed on a long-term basis to an environment with high humidity or if it is in contact with liquid water. Hanna & Anna, (2008)in the study of bast fibers of Flax and hemp as insulation materials, suggests for the adoption of careful procedures during harvesting, processing, manufacturing, building and maintenance of buildings to avoid the risk of negative effects such as moulding caused by moisture and free water. Further, product development of bast-fibrous thermal insulations, the use of additives are evidently desired in order to avoid undesirable effects on indoor air quality. Liu et al.(2017)suggest coating the surface of bio insulations with a water proof film or adding water repellent to improve water proof / resistance ability.

1.5 Biodegradation

Renewable fibrous thermal insulation from agricultural wastes has the ability to regenerate itself and it requires less energy for production and biodegrade easily when disposed as waste, hence have low environmental impact (Kyauta & Justin, 2014). As an alternative to traditional insulating materials, the fiber from coconut, sugarcane, cotton, wheat straw, palm leaves, oil palm fiber and others consist of lignocelluloses fibers. They are biodegradable, renewable, environmentally friendly building thermal insulators(Zhou et. al., 2010). (Hanna & Anna, 2008; Korjenic & Petránek, 2011)suggest the use of bast fibers ofFlax and hemp for insulation due to their comparable thermal properties and some ecological features i.e. biodegradability.

Organic and inorganic binders are used to increase the thermal conductivity of the final product. The binders have the drawback that they emit volatile organic matters that influence the indoor environment of the house. All these binders increase the embodied energy and prevent biodegradability of the final product, causing problems of waste disposal or recycling. Palumbo et.al., (2014)suggest the use of natural binders such as starch or casein as alternative to overcome these problems. The developed panels from natural binders are light, formaldehyde free and completely biodegradable.

3.6 Mechanical Strength

The agricultural wastes such as rice hulls, sugarcane stalks, coconut husk, corn cob or stalk, oil palm shell and leaves or straw from cereal crops has the possibility to use a raw material for producing insulating materials as they possess high degree of fibrous content i.e. lingo-cellulosic compound (Kyauta & Justin, 2014).The mechanical properties such as the compressive, tensile and bending strength, modulus of rupture(MOR), modulus of elasticity (MOE), IBS, tensile strength, impact strength of insulation block need to be determined. The verification of compressive strength has gained more interest of most of the researchers (Liu et al. 2017). However, natural fibers have a risk for microbial and other contaminants; their quality should be monitored regularly. Multi-layer structure should be adopted as some specific layers play the role of microorganism's prevention. The eggs of microbes can be removed by high temperature sterilization processes and adding antiseptics into bio insulations(Liu et al. 2017).

2. Conclusion

The agro-industrial residues can be used in the development of composite material for use in construction industry. The by-products of agriculture can be a suitable alternative for the development of building insulating materials, which are helpful in solving the issues related to heat and sound insulation and moisture management.The bio based materials are easy to obtain and the production process are simple. The replacement of mineral based insulation materials with bio based renewable insulation is essential to meet the targets of carbon reduction as biomass based construction materials sequester carbon dioxide and reduces the environment load and makes everything as required.

References:

Abdou, A., & Budaiwi. (2005). Comparison of Thermal Conductivity Measurements of Building Insulation Materials Journal of Building Physics. *Journal of Building Physics*, *29*(September 2014). https://doi.org/10.1177/1744259105056291

Al-homoud, M. S. (2005). Performance characteristics and practical applications of common building thermal insulation materials. *Building and Environment*, *40*, 353–366. https://doi.org/10.1016/j.buildenv.2004.05.013

Asdrubali, F., Alessandro, F. D., & Schiavoni, S. (2015). Sustainable Materials and Technologies A review of unconventional sustainable building insulation materials. *Sustainable Materials and Technologies*, *4*(2015), 1–17. https://doi.org/10.1016/j.susmat.2015.05.002

Ashour, T., Georg, H., & Wu, W. (2011). Performance of straw bale wall: A case of study. *Energy and Buildings*, *43*(8), 1960–1967. https://doi.org/10.1016/j.enbuild.2011.04.001

Ashour, T., Wieland, H., Georg, H., Bockisch, F. J., & Wu, W. (2010). The influence of natural reinforcement fibres on insulation values of earth plaster for straw bale buildings. *Materials and Design*, *31*(10), 4676–4685. https://doi.org/10.1016/j.matdes.2010.05.026

Bjegovic, D., & Roskovic, R. (2005). Role of mineral additions in reducing CO2 emission. *Cement and Concrete Research*, *35*(11), 974–978. https://doi.org/10.1016/j.cemconres.2004.04.028

Bozsaky, D. (2015). Laboratory Tests with Liquid Nano-ceramic Thermal Insulation Coating Laboratory tests with liquid nano-ceramic thermal insulation coating. *Procedia Engineering*, *123*(December), 68–75. https://doi.org/10.1016/j.proeng.2015.10.059

Bozsaky, D. (2016). *New thermal insulation material from agricultural waste product*.

Buratti, C., Belloni, E., Lascaro, E., Merli, F., & Ricciardi, P. (2018). Rice husk panels for building applications : Thermal , acoustic and environmental characterization and comparison with other innovative recycled waste materials. *Construction and Building Materials*, *171*, 338–349. https://doi.org/10.1016/j.conbuildmat.2018.03.089

Chaussinand, A., Scartezzini, P. J. L., & Nik, V. (2015). Straw bale : A waste from agriculture , a new construction material for sustainable buildings. *Energy Procedia*, *78*, 297–302. https://doi.org/10.1016/j.egypro.2015.11.646

FAO. (2018). FAO Rice Market Monitor (RMM), Volume XXI, Issue No. 1. *FAO. Rice Market Monitoring*, *XXI*(1).

Gailius, A., & Vaitkus, S. (2011). Development of thermal insulation from local agricultural waste. In *Development of thermal insulation from local agriculture waste*.

Hanna, K., & Anna, S. (2008). Flax and hemp fibres as raw materials for thermal insulations. *Building and Environment*, *43*, 1261–1269. https://doi.org/10.1016/j.buildenv.2007.03.006

Johnsson, E., & Yang, J. C. (2008). Experimental study on tire fire penetration into a motorcoach. *Fire and Materials*, *32*(March), 259–279. https://doi.org/10.1002/fam

Kalapathy, U., Proctor, A., & Shultz, J. (2003). Silicate Thermal Insulation Material from Rice Silicate Thermal Insulation Material from Rice Hull Ash. *American Chemical Society*, *42*(February), 46–49. https://doi.org/10.1021/ie0203227

Khoukhi, M., & Tahat, M. (2015). EFFECT OF TEMPERATURE AND DENSITY VARIATIONS ON THERMAL CONDUCTIVITY OF POLYSTYRENE INSULATION MATERIALS IN OMAN CLIMATE. *Journal of Engineering Physics and Thermophysics*, *88*(4), 960–964. https://doi.org/10.1007/s10891-015-1275-6

Korjenic, A., & Petránek, V. (2011). Development and performance evaluation of natural thermal-insulation materials composed of renewable resources. *Energy and Buildings*, *43*, 2518–2523. https://doi.org/10.1016/j.enbuild.2011.06.012

Kyauta, D., & Justin, E. (2014). Investigation on Thermal Properties of Composite of Rice Husk , Corncob and Baggasse for Building Thermal Insulation. *American Journal of Engineering Research (AJER)*, *03*(12), 34–40.

Liang, H., & Chin, M. (2007). Toxicity characteristics of commercially manufactured insulation materials for building applications in Taiwan. *Construction and Building Materials*, *21*, 1254–1261. https://doi.org/10.1016/j.conbuildmat.2006.05.051

Liu, L., Li, H., Lazzaretto, A., Manente, G., & Tong, C. (2017). The development history and prospects of biomass-based insulation materials for buildings. *Renewable and Sustainable Energy Reviews*, *69*(July 2016), 912–932. https://doi.org/10.1016/j.rser.2016.11.140

Lopez, P., Rouilly, A., Vandenbossche, V., & Raynaud, C. (2016). A review on the properties of cellulose fi bre insulation. *Building and Environment*, *96*, 170–177. https://doi.org/10.1016/j.buildenv.2015.09.031

Osanyintola, O. F., & Simonson, C. J. (2006). Moisture buffering capacity of hygroscopic building materials : Experimental facilities and energy impact. *Energy and Buildings*, *38*, 1270–1282. https://doi.org/10.1016/j.enbuild.2006.03.026

Palumbo, M., Lacasta, A. M., Giraldo, M. P., Haurie, L., & Correal, E. (2018). Energy & Buildings Bio-based insulation materials and their hygrothermal performance in a building envelope system (ETICS). *Energy & Buildings*, *174*, 147–155. https://doi.org/10.1016/j.enbuild.2018.06.042

Palumbo, M., Lacasta, A. M., Holcroft, N., Shea, A., & Walker, P. (2016). Determination of hygrothermal parameters of experimental and commercial bio-based insulation materials. *Construction and Building Materials*, *124*, 269–275. https://doi.org/10.1016/j.conbuildmat.2016.07.106

Palumbo, M., Navarro, A., Avellaneda, J., & Lacasta, A. M. (2014). Characterization of thermal insulation materials developed with crop wastes and natural binders. In *In WSB14 World Sustainable Building Conference, GBC, Barcelona (pp. 28-30).* (pp. 28–30).

Panyakaew, S., & Fotios, S. (2008). Agricultural Waste Materials as Thermal Insulation for Dwellings in Thailand : Preliminary Results. In *PLEA 2008 – 25th Conference on Passive and Low Energy Architecture, Dublin*.

Papadopoulos, A. M. (2005). State of the art in thermal insulation materials and aims for future developments, *37*, 77–86. https://doi.org/10.1016/j.enbuild.2004.05.006

Petter, B. (2011). Traditional , state-of-the-art and future thermal building insulation materials and solutions – Properties , requirements and possibilities. *Energy and Buildings Journal*, *43*(7465), 2549–2563. https://doi.org/10.1016/j.enbuild.2011.05.015

Saulles, T. (2009). Thermal Mass Explained. *Thermal Mass Explained: The Concrete Centre*. Retrieved from www.mineralproducts.org

Schiavoni, S., Alessandro, F. D., Bianchi, F., & Asdrubali, F. (2016). Insulation materials for the building sector : A review and comparative analysis. *Renewable and Sustainable Energy Reviews*, *62*, 988–1011. https://doi.org/10.1016/j.rser.2016.05.045

Toman, J. A. N., & Erný, R. Č. (2001). Determination of changes in thermal properties of building materials in the conditions of a fire jan toman, robert č erný. *CIB World Building Congress*, (April), 1–11.

Vejeliene, J., Gailius, A., Vejelis, S., Vaitkus, S., & Balčiunas, G. (2011). Evaluation of structure influence on thermal conductivity of thermal insulating materials from renewable resources. *MATERIALS SCIENCE*, *17*(2), 208–212. https://doi.org/10.5755/j01.ms.17.2.494

Wang, D., & Sun, X. S. (2002). Low density particleboard from wheat straw and corn pith. *Industrial Crops and Products*, *15*, 43–50.

Wilde, D., & Lawrence, M. (2013). Hygrothermal performance of bio-based insulation materials. In *Proceedings of the Institution of Civil Engineers: Construction Materials. ISSN 1747-650X (In*.

Zach, J., Hroudová, J., Brožovský, J., Krejza, Z., & Gailius, A. (2013). Development of Thermal Insulating Materials on Natural Base for Thermal Insulation Systems. *Procedia Engineering*, *57*, 1288–1294. https://doi.org/10.1016/j.proeng.2013.04.162

Zhou, X., Zheng, F., Li, H., & Lu, C. (2010). An environment-friendly thermal insulation material from cotton stalk fibers. *Energy & Buildings*, *42*(7), 1070–1074. https://doi.org/10.1016/j.enbuild.2010.01.020

STUDY OF SOCIO-ECONOMIC STATUS AND AGRICULTURAL PRACTICES OF GINGER/TURMERIC CULTIVATING FARMERS

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ABSTRACT

Socio-economic status (SES) is a combined measurement of economic and social position of an entity compared to others in society. Different variables from 86 respondents were accessed by random sampling through structured questionnaire to obtain SES.This research is truly based on the primary data whose goal is to understand the status and existing cultivation practice of ginger and turmeric production in the Bishnupaduka. SES shows that majority of farmer on that belt are dependent on agriculture and mostly on ginger/turmeric cultivation. The average number of family member of that pocket area is 5.1. Ginger /Turmeric had been cultivated on 52.13% of total land holdings. Productivity of Ginger is found to be 165 kg/kattha and Turmeric (in suttho form) is found to be 35 kg/kattha. The market value of Ginger/Turmeric is found to be increasing in past three years. The average annual income of a family from ginger/turmeric production is found to be 75907.13 NRs only. 95% of the families have their family member employed abroad. Due to lack of adequate knowledge, generalized thinking, traditional methods, proper training, soil testing and cultivation practices; there is low production from agriculture in Nepal. Hence, it is great need for these problems to be addressed so that farmers will taste the sweet buds of their hardships & thereby serving for socio-economic uplift of farmers.

Keywords: socio-economic status, farmers, income, production

1. Introduction

Agriculture is the backbone of Nepalese people's livelihood. Majority of Nepalese farmers are constrained to adopt subsistence agriculture practices although there is varying land topography, small and marginal land holdings and lack of infrastructure and investment (Pradhan et al., 2016). The average land holding per family across Nepal is found to be less than 0.8 hectare. Because of small land size, unavailability of the other employment opportunities in the country, majority of farmers in the country are compelled to adopt subsistence agriculture (Shrestha, 2011). According to census 2011 population of Nepal is 26.5 million. The average household size recorded by the census of 2011 is 4.9. Household size is decreasing these days. It was 5.6 in 1991 and 5.4 in the 2001 census. Sex ratio in the

1981 census was 105, which is equivalent to theoretical sex ratio at birth and it began to decrease from 1991. It was 99.5 in 1991 and 99.8 in 2001 and came down to 94 in 2011. The literacy rate is 65.9% in Nepal based on the 2011 census. The gender gap is wider in literacy, which is 75.1% for males and 57.4% for females with a difference of about 18 percentage points (Gurung, 2015) .

Turmeric has been used as a medicine, a condiment and a dye since at least 600 B.C. while ginger has been used extensively throughout history for its medicinal purposes (Nair, 2013). Ginger/turmeric is an essential spice for the Nepalese households and is listed as one of the top five major spice crops in Nepal ("HoS in India," 2013). The cultivation practice adopted for ginger is ploughing of land 4 to 5 times or dug thoroughly with receipt of early summer showers to bring the soil to fine tilth. Beds of about 1 m width, 30 cm height and of convenient length are prepared with an inter-space of 50 cm in between beds. In the case of irrigated crop, ridges are formed 40 cm apart. In areas prone to rhizome rot disease and nematode infestations, solarization of beds for 40 days using transparent polythene sheets is recommended. Ginger is cultivated as rain fed crop in high rainfall areas (uniform distribution for 5 to 7 months) and irrigated crop in less rainfall areas where distribution is not uniform. Ginger requires 1300-1500 mm of water during its crop cycle (Jayashree et al., 2014). Similarly for turmeric, the land is prepared with the receipt of early monsoon showers. The soil is brought to a fine tilth by giving about four deep ploughings. Immediately with the receipt of pre-monsoon showers, beds of 1.0 m width, 30 cm height and of convenient length are prepared with spacing of 50 cm between beds. Planting is also done by forming ridges and furrows. Small pits are made with a hand hoe on the beds with a spacing of 25 cm x 30 cm. Pits are filled with well decomposed cattle manure or compost seed rhizomes are placed over it then covered with soil. The optimum spacing in furrows and ridges is 45-60 cm between the rows and 25 cm between the plants (Kumar et al., 2015).

2. OBJECTIVES

- To find out the socio-economic status of ginger/turmeric cultivating farmers.
- To study the existing practices of cultivation of ginger/turmeric.

3. METHODOLOGY

- **Study Area**

  Bishnupaduka is one of the ward of Dharan Sub-Metropolitan City in Sunsari district in province no. 1 of Nepal. It is situated at foothills of Mahabharatrange. The population of study area is 3391 and comprises 794 households. The total area of Dharan-20, Bishnupaduka is 48.72 km^2. Bishnupaduka temple is located in our study area which is one of the religious places of Dharan.

- **Random sample size determination: -**

  The sample size calculation is given below: -
  Sample size (n) = $(N*X)/(X+N-1)$
  $=(794*96.04)/(96.04+794-1)$
  $= 85.77 \approx 86$
  Where,
  X = $(Z\alpha/2)^2 * p * (1-p)/(MOE)^2$
  $= 1.96^2 * 0.5 * (1-0.5)/ (0.1) *2$
  = 96.04
  MOE = Margin of error = 10%
  N = Population size = 794

P = Sample proportion = 50%

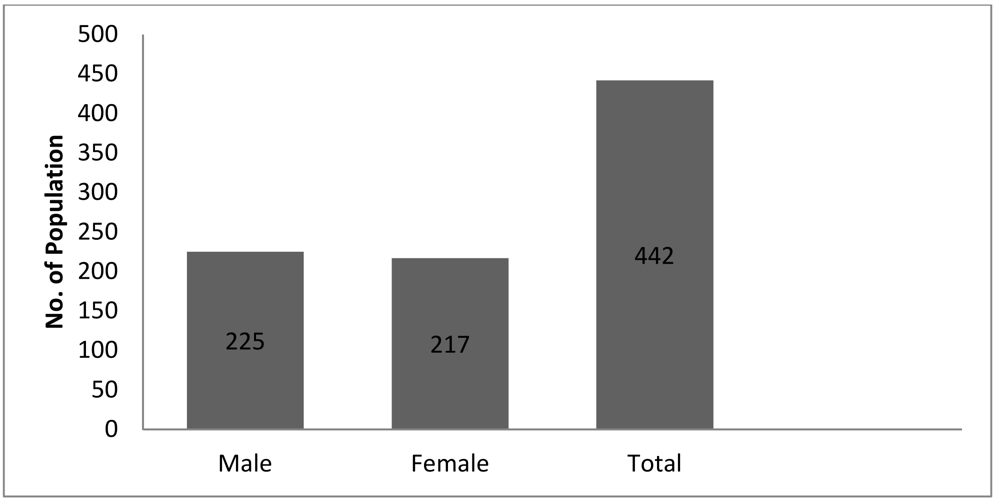
At 95% confidence limit, $Z\alpha/2=1.96$ Source: (Daniel, 2009)

- **Questionnaire survey**

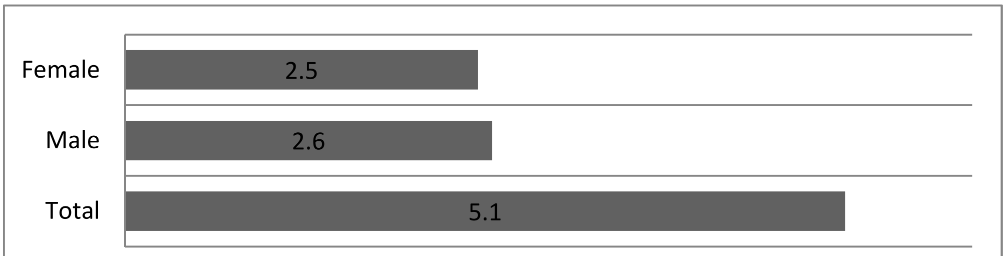
We had visited our selected site and collect information related to the social status of farmers, cultivation practice, use of fertilizer and pesticides, its yield, market, market value etc. through the means of structured questionnaire to the farmer. Due to lack of time and difficult geographical condition of study area, random sampling was done with 10% margin of error.

4. Socio Economic Analysis:

- **Population**



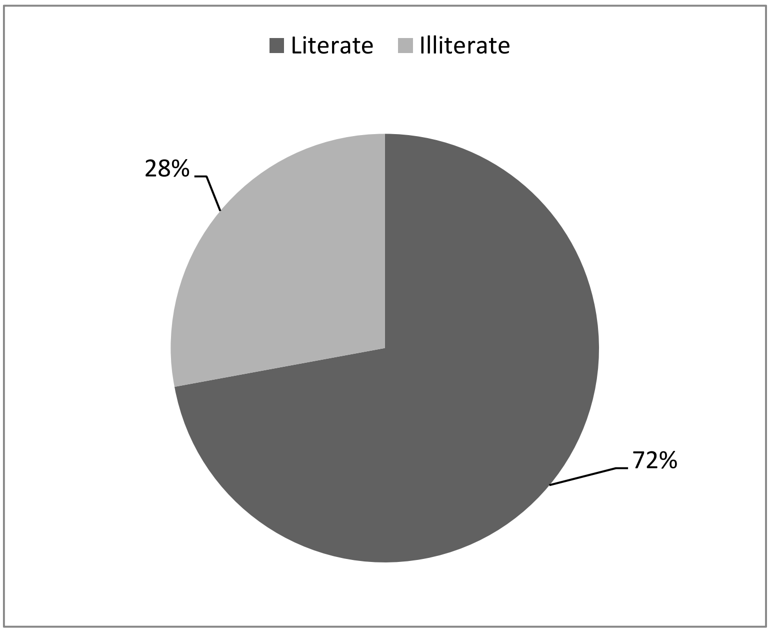
The number of households involved in the survey was 86 which comprises of 442 numbers of peoples. The male population was 225 and female population was 217.



	Total	Male	Female
Average number of family member	5.1	2.6	2.5

The family of household comprises an average of 5.1 total family member, 2.6 male family members and 2.5 female family members.

➢ Literacy



The data shows that out of total farmer respondents 27.9% farmers were illiterate and 72.1% farmers were literate.

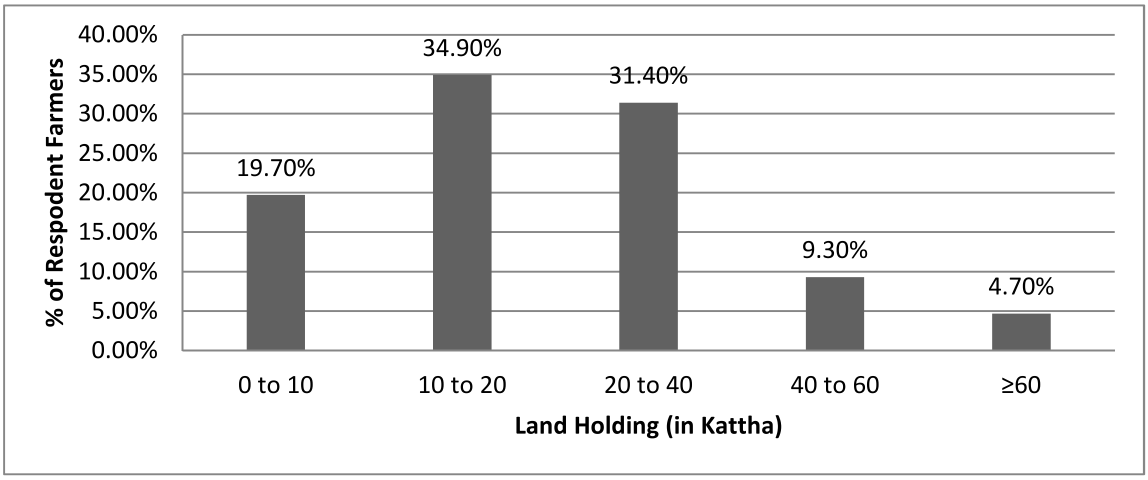
➢ Land Holdings of surveyed House Hold

From the land holding tableshown below, it was found that the range of land holding was from 2.5 kattha (minimum) to 80 kattha (maximum) with an average of 21.05 kattha. It was found that maximum farmer has land holdings within the range of 10-20 kattha.

Total No. of respondents	Min. Land Holding(B-K-D)	Max. Land Holding(B-K-D)	Total Land holding(B-K-D)	Average Land Holding(B-k-D)
86	0-2-10	4-0-0	90-9-14	1-1-1

From the table below, it was found that maximum farmer has land holdings within the range of 10-20 kattha.

Land holding (kattha)	0-10	10-20	20-40	40-60	>60
No. of household	17	30	27	5	4
% household	19.7 %	34.9 %	31.4 %	9.3 %	4.7 %



From the chart, it indicates that the large number of farmers (34.9%) had land holding from 10 to 20 kattha, 31.4% of them had land holding from 20 to 40 kattha, 19.7% had 0 to 10 kattha, 9.3% had 40 to 60 kattha and 4.7% had equal & more than 60 kattha.

- **Cultivated Land for Ginger/Turmeric**

The area of land used for ginger/turmeric cultivation is shown in tablebelow:

Name of crop	Cultivated area (in B-K-D)
Ginger	10-15-6
Turmeric	36-8-1
Total Cultivated	47-3-7

$\%\ cultivation\ for\ ginger\ \&turmeric$ is given by

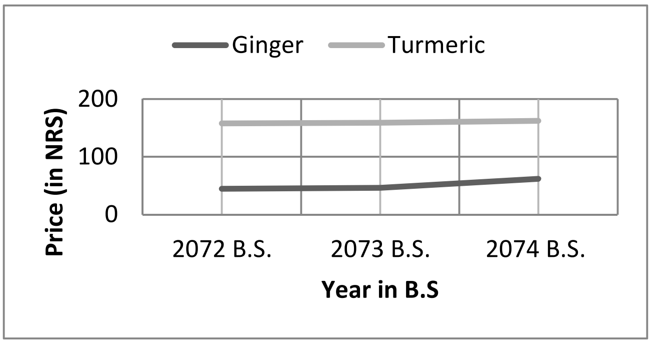
$$= \frac{Total\ cultivated\ land}{Total\ land\ holding}$$

$$= \frac{18867\ dhur}{36194\ dhur}$$

$=52.13\ \%$

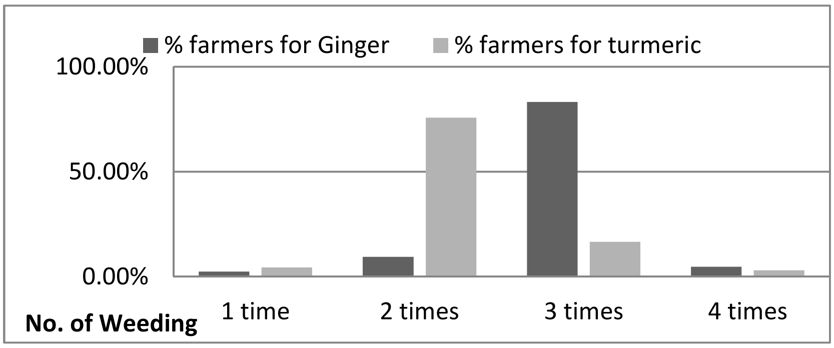
Out of total land holding of surveyed households, ginger/turmeric had been cultivated on 52.13% of land.

- **Market Value**



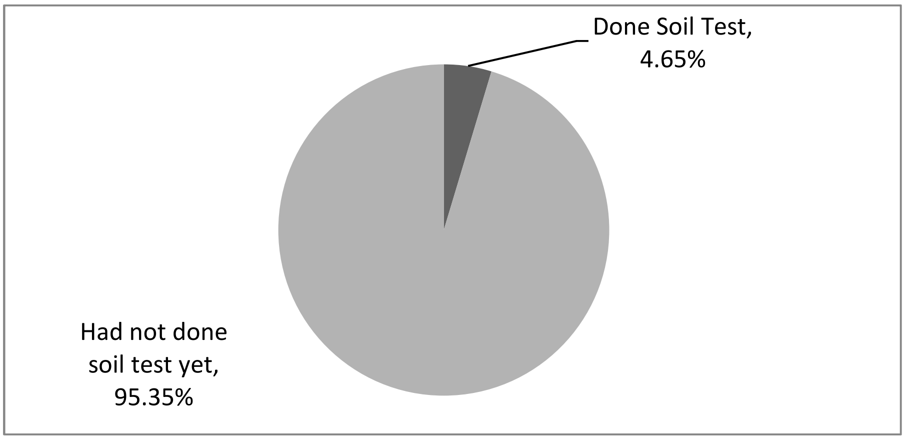
From the above chart, it shows that the average market value of past three years of ginger/turmeric is increasing. The average market value of ginger/turmeric in the year 2072 B.S. were Rs. 44.66 and Rs. 157.7 respectively while it increased to Rs. 61.78 and Rs. 162.2 respectively in the year 2074 B.S.

- **Weeding**



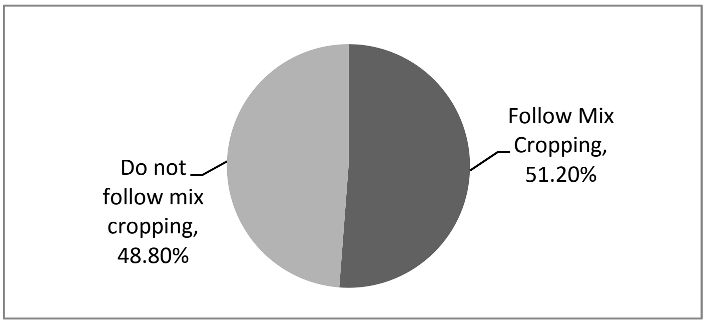
This chart shows that 83.3% ginger farmer do 3 times weeding and 75.8% turmeric farmers do 2 times weeding during the entire cropping period. The month of weeding vary from farmer to farmer and most commonly weeding operation is done in the month of Baishak, Jestha, Ashad and Shrawan.

- **Soil Test**



Out of total surveyed farmers only 4.65% had done soil test while 95.35% of them had not tested soil their yet.

- **Cropping Pattern**



Out of total farmers 51.2% of them follow mix croppingpattern while 48.80% of them followed sole cropping. The mix crops cultivated by farmers are:

- Ginger/ Turmeric + Maize
- Ginger/Turmeric + Akabare(hot pepper)
- Ginger /Turmeric+ Fruits
- Ginger /Turmeric+ Pulses

Expense (Rs) perKattha (Excluding Seed and Manureonly)

From the below table, we can say that average expense per kattha for ginger production is Rs. 1700 with minimum and maximum rate of expense Rs. 900 and Rs. 1800 respectively and turmeric production is Rs.1080 with minimum and maximum rate of expense Rs. 700 and Rs. 1500 respectively excluding seed and manure only.

Crop	No. of respondents	Minimum	Maximum	Average
Ginger	42	900	1800	1170
Turmeric	66	700	1500	1080

Seed and fertilizer Rate

The table shows that seed rate (in Kg/kattha)varied widely for both crops. The seed rate of ginger ranges from 55 Kg (minimum) to 120 Kg (maximum) with an average of 67.02 Kg per kattha. Similarly, the seed rate of turmeric ranges from 35 Kg (minimum) to 100 Kg (maximum) with an average of 56.97 Kg per kattha.

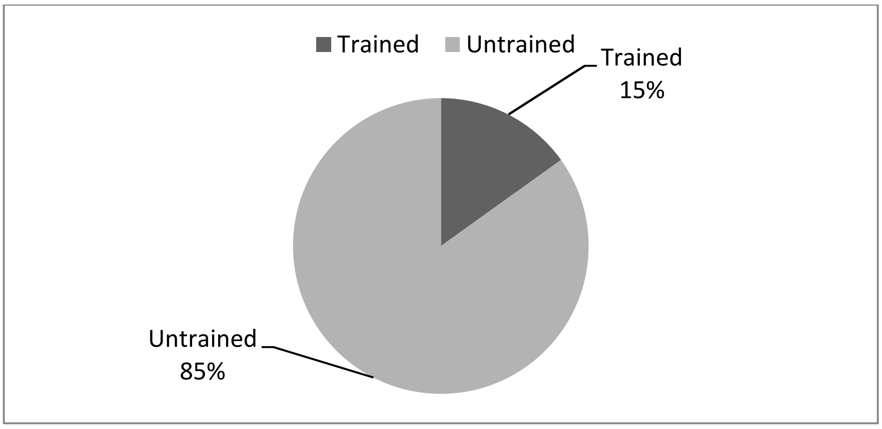
Crop	No. of respondents	Minimum	Maximum	Average
Ginger	42	55	120	67.02
Turmeric	66	35	100	56.97

Amount of farm yard Manure (FYM) (in Doka per Kattha)

The table shows that only FYM was applied by farmers for cultivation of ginger and turmeric. Neither of them used inorganic fertilizers for cultivation of both crops. The amount of FYM applied varies from 5 Doka (minimum) to 50 Doka (maximum) with an average of 30.26 Doka per kattha. The FYM was applied during the time of land preparation only for culvitaion of both crops.

Crops	No. of respondents	Minimum	Maximum	Average	Usage Time
Ginger/Turmeric	86	5	50	30.26	During Land Preparation

➢ Training



Only 15.1% farmer cultivated Ginger/Turmeric by taking training from various organizations like cooperatives, PMAMP, etc.

➢ Ginger and Turmeric productivity

Ginger productivity = 165 kg/kattha

Turmeric productivity (in suttho form) = 35 kg/kattha

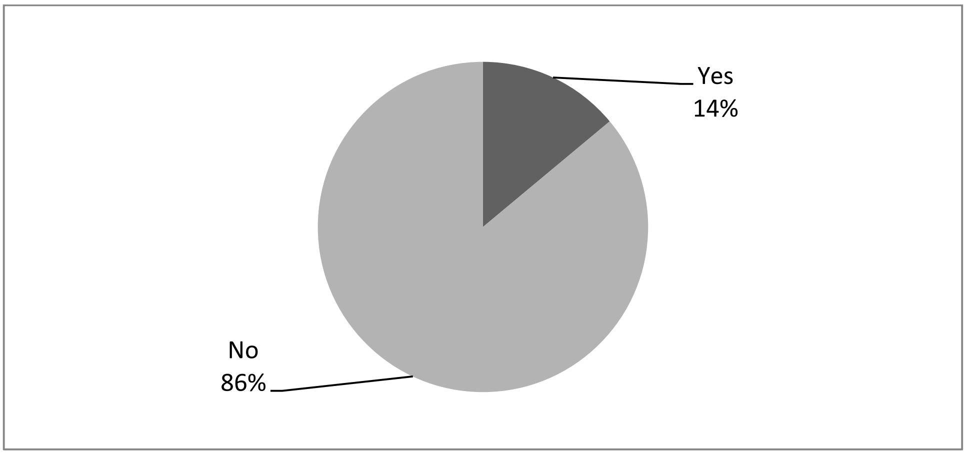
➢ Annual average income from Ginger and Turmeric production

Total income of respondents = Rs. 65,28,000/-$Average\ income\ of\ respondent = \frac{65{,}28{,}00}{86}$

$$= Rs. 75{,}906.98/-$$

The average yearly income of a family from ginger/turmeric production only is calculated to be seventy five thousand nine hundred and seven rupees in Bishnupaduka.

➢ Foreign Employment Status



Only 13.95% of the family had their family member employed abroad.

➢ Conclusion

Based on the data obtained through questionnaire survey following conclusions were made:

- Majority of farmers are dependent on agriculture and mostly on ginger/turmeric cultivation for their livelihood.
- Farmers are using primitive type of tools and equipment for cultivation.
- Most of the farmers cultivate ginger/turmeric without getting technical knowledge and training.
- The farmers are using local seeds and the same seed is being cultivated every year.
- The average yearly income of a family from ginger/turmeric production is seventy five thousand nine hundred and seven rupees only.

If ginger/turmeric are grown with improved seed, with proper care and technical handling, with applications of proper quantity of FYM and inorganic fertilizer during need and with use of modern topography friendly tools and equipment then definitely it will increase the production.

➢ Recommendation

- In order to boost up production and improve the quality of ginger/turmeric, farmers are suggested to use improved varieties and protection measures to overcome pest and disease problems with good management practice.
- Farmers are suggested to use improved modern tools and equipment for cultivation.
- Training of farmers on proper cultivation practice is recommended.
- Concerned authorities can make policy to develop this area as organic farming zone.
- To increase value of ginger/turmeric farmers are recommended to do value addition techniques (cleaning, grading, processing and packaging) before selling their product to the market to enhance income from their product. Likewise to enhance value of product farmers can change their crop into powder form, can make candies from their production and can also boost it towards medicinal purposes.

5. ACKNOWLEDGEMENT

We feel extremely privileged to express our deep sense of reverence and indebted to our advisor Er. Sameer Shakya for his valuable effort, unflagging enthusiasm, constructive criticisms and inspiring advices throughout the period of research works and thesis writing.

6. REFERENCES

- Gurung, Y. B. (2015). *Social Demography of Nepal : Evidences from Population and Housing Census 2011*.
- HoS in India. (2013). Retrieved February 11, 2018, from http://thespicejournal.com/spice-producing-countries/india/history-of-spices-in-india/
- Jayashree E, Kandiannan K, P. D. (2014). ICAR-Indian Institute of Spices Research.
- Kumar, S. C., Bhai, S. R., Editors Lijo Thomas, T. C., & Publisher Director, R. P. (2015). Contributors Jayashree. *Turmeric by ICAR*.
- Nair, P. P. (2013). *The Agronomy and Economy of Turmeric and Ginger*. *The Agronomy and Economy of Turmeric and Ginger*. https://doi.org/10.1016/C2011-0-07514-2
- Pradhan, A., Jayasuriya, H. P. W., & Mbohwa, C. (2016). Status and potentials of agricultural

mechanization in sunsari district Nepal. *Applied Engineering in Agriculture*, *32*(6), 759–768. https://doi.org/10.13031/aea.32.10763

- Shrestha, S. (2011). Status of Agricultural Mechanization in Nepal. *Proceedings of Sustainable Agricultural Mechanization Roundtable: Moving Forward on the Sustainable Intensification of Agriculture 8-9 December 2011, Bangkok Thailand* ., *4*(April), 1–4. Retrieved from un-csam.org

SYSTEM OF WHEAT INTENSIFICATION: A COST EFFICIENT TECHNOLOGY FOR WHEAT FARMING

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Agricultural Technology Center (ATC)

ABSTRACT

A field experiment was conducted at Suryabinayk-5, Bhaktapur district to test the effect of intensification in wheat yields under hilly farming condition. Treated seeds sown 2 seeds per hill at a spacing of 20cmx12cm and grown under intensive crop management practice was considered as System of Wheat Intensification (SWI). The experiment consisted of a total of six treatments (T1= Non primed Broadcasting, T2= Non primed Continuous line sowing, T3= Non primed line sowing with spacing, T4= Primed Broadcasting, T5= Primed Continuous line sowing, T6= Primed line sowing with spacing) with three replication, designed in randomized block design. Seed priming was done (only for T4, T5 and T6) by treating the seeds with warm water (60ºC), molasses and local compost and soaked overnight. Seeds were dried in shade before cultivation. In the broadcasting plots, seeds were applied at the rate of 160kg/ha. Same seed rate was used in the continuous line sowing plots (T2 and T4), maintaining a spacing of 20 cm between rows. However, in T3 and T6, seeds were sown at a spacing of 20cmx12cm using only 10 grams of seed per plot (equivalent to a seed rate of 50kg/ha). Agronomical parameters like Plant height, Spike length, Biomass, Grain Yield and 1000 grain weight were recorded in a single sampling at the time of harvest. Results from data analysis of various yield parameters show that the difference in yield attributes like plant height, biomass, grain yield and thousand grain weights were insignificant between treatments that utilize intensification and that don't. Our results did not show any significant gain in biomass and grain yield with SWI. A fair correlation was found between plant height and biomass, but superior plant heights did not contribute to higher grain yield. Further, no correlation was found between spike length and grain yield. Our findings show that wheat productivity (both grain and biomass) does not reduce significantly with seed rates much lower than the prevailing rate and safely allows us to conclude that cultivation costs in cereal farming can be reduced substantially by reducing the seed rates by up to 70% without compromising the yields, simply by maintaining proper spacing and intensive crop management.

INTRODUCTION

Wheat (Triticumaestivum L.), rice (Oryza sativa L.), and maize (Zea mays L.) provide about two-thirds of all energy in human diets, and four major cropping systems in which these cereals are grown represent the foundation of human food supply.(Cassman, K. G., 1999) Increased and sustained production of cereals is thus vital to food security in context of rising population and changing climates. Cereal production increased significantly in the period starting from 1970s through intensive crop management involving improved germplasms, greater inputs and better irrigation. However, input intensiveness in farming practices continues to raise concerns about its negative effect on environment and profitability of small farms, especially in the developing countries where farmers cannot afford expensive inputs. An alternative approach to increase productivity is therefore necessary to ensure sustained yield of cereals. (Adhikari, P. et al, 2017)

The system of rice intensification (SRI) developed in Madagascar during the early 1980s by Fr. Henri de Laulanie is a promising technology that demonstrated remarkable results in tapping the genetic potential of existing rice varieties by creating optimal growing condition for plants. SRI systems in Madagascar recorded yields as high as 5, 10, even 15 t/ha rice on farmers' fields where previous yields averaged around 2 t/ha. The high yields were obtained with whatever varieties farmers were already using without having to utilize additional purchased inputs like fertilizers. (Uphoff, N., 1999) The principles of SRI have now been utilized in many other crops in various parts of the world especially in China, India, Indonesia, the Philippines and Sri Lanka.

Wheat is the third major cereal crop by area of production and productivity in Nepal (MoAD, 2017). Current data show that the yield per unit area of wheat is approximately 2.5 Mt/ha under conventional agriculture practices in Nepal (MoALC, 2018). But as information provided by (MoAD, 2018) every released variety has the potential to catch yield of 3-6mt/ha under given ecological conditions. However random data collection on productivity of wheat from various parts of the mid hills of Nepal shows that wheat productivity is limited to a mere 1 ton/ha under farmers' practice.

Similar to SRI, System of Wheat Intensification (SWI) is a modern concept of wheat cultivation that allows high yield per unit inputs (fertilizer, irrigation, seed, etc.) applied (Rana et al., 2017). It is regarded as one of the promising techniques for wheat production which allows adequate plant density and maintains proper spacing which ultimately plays role in increased productivity (Khadka & Raut, 2010). It is proven agro ecological method and resource conservation method of wheat cultivation with 32% higher grain yield and 26% less cost of production than the conventional method (Kumar, A., Chakarwal, D., Nandan, R., 2017). Study of (Adhikari, D., 2013) on SWI in Sindhuli also concluded that SWI showed better performance regarding all the agronomical parameters of wheat.

A number of trials on SWI have been conducted by various organization and researchers (Khadka, R.B., Raut, P., 2013; Adhikari, D., 2013)in Nepal. However, majority of such experiments have been done on farmers' fields. Therefore, the data have not always been as systematic or as controlled as scientists usually expect. Scientific trials conducted by researchers in other parts of the world also usually compare the yield from various planting geometry (Saxena, A. et al, 2019; Chopra, R., Sen, D., 2013) ignoring the potential yield differences that might arise from seed treatment and the results vary between locations. A need for scientific field trial for SWI under hilly condition in Nepal to test the validity of the results from farmers' field condition was thus realized to provide a scientific basis for widespread adoption of this technology.

MATERIALS AND METHODS:

A field experiment was conducted at Suryabinayk-5, Bhaktapur district (ATC Research Plot A101) located at 27°39'31.5"N latitude and 85°24'34.6"E longitude, in the wheat growing season of 2018/19. The experiment consisted a total of six treatments (T1= Non primed Broadcasting, T2= Non primed Continuous line sowing, T3= Non primed line sowing with spacing, T4= Primed Broadcasting, T5= Primed Continuous line sowing, T6= Primed line sowing with spacing) with three replication, designed in randomized block design. Wheat variety WK 1204 was grown in 18 plots of $2m^2$ size. Field was prepared with hand spades. Seed priming was done (only for T4, T5 and T6) by treating the seeds with warm water (60ºC), molasses and local compost and soaked overnight. Seeds were dried in shade before cultivation. In the broadcasting plots, seeds were applied at the rate of 160kg/ha. Same seed rate was used in the continuous line sowing plots (T2 and T4), maintaining a spacing of 20 cm between rows. However, in T3 and T6, seeds were sown at a spacing of 20cmx12cm using only 10 grams of seed per plot (equivalent to a seed rate of 50kg/ha).

Fertilizer was applied at equal rate of 80:40:40 NPK and FYM was applied at the rate of 10 ton per ha. Plots were irrigated 15, 25, 35, 60, 80 and 100 days after sowing with 30 liters of water per plot.

Intermittent rainfall occurred during the flowering and grain-filling stage thus ensuring appropriate moisture in the soil at critical stages. Weeding was not required during the growing period.

Agronomical parameters like Plant height, Spike length, Biomass, Grain Yield and 1000 grain weight were recorded in a single sampling at the time of harvest. A total of six random plants were selected from each plot to record the data on plant height and spike length. For Fresh Biomass and Grain Yield, plants were harvested (5 cm above the ground) from an area of 40cm*50cm. Fresh samples were weighed, threshed and grain weights were taken. 1000 grains were collected from each plot and weights were recorded. Variance was analyzed by using one way ANOVA in R software and significant means were subjected to a Post-hoc analysis using Tukey test.

RESULTS AND DISCUSSION:

Effect of intensification on yield and yield attributes

Results from data analysis of various yield parameters (Table 1) show that the difference in yield attributes like plant height, biomass, grain yield and thousand grain weights were insignificant between treatments that utilize intensification and that don't. Plant height for instance was observed to be highest in T6 (89.87cm) and lowest at T1 (84.12cm). However the difference was statistically insignificant. This is in agreement with the findings of (Saxena, A. et al, 2019) that report no difference in plant height between conventional and SWI treatments.

Table 1. Yield parameters recorded at harvest and results of data analysis

Treatment	Plant Height (cm)	Spike Length (cm)	Biomass (mt/ha)	Grain Yield (mt/ha)	1000 grain weight (g)
T1	84.12	12.83 abc	14.31	5.96	51.35
T2	86.59	10.79 bc	18.45	6.22	50.95
T3	89.56	13.03 ab	19.68	6.83	51.87
T4	86.97	13.54 a	14.50	7.07	50.26
T5	87.46	11.22 bc	19.10	7.63	50.50
T6	89.87	12.38 abc	19.64	8.21	52.38
P value	**0.135**	**0.008**	**0.08**	**0.126**	**0.857**
SEm (±)	**2.014**	**0.622**	**2.148**	**0.795**	**1.885**
CV (%)	2.8	6.2	14.9	13.9	4.5

(T1= Non primed Broadcasting, T2= Non primed Continuous line sowing, T3= Non primed line sowing with spacing, T4= Primed Broadcasting, T5= Primed Continuous line sowing, T6= Primed line sowing with spacing)

Our results did not show any significant gain in biomass and grain yield with SWI. Biomass was found insignificantly high at T6 (19.64mt/ha) which was at par with all other treatments. Least biomass was recorded at T1 (14.31mt/ha). Likewise grain yield was also found insignificantly high at T6 (8.21mt/ha) and least at T1 (5.96mt/ha). Grain yield was statistically similar with all other treatments. In case of 1000 grain weight, insignificant high was found at T6 (52.38g) while least was observed at T4 (50.26g). The study of Saxena et al found out significant difference in biomass and grain yield between wheat grown at a spacing of 10cmx10cm and 15cmx15cm with broadcasting, however the yield gain was recorded close to 15% only. Other study on SWI by (Chopra, R., Sen, D., 2013) report that SWI harvests routinely show increases of 80 to 100 percent grain yields compared to the conventional irrigated wheat crop. Even under rainfed conditions, the average SWI yields have increased by 50 to 70 per cent. Similarly, (Khadka, R.B., Raut, P., 2013) reported a yield increase of up to 91% with adoption of SWI technology. Our findings are in contrast with that of these studies.

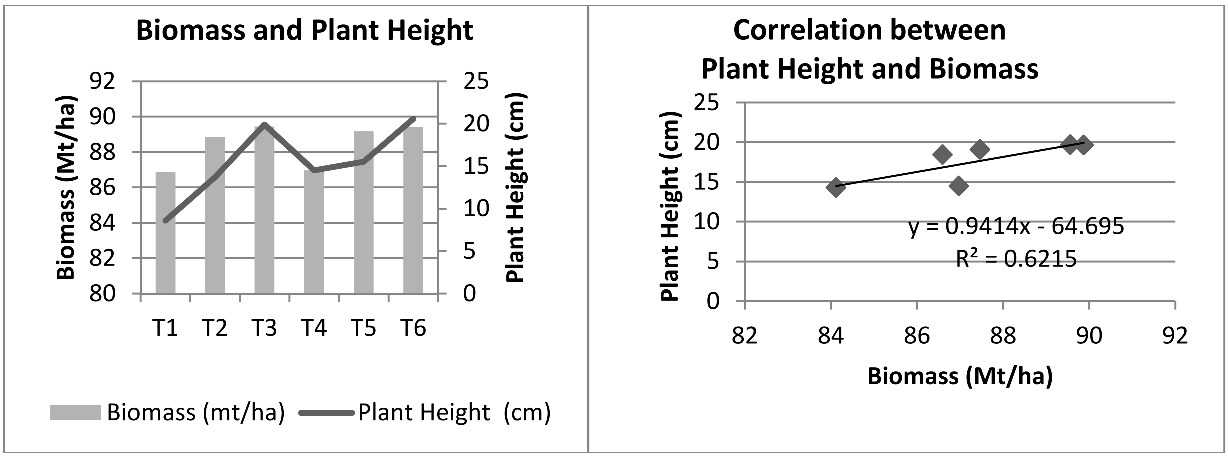

Fig. 1 Effect of treatment on biomass and plant height

Effect of seed rates on grain yield and biomass:

A seed rate of 50 kg/ha was used in T3 and T6 in contrast to 160 kg/ha used for other treatments. Despite the substantially low seed rate, there was no significant difference in fresh biomass and grain yield between plots. This is in contrast with the findings of (Rana, L., Banerjee, H., Ray, K., Sarkar, S., 2017) that report wheat grain yield doubled or almost tripled with SWI under similar plant spacing.

From our results, it is difficult to explain how extremely low seed rates sill gave yield comparable to higher seed rates. In their experiment with SWI (Saxena, A. et al, 2019) reported that 20cmx20cm spacing resulted in a poor plant population thus giving lower grain yield than 15cmx15cm spacing. In our experiment, it seems that better tillering compensated for the lower plant population because WK 1204 is a high yielding wheat variety with enhanced tillering capacity. A fair correlation was found between plant height and biomass, but superior plant heights did not contribute to higher grain yield. Further, no correlation was found between spike length and grain yield. T4 for instance had the lowest 1000 grain weight, despite a significantly high spike length. Grain yield obtained for all treatments (5.96 to 8.31 Mt/ha) were much higher than the national average, closer to the genetic potential of the specific variety. We assume that the ideal conditions for wheat farming maintained at the experimental site including better land preparation, timely irrigation and proper manuring might have resulted in better yield of wheat in all plots irrespective of the treatments.

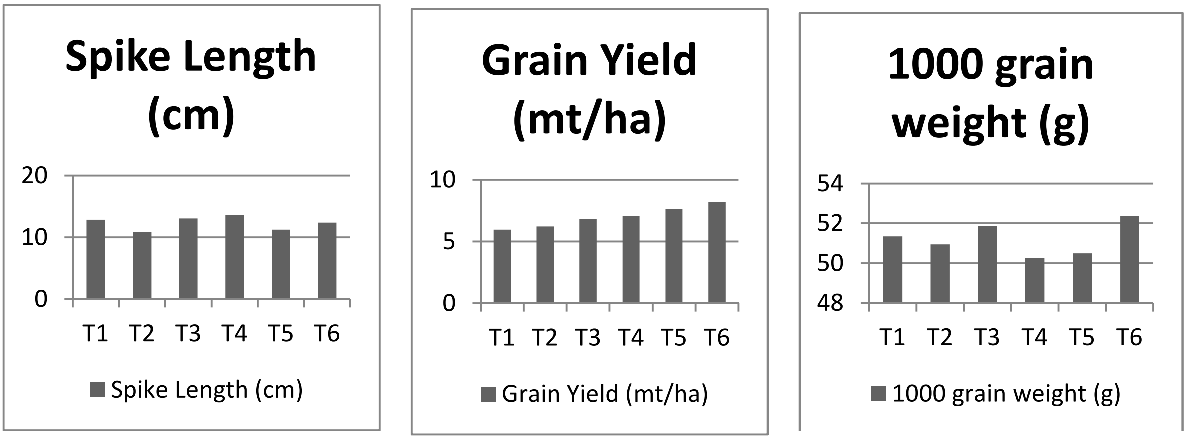

Fig. 2 Effect of treatment on spike length, grain yield and 1000 grain weight

CONCLUSION AND RECOMMENDATION

Improved seed is one of the major inputs which account for a large percentage of the total production cost in wheat farming. Conventionally, farmer have been using seed rates as high as 200 kg/ha. Our findings show that wheat productivity (both grain and biomass) does not reduce significantly with seed rates much lower than the prevailing rate and safely allows us to conclude that cultivation costs in cereal farming can be reduced substantially by reducing the seed rates by up to 70% without compromising the yields, simply by maintaining proper spacing and intensive crop management.

Since manual labor is utilized for almost all intercultural operations in cereal farming in context of hilly Nepal, more costs are involved in intensive crop management compared to conventional systems. Scale appropriate mechanization for controlled line sowing for instance; seed drills driven by hand tractors can be utilized to reduce the labor cost involved in line sowing. It is therefore necessary to consider the availability of household labor and compare the cost of production before deciding on adopting crop intensification practices.

REFERENCES:

Adhikari, D. (2013). Short Communication: System of wheat intensification in farmers field of Sindhuli, Nepal. *Agronomy Journal of Nepal , 3*.

Adhikari, P. et al. (2017). System of crop intensification for more productive, resource-conserving, climate-resilient, and sustainable agriculture: experience with diverse crops in varying agroecologies. *International Journal of Agricultural Sustainability* , 1-28.

Cassman, K. G. (1999). Ecological intensification of cereal production systems: Yield potential, soil quality, and precision agriculture. *National Academy of Sciences colloquium* (pp. 5952–5959). Irvine, CA: Proc. Natl. Acad. Sci. USA.

Chopra, R., Sen, D. (2013). *https://leisaindia.org/golden-wheat-becomes-more-golden-extending-sri-to-wheat/.* Retrieved 06 09, 2019, from https://leisaindia.org.

Khadka, R.B., Raut, P. (2013). *http://sri.ciifad.cornell.edu/countries/nepal/Nepal_SWI_Khadka11.pdf.* Retrieved June 05, 2019, from http://sri.ciifad.cornell.edu: http://sri.ciifad.cornell.edu/countries/nepal/Nepal_SWI_Khadka11.pdf

Kumar, A., Chakarwal, D., Nandan, R. (2017). System of wheat intensification- a resource conservationand agro-ecological method of wheat cultivation. *Indian Farmer , 4* (2), 194-197.

MoAD. (2018). *Released Varieties of Crops.*

MoAD. (2017). *Statistical Information of Nepalese Agriculture 2016/17.*

MoALC. (2018). *Krishi Diary 2075.*

Rana, L., Banerjee, H., Ray, K., Sarkar, S. (2017). System of wheat intensification (SWI) – A new approach for increasing wheat. *Journal of Applied and Natural Science* , 1453-1464.

Saxena, A. et al. (2019). System of Wheat Intensification Study using Hydroponically raised Wheat Seedling – A New Approach towards Farmer's Welfare. *International Journal of Advances in Agricultural Science and Technology,* , 24-40.

Uphoff, N. (1999). Agroecological Implications of the System of Rice Intensification (SRI) in Madagascar. *Environment, Development and Sustainability* , 297–313.

Assessment of Water Resources and Irrigation Potential in Nepal case Study: Sunsari, Saptari and Dhanusha Districts

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Abstract

Water Resource assessment is the estimation of available water resources and its use for effective planning, sustainable development and management of water resources. Irrigation potential is the area that can be irrigated with the available water resources based on irrigation requirement in soil types, cropping pattern and climate. In this study, available water resources for dry season was estimated based on the groundwater recharge and storage volumes in the ponds for dry season irrigation in of Rabi crops of Sunsari, Saptari and Dhanusha districts in Terai region of Nepal. For groundwater assessment, estimation of recharge is the pre-requisite for management of groundwater resources. Since, recharge computation helps to compute the water that can be potentially used from the groundwater aquifers. In this study, Surfer (golden software) and Water Table Fluctuation method has been used for recharge estimation. Surfer is computational software which creates grid based map using XYZ data file and from created grid file contour map is produced. In Surfer, annual storage volume was computed from plotted contour of maximum and minimum water table depth of May and September annually for study period and then subsequently annual recharge and discharge rate was obtained from storage volume. Also to have more confirmation on result of Surfer, Water Table Fluctuation method was applied to know the seasonal groundwater table fluctuations and to estimate the annual groundwater recharge in the study period. In addition to it, water table data was plotted in the Surfer to have understanding about the spatial and temporal distribution of groundwater table in study districts. Furthermore, annual and monthly fluctuation of water table contours and graph reveals that there is spatial and seasonal fluctuation of water table in study districts. Average annual recharge of 138, 165 and 126 mm/yr was estimated for Sunsari, Saptari and Dhanusha districts respectively which were found 6, 9 and 8 % of annual rainfall in respective districts. Monsoon precipitation was found to be the main source of recharge and about 85 % rainfall occurrence from May to September and June to September appears as major recharge period as well as water source for ponds in study area.

In addition, for pond water, pond volume was computed from the area of the pond obtained using GIS and depth was collected from sample ponds during field visit. Finally, annual pond storage volume was calculated and it was found to be1.54, 6.99 and 4.81 MCM Sunsari, Saptari and Dhanusha districts respectively. By summing up estimated groundwater and pond water volume, total annual water volume available for potential use was computed as 159, 209 and 148 MCM for Sunsari, Saptari and Dhanusha districts respectively. Furthermore, total water demand was estimated by calculation of the water use in different sectors like agriculture, domestic, cattle and industry. Agriculture demand of water is obtained by calculating the gross irrigation requirement of common crops growing in study area. Agricultural water demand was computed based on the gross irrigation requirement and non irrigated area in existing cropping pattern. However, for other uses secondary data was used for calculation consequently; total water demand was computed as 131, 239 and 282 MCM in Sunsari, Saptari and Dhanusha districts respectively. By comparing the water availability and its demand it was identified that estimated available water was found to be higher than demand for Sunsari district *however lower for Saptari and Dhanusha districts. In Saptari and Dhanusha districts it could meet the total demand of winter and spring seasons crops however for summer season available water can meet only about 85 % and 11% of non irrigated area in Saptari and Dhanusha district respectively. This indicates there is sufficient water availability to meet the demand of dry season cropping in all three districts, which reflects that there is potential to irrigate all rained land in winter and spring season and most of the lands in summer season of study area which will finally raise the agricultural production and productivity in the study area and indeed helps in income generation of subsistence farmers and reduction of poverty in study area.*

Keywords: Water Resources, Assessment, Recharge, Terai, Groundwater, Pond, irrigation, Water demand

1 INTRODUCTION

Background

Assessment of water resources and irrigation potential is the estimation of available water resources with the water balance, extensive use and the projection of available water in future for the planning and management. Water resource assessment study is basic component for sustainable water related development like irrigation, water supply and use of available water resources (World Meteorological, 2012). It helps in evaluating temporal and spatial variation of the available water and sustainable levels of irrigation for crops and demand. Similarly, Irrigation potential is the area that can be irrigated with the available water resources depending on the type of soil, irrigation requirement and climate (Frenken and Faurès, 1997).This study concentrates on three districts of the Nepal Terai region (Sunsari, Saptari and Dhanusha) to explore water resources and viable irrigation potential. In this study, groundwater and pond water is evaluated for the dry season irrigation of Rabi crops. Irrigation is one of the crucial input for the sustainable agricultural production (Singh, et al., 2012).Water is the key component for sustainable and economic development (World Meteorological, 2012) especially in a country like Nepal where it can acts as the catalyst for all round development and economic growth of the country (Thapa, 2007).

Although in 1995, agricultural perspective plan identifies that for agricultural growth and poverty reduction year round irrigation is the prerequisite for intensification of Nepalese agriculture (Shrestha, et al., 2015). Only about 33 % of irrigated area has got winter season irrigation till date. Due to seasonal and spatial variability of rainfall and surface source, agriculture sector demands for the reliable source of groundwater. Even in study area only less than 35% of irrigated area has winter irrigation facility which is based on the irrigation provided by department of irrigation however, there may be some part of agriculture irrigated by individual tube wells of the farmers. Recently, Nepal government formulated new irrigation policy to provide year round irrigation using conjunctive use of available groundwater and surface water sources. Hence, this assessment of water availability and demand estimation will help in formulation of year round irrigation facility in study districts. It is in these perspectives that this study has been taken-up to evaluate the water sources and irrigation potential of the study area based on study of the groundwater and pond water use and its further potential to use of existing resource for the sustainable irrigation development in the three districts of Nepal.

Problem Statement

In Nepal, majority of the population lives in rural area and 80 percent of rural livelihoods dependent on subsistence farming (Pariyar, 2003). Most of the farmers, who depend upon rain-fed agriculture for their livelihoods to produce food and generate income, are severely affected by fluctuations in water resources, fluctuation in precipitation and climatic variation (Duncan and Biggs, 2012). Nepalese agriculture contributes 32 % in total GDP and provides employment to 66% of the economically active population (Haefele, et al., 2014). Poor utilization of the available water resources followed by the small, fragmented landholdings and poverty, are the major constraint which reduces the productivity of various agricultural produce in the study area (Rajmohan and Prathapar, 2013). Most of the farmers, who depend upon rain-fed agriculture for their livelihoods, are severely affected by fluctuations of water resources (Duncan and Biggs, 2012). Although Nepal is the second largest water resource rich country following Brazil, the people of study area have been suffering from consequences of drought. Furthermore, According to Department of Hydrology and Meteorology, in Nepal, the data shows the frequency of the drought is increasing in recent years.

In the past decades, the country has faced several dry spells in 1972, 1977, 1982, 1992, 2002, 2004, 2005, and 2006 in both dry and wet monsoon. However, some of these droughts have been followed by the floods and heavy rainfall (Miyan, 2014). According to the Department of Hydrology and Meteorology, the winter drought in 2008 - 2009 was the worst on record when country received less than 50% of average precipitation during the period November 2008 to February 2009. The past records indicate that the frequency of the droughts is in increasing and causing problems in the livelihood. It has caused on crop loss in rainfed farming and has had severe implications on household food security (Miyan, 2014). Due to not having reliable irrigation facility in study area, every year significant parts of the agricultural land remain uncultivated in study area.

Rained farming in Terai suffers from frequent and often prolonged, drought due to poor rainwater management during monsoon season (Miyan, 2014). Often these lands remain fallow in winter season due to scanty rainfall and lack of assured irrigation facilities (Synnott, 2012). In order to meet the food demand of the growing population at the current growth rate, the productivity of rain-fed farming in the study area has to be raised from the present level. The Problem is going to be still worse for those areas where possibility of developing conventional irrigation facility, mainly run-of-the-river and groundwater irrigation are limited. The fate of millions of rainfed farms in the region can be greatly improved by adopting the effective utilization of the groundwater (Shrestha, et al., 2013) and rainwater harvesting, conservation and management practices (Sharma and De Datta, 1994). In the view of dwindling water supplies in the study districts, greater emphasis has to be placed in groundwater and pond water and then using it as conjunctive use for supplemental irrigation to crops. Thus, to cope with the frequent drought viable alternative solution is pre-requisite for the study. This study has therefore been conceived to assess the water resources and irrigation potential in Sunsari, Saptari and Dhanusha Districts of eastern Terai region to utilise the available water resources for the agricultural area intensification and crop production to convert the subsistence farming to commercial farming in study area.

OBJECTIVES OF THE STUDY

The overall objective of this study is to evaluate the temporal and spatial variation of water availability and sustainable levels of irrigation of Rabi crops for the expansion and intensification of irrigated agriculture in study area of the country. The specific objectives the study is as under:

- To assess the potential of groundwater and pond water within each district.
- To determine crop water requirements of common crops grown within each district.
- To project the irrigation area based on the water assessment and irrigation potential.
- To determine sustainable levels of rabi crop irrigation for each district.

Study Justification

Proper assessment and understanding of available water resources is crucial for informed irrigation development in Nepal, where majority of the population live in rural areas and 80 percent of rural livelihoods dependent on subsistence farming (Pariyar, 2003). In the Terai region, FAO reported that additional assessment of ground water is necessary (Rajmohan and Prathapar, 2013). It is in this context, this study has been conducted at district level to assess the seasonal variability available resources and irrigation potential. Availability of irrigation has been established to be a major constraint to enhancing agricultural productivity in the Terai region.

The agricultural data claims most of the potential arable land is already used for cultivation. The rapid increase in population forcing for stable and improved productivity from cropping systems for the food security (Sherchan and Karki, 2006). The productivity of the irrigated agriculture shows the sustainable irrigation is necessary to meet the growing food demand. Hence, proper planning and use of the available water will enhance the land productivity, and will help in reducing poverty and ensuring food security.

The means of further intensification of irrigated agriculture in Terai is expansion of area under groundwater based irrigation schemes because the most of the large potential sites for run-of-the-river type schemes have already been used. Now the development of ground water irrigation appears as potentially feasible option for further development of irrigation in the study districts. The need for the increased food production and heightened awareness of intensive agriculture has led to assess the unutilized potential water sources. Due to spatial and temporal variation of the surface water source, it is not enough to meet the water demand during dry season. The significant seasonal variation in irrigation indicates that there is a need of utilization of other water sources in winter and spring season along with the use of surface water sources to raise the agricultural production and productivity in study area. Utilization of groundwater and pond water will certainly help in enhancement of yield in rainfed farming of study area. As groundwater is sensitive, it would be better to evaluate the present water availability for effective development and management of the groundwater resources. Groundwater information shows that the groundwater assessment was carried more than 20 years ago which suggests the long study gap. Also, in this period land use, weather pattern and discharge in the rivers have changed remarkably due to increase in population and change in climatic condition. This seeks for the present study prior to groundwater use in study area. If groundwater and pond irrigation is used with proper planning and management then it will enhance the use of land and water resources, resulting in increased crop production with reduction in poverty (Rajmohan and Prathapar, 2013). Although conjunctive use of surface and groundwater is already been in practise of the limited farmers in the study area; hence, before boosting the uses of groundwater, sustainability issues need to be addressed through recharge evaluation of the study area (Sapkota, et al., 2013).

2. DATASETS AND METHODOLOGY

To fulfil the objectives of the study, field study was conducted as a part of the primary and secondary data collection. Based on the data requirement, location and situation face to face interviews, telephone conversation, emailing was mainly used for the data collection.

2.1 Summary of Methodology

Methodology adopted to fulfil the objectives briefly mentioned in **Table 2.1**.

Table 2.1 Brief Summary of Methodology

Research Questions	Methodology	Data Used	Outputs
Assessment of pond water source.	Analysis of the primary data collected during ground during ground truthing of ponds. Estimation of average depth from pond from collected data. Estimation of Pond area from shape file prepared by IWMI using NDWI.	Depth of Ponds collected during ground truthing of ponds. Secondary data from IWMI, GIS shape file prepared by IWMI	Availability of seasonal storage water in the ponds. Volume of Water in the ponds before and after the monsoon period. Volume of water available in pond for irrigation.
Assessment of Ground water source.	Use of monitoring well data in Surfer to estimate seasonal groundwater storage. In Surfer, by using monitoring well co-ordinates and water table depth, it plotted water table contour and provides volume for wet and dry months. Difference of wet and dry month gives seasonal storage. Use of Water fluctuation method. Using difference water depth between May and September (Δh), specific yield (S_y) and area gives storage volume.	Monthly groundwater monitoring well data. Location co-ordinate of monitoring well stations. May and September water depth to calculate Δh. Specific yield values. Area of aquifer.	From Surfer, water table contour map and seasonal groundwater storage volume of each year. Based on storage volume estimation of recharge and discharge. Estimation of recharge also from Water Fluctuation Method.
Determination of the current extent of the irrigated cropping in the Rabi season	Secondary data of irrigation area was collected based on the study area information.	Irrigated and un-irrigated area of the study area. Surface and groundwater irrigated area.	Extent of irrigated cropping area in the Rabi season. Additional requirement of irrigation in different season.
Calculation of the crop water requirement.	Estimation of crop water use and net irrigation requirement. Estimation of gross crop water requirement for common crops.	Climate data, soil data, crop area in the districts. Secondary data of water uses in other sectors like domestic, industrial Cropping pattern and secondary soil data.	Seasonal Crop water demand. District wise irrigation water demand for rainfed farming.

Potential of irrigation and Rabi crops within each district.	Computation of gross irrigation requirement and water availability of districts.	Computed Irrigation water requirement. Assessed Water resource and its availability.	Projection of irrigable area based on the water availability.

3. RESULTS ANALYSIS

3.1 Water Resource Assessment

3.1.1 Pond Water Source

Large numbers of permanent and temporary ponds are available in study districts. Based on the remote sensed image information, altogether 1283, 2844 and 2858 number of permanent and temporary ponds are existed in Sunsari, Saptari and Dhanusha district respectively.

Storage area and Volume of Ponds

Table Permanent Ponds Area and Potential Volumes for Use

District	*No. of Permanent ponds*	*Permanent Ponds Area (Ha)*	*Average wet season depth (m)*	*Average dry season depth (m)*	*Wet season volume (MCM)*	*Dry season volume (MCM)*	***Total volume (MCM)***	*Evaporation loss (MCM)*	*Seepage loss (MCM)*	***Potential Volume for use (MCM)***
Sunsari	707	137	2.34	1.21	3.20	1.65	**1.55**	0.7	0.3	**0.6**
Saptari	1848	426	3.03	1.39	12.92	5.93	**7.00**	2.1	0.9	**4.0**
Dhanusha	1956	473	2.75	1.73	13.02	8.20	**4.82**	2.3	1.0	**1.5**

Source: IWMI Ponds Map

Number of permanent ponds indicates that there is large number of existing ponds which can be used for supplemental irrigation in study area. Altogether 13 MCM volume of water was found as pond storage volume but by considering the evaporation and seepage losses only about 6 MCM volume was found for potential use of dry season crops in study area. Evaporation and seepage losses were determined by following the procedure adopted by FAO.

Although, ponds are mainly used for fishery purpose, it is found that most of the ponds are using for dry season irrigation depending on the availability of water in ponds. Especially, in the area where there is no surface and groundwater facility available pond is crucial for supplemental irrigation. Result shows that altogether 6.0 MCM of pond water volume is available for potential use in the study districts

3.1.2 Groundwater Source

Assessment of the change in groundwater storage involves periodic water level measurements, construction of water level change maps from water level measurements and computation of the volume change with time. Unless artificial abstraction disturbs the natural phenomena, the storage change of the aquifer reflects the seasonal change in precipitation and evapotranspiration. Monitoring well data explains the trend and fluctuation of the water table in the aquifer. These results cover general groundwater concepts and are the result of data collected for the assessment of groundwater and finally quantify groundwater availability in the districts.

In the Terai plain of Nepal, precipitation is the primary source of groundwater. As mentioned in the hydrogeology of the Terai plain, upper part of Terai is the Bhabar zone, is highly permeable. It is the principal recharge zone of the Terai groundwater. It recharges either by the direct rainfall infiltration or inflow from the rivers traversing it (Rajmohan and Prathapar, 2013) and (Dahal, 2014). Area covered by the Bhabar zone is 100, 200 and 140 Sq. km in Sunsari, Saptari and Dhanusha district respectively (Kanzler and Shrestha, 1989), (Echhya K, 1992b) and (Echhya K, 1992a).

3.1.2.1 Maximum Water Depth Fluctuation

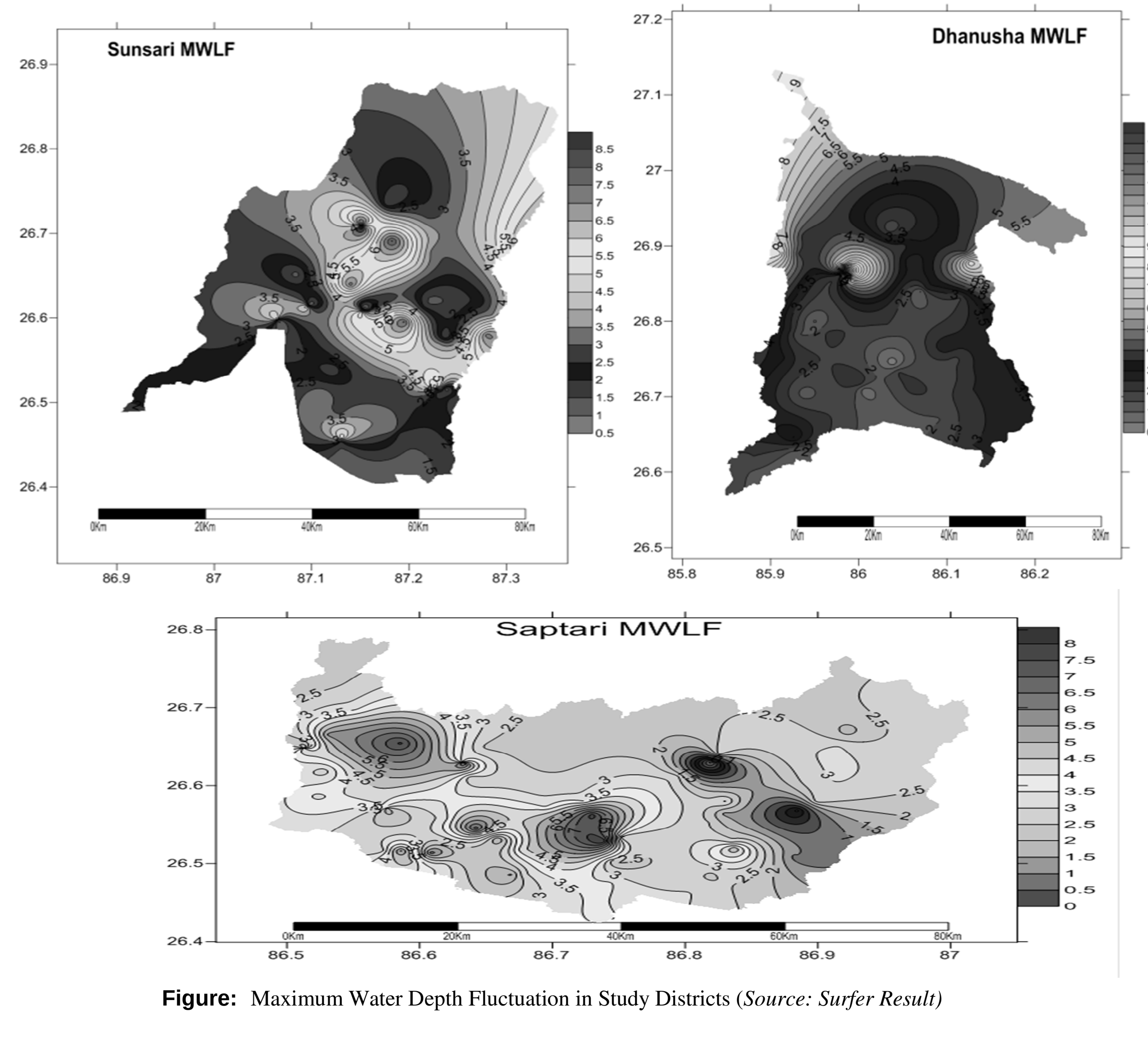

Figure: Maximum Water Depth Fluctuation in Study Districts (*Source: Surfer Result)*

Water depth fluctuation describes the spatial groundwater table trend in the study area during study period. It helps to analyse the variation in different location and reason of spatial water table change in different parts of district and finally it helps to understand the variation of the groundwater spatially in the districts. Maximum water depth fluctuation is the difference in deepest water depth in May (pre monsoon) and shallowest water depth September (post monsoon) for each station during study period. Maximum fluctuation water table contours of study area shows that the fluctuation is the maximum in Dhanusha andSaptari districts whereas it is not beyond 7m in Sunsari district. Maximum water depth fluctuation contour illustrates that water table fluctuation is spatially diverse in districts. Plot showed that fluctuation is lower in the region where river passes across it and higher in the city area except in Dhanusha district where table fluctuation more in northern part of district. In significant part of districts area, it appears as fluctuation is about 2 to 3 m which explains that there can be potential groundwater storage in most part of study area.

3.1.2.2 Groundwater Storage

In order to quantify the groundwater storage, it is necessary to calculate Δh and specific yield (Sy) of the aquifer. Δh is calculated based on the monthly measurements of 24, 42 and 28 monitoring wells in the Sunsari, Saptari and Dhanusha district respectively. Though these numbers of stations were mentioned for the calculation but all these stations did not have the complete datasets of throughout the study period. Hence the number stations of vary in some years of the calculation.

The annual Δh was obtained from difference between maximum water depth in May and minimum water in September. Specific yield value was used based on the review of literature of similar geologic formation of India (Ambast, et al., 2006), as study area is also a part of the Gangetic basin. To be on the safe side it was assumed as 10% for whole study area although in India it is ranges from 10-18 percentages. However, (Machiwal and Jha, 2014) emphasized that in real world aquifer system Sy values are spatial and Sy value need to be determined for the different region of the aquifer. But, due to unavailability of the spatial data of Sy and limitation of time it was not possible to obtain specific field of study area. Thus, in this study specific value of Indo Gangetic Basin of India has been used as reference value.

The changes in storage volume in May and September reflect the recharge and discharge in the aquifer of the study area. In this study Surfer was used to compute the storage volume in May and September.

a) Annual Storage and Recharge Calculation based on Surfer

The average annual recharge was computed as 141 mm/yr, 161 mm/yr and 119 mm/yr Sunsari, Saptari and Dhanusha district respectively. Annual average recharge obtained from the Surfer is identical to the results of national groundwater recharge estimated by IGRAC. (Margat and Van der Gun, 2013) suggests groundwater produced internally as 142 mm/yr and diffuse natural groundwater recharge as 135 mm/yr for Nepal. Result obtained from the Surfer was found near to national recharge estimation. Hence it verified the result of Surfer. However, this result deviates from recharge estimated by UNDP in the Terai region of Nepal. UNDP claims annual recharge as 200 MCM/yr, 400 MCM/yr and 300 MCM/yr for Sunsari, Saptari and Dhanusha district respectively (Echhya K, 1992a, Echhya K, 1992b, Kanzler and Shrestha, 1989).

b) Annual Storage and Recharge Estimation Using Water Table Fluctuation (WTF)

It is the most commonly used method for the computation of the groundwater recharge (Healy and Cook, 2002). This method is based on the assumption that the fluctuation of the static water level in the unconfined aquifer is mainly due to the contribution of recharge to the water table (Healy and Cook, 2002). This method is suitable where groundwater monitoring data is available and in humid region like study area. The average water table was found deepest in the May and shallow in September. Summary of the annual recharge results indicates significant annual variation in recharge within district as well as among districts in study area. However, average annual recharge of study period found likely among the districts.

In summary, recharge value for each district was estimated as an average of the recharge rate computed from Surfer and Water Table Fluctuation method. Average of the evaluated recharge rate value is 138, 165 and 126 mm/yr and terms of total groundwater availability 158, 205 and 146 MCM/yr for Sunsari, Saptari and Dhanusha district respectively. If we look at study area average recharge is 143 mm/yr more closely to national internal ground water recharge of 145 mm/yr (Margat and Van der Gun, 2013). This indicates the good accuracy of the results.

Result Accuracy

The accuracy of the result calculated from the Surfer was checked with the result from the water fluctuation technique. The volumes estimated by using both methods are nearby and result deviates by only 4 %, 5 % and 10 % in Sunsari, Saptari and Dhanusha district respectively. This suggests that obtained result is good. In addition, calculated groundwater recharge value for the districts are near to internal annual groundwater recharge and diffuse natural groundwater recharge estimation 142 and 135 mm/yr respectively for Nepal by (Margat and Van der Gun, 2013). Hence, computed results are supported by the previous studies result and also in this study 11 years of groundwater data has been analysed which may give reasonable recharge estimates than (Kanzler and Shrestha, 1989) study in which only 3 years data were use and result was different than present estimation. To conclude, evaluated results for study area appears as suitable for future research and could be used for development as well as management of groundwater in study area.

Groundwater Recharge Estimates from Surfer and WTF

The recharge estimates include the total recharge contributed to raise the ground water table. It includes the precipitation, sub-surface inflow, and inflow from the river, return flow from irrigation and recharge from the ponds in the study area. Although there may be the part of the contribution from the sub-surface, river inflow and irrigation return flow; precipitation is the major source of recharge and cause of water table fluctuation. Groundwater recharge is estimated using Surfer and WTF method, using groundwater monitoring data from 2000 to 2010. Result obtained from the both method is meaningful because average annual results study period are close each other. Although recharge results illustrate, significant inter and intra annual variation likely to occur in study districts. The variation might be due to variation of rainfall, rainfall intensity in districts, different land use and difference in area of Bhabar Zone in districts. Generally, Bhabar zone acts as major recharge zone of districts due to having permeable formation of sand and gravel. It has been suggested that 32.5 % of rainfall in Bhabar zone for study area recharge to the aquifer. However, in Terai zone percolation vary in study districts. In Saptari district 21 % of rainfall percolates to the aquifer while for the same Terai region of Dhanusha percolation is only 15 % (Echhya K, 1992a). In present estimation, Saptari district has relatively higher recharge rate than Dhanusha and Sunsari district, might be due to having higher percolation in Saptari district in comparison to two other district. The recharge rate estimated for study districts in previous study is higher than present Surfer and WTF method computation mainly due to assumption of specific yield as 0.15 which is higher than the current assumption of 0.10 and partly might be due to different time of estimation. Previous estimation was carried more than 20 years ago, at that time land use type and precipitation might be different than the study period condition. Also, at that time May and September water table difference was assumed as 2.5 m which is significantly higher than present difference value of 1.35, 1.69 and 1.32 m in Sunsari, Saptari and Dhanusha districts respectively for the same. Hence, annual net recharge estimation provides the understanding of water table fluctuation and annual groundwater that can be potentially used in study area. Finally, it describes the annual groundwater availability to the district area. In Dhanusha, it shows negative recharge in the year 2009 and 2010 which means that water table in September is deeper than May for 2009 and 2010. It might be due to having low rainfall monsoon and high in spring season. Both recharge estimation from Surfer and WTF method indicate the close results of recharge in the districts. Average annual groundwater recharge and storage volume from estimations proves that there is availability groundwater source in study districts. Annual average recharge and rainfall need to be further analysed to know their consequences.

Rainfall and Recharge

Table Annual Average Recharge and Rainfall

Name of Districts	***Surfer Annual Recharge (mm/yr)***	***WTF Annual Recharge (mm/yr)***	***Average Annual Recharge (mm/yr***	***Average Annual Rainfall (mm/yr)***	***Recharge as % of Rainfall***
Sunsari	141	135	138	2163	6%
Saptari	161	169	165	1749	9%
Dhanusha	119	132	126	1624	8%

For the same study districts, recharge estimated in 1992 claims that 10, 26 and 19 % of rainfall was recharged to the groundwater (Echhya K, 1992a, Echhya K, 1992b, Kanzler and Shrestha, 1989). This estimation was based on the percentage recharge in Bhabar as 32.5 % and in Terai zone about 16 % in Saptari and Dhanusha districts which could not be possible. As looking to monitoring well data it shows wide variation across the district, it was not good idea to assume recharge percentage of rainfall like such. Except Sunsari district, the annual recharge calculated from rainfall seems to considerably high. In previous study, recharge was also estimated using specific yield of 0.15 and average rise of water table during monsoon which was 2.50 m. Due to this high water table and specific result values previous result was relatively higher than present estimation (Echhya K, 1992a, Echhya K, 1992b).

Irrigation of Requirements

FAO irrigation and drainage paper No. 24 (Source: DOI, Nepal) was used to estimate the crop water use and irrigation requirement of the crops with input data from collected average climatic conditions in each district. Irrigation water demand was finally prepared for each district by coupling the crop coverage and the crop water demand.

Table Seasonal Gross Irrigation Requirements of common crops

	Gross Irrigation Requirement (mm)				
Crops	Paddy	Wheat	Pulses/Oilseeds	Winter Vegetable	Maize
Duration(days)	135	120	100		105
Sunsari	186	150	110	115	48
Saptari	350	245	151	154	125
Dhanusha	327	169	122	187	72

Irrigation requirement of crops are affected by groundwater table depth in agricultural area. Especially, in case where groundwater table is shallow part of the crop water requirement contributed by capillary rise. (Mishra, et al., 1995) identified that it is not necessary to apply more than 120 to 180 mm irrigation in wheat where water table is (< 0.9 m) and (< 1.3 m) respectively in the Terai region of India.

Available Water, Use and Demand

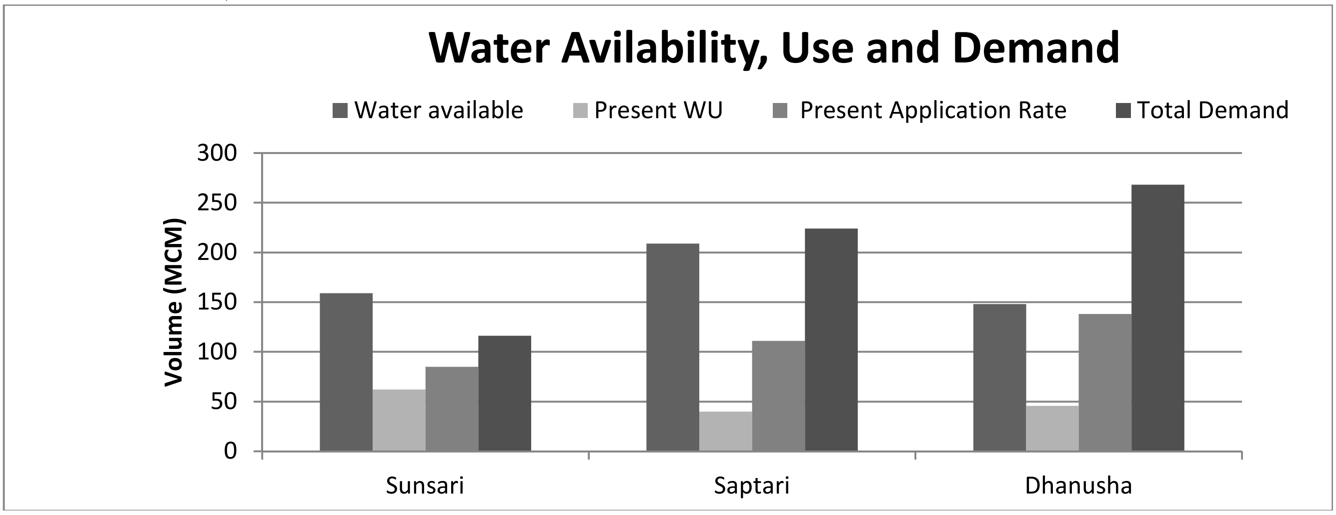

Figure 5 Water Availability, Uses and Demands Based on Present Application Rate in Agriculture and Gross Irrigation Requirement of Crops in Study Districts

Based on the water availability and water demand in current situation, all water demand can be possible to meet in the Sunsari district whereas for Saptari and Dhanusha districts water demand of only 20,500 and 3500 ha of paddy field can be meet during summer with respect to present demand and availability. However water demand in winter and spring season can easily meet the present availability in Dhanusha and Saptari too.

Limitations of the study

Following limitations were found during the study:

I. Lack of complete monitoring wells data. Monitoring wells data of all the months and all parts of the district were not available. Reliable spatial and regular monitoring well data is essential for good result.

II. Unavailability of the surface water source river data make uncomfortable to make water balance of the study area.

III. Assumption of specific yield value instead of having representative values of specific yield spatially in study area, as it was not possible to conduct pumping tests throughout district area due to limitation of time.

IV. Lack of runoff and rainfall intensity data in study area.

V. Lack of past study data in related research area. Due to which most of the infomation used for this study in terms of Terai region context.

A more comprehensive study on spatial specific yield, aquifer properties and economic study of groundwater use is recommended to arrive at guiding conclusive results.

Conclusion

There was wide spatial and temporal variation of precipitation in the study area. Occurrence of rainfall was excess during monsoon whereas deficit during the dry season with respect to ET demand. Available rainfall in dry season is insufficient to meet the crop water requirement of during dry season because more than 85% of precipitation occurs in from May to September and with significantly less rainfall in rest of the months. This annual and seasonal variation in rainfall has considerable affect in rainfed farming of Rabi crops and subsistence farming even more. Variation of the climatic condition indicates that it is important to shift from rainfed to irrigated agriculture to have better yield and profitable agriculture.

Based on the analysis of groundwater and pond water sources in the study area, potential annual water sources available for use are 159, 209 and 148 MCM, for Sunsari, Saptari and Dhanusha district respectively. Average annual groundwater recharge of 138, 165 and 126 mm was estimated using Surfer and Water Table Fluctuation method in study districts Sunsari, Saptari and Dhanusha districts respectively. The major contributor for the recharge is precipitation and was found 6, 7 and 8% of annual rainfall in Sunsari, Saptari and Dhanusha district respectively. Rainfall is Excess during monsoon and deficit from October to May far below than evapotranspiration demand. Based on the monitoring well data analysis and recharge estimation using different technique it can be concluded that there appears good prospects of groundwater in almost whole study area, except in the few northern part, at the foot hills where water table was recorded deeper than 10 m. In most part of the study area water table was appears near to the ground surface not below than 5 m, which indicates that water can be accessed easily and cheaply. Even a hand pump, treadle pump and centrifugal pump can be sufficient for the abstraction water which is relatively cheaper way achieving water than achieving water from deep depth with submersible pump or high capacity motors.

Existing groundwater and pond water in study districts can be the viable available water to meet the water requirement of the Rabi crops. As the most of the surface water source gets dry during dry season, available sources are pond water and groundwater. Groundwater table is near to the ground surface after monsoon season, which indicates that there is high potential to use groundwater for Rabi crops. The average monthly water table pattern shows that the water table depletes during the dry and recharged with the rain water during monsoon season. Since average annual groundwater recharge was found significantly higher than the current demand for dry season irrigation of winter and spring seasons hence it can be used for long term for irrigation in dry season for better yield in rainfed agriculture. In addition, use of ground water lowers the water table during dry season and makes more space for water to come in during dry season. This may helps to control the flood during high rainfall in monsoon season and also better aeration in the root zone where water table is near to the root zone during post monsoon season. Water availability shows that it can easily meet the irrigation requirement of dry season's crops.

Gross irrigation requirement of the crops based on the non irrigated area, existing cropping pattern and climatic conditions in Sunsari, Saptari and Dhanusha district was found 116, 224 and 268 MCM respectively which is below the available water in the Sunsari whereas higher for Saptari and Dhanusha districts. Hence for these two districts it is possible to irrigate only about 85 % and 11 % of non irrigated paddy field while for dry season crops it meets all the demand of water. Sufficient groundwater and pond water availability in dry season for Rabi crops indicate that by using these water sources agricultural production as well as productivity of Rabi crops can be increased in the study area. Water availability and demands of Rabi crop season confirms that Rabi crops can be irrigated sustainably for long term use since it requires only 50, 48 and 60 % of total water availability in Sunsari, Saptari and Dhanusha districts respectively. Hence, it concludes that there is good potential of groundwater to use as irrigation in dry season crops.

Finally, assessment of water resource is an important for good planning and sustainable development as well as management of available water resources. Especially, in the country like Nepal, where there is large spatial and temporal variation of water resources across the country.

Recommendations

- Specific to this study, based on the water availability and water demand in the study districts it would be good to use the groundwater and pond water sources as irrigation to raise the production and productivity in the study area. Study results shows that potential volume of water has not been used in agriculture hence effective utilization of the available water sources could be the wise decision in the study area to raise the production and productivity.
- It is recommended for conjunctive use of groundwater with surface water for economical and sustainable use. Also, enhancement of groundwater use through appropriate conveyance and irrigation methods to increase water use efficiency, which may help in control of pumping volume and costs.
- It would be good to recommend that as groundwater is common pool resources it would be better to make some policy for control use of groundwater. It would help in over abstraction as well as reduce the cost of pumping.
- Study shows that large number of permanent and temporary ponds spatially exists in the study districts with considerable volume of the pond water which can be the potential source for dry season irrigation which has not been taken in to account by government although it has long history of use.
- It is important to understand the rainfall intensity in order to relate rainfall and recharge, daily rainfall intensity data may provide better information for the groundwater recharge consequences. As it is seen in the result analysis although rainfall had not varied in some years but recharge rate of the same years were found significantly. Hence, it would be better to know the rainfall intensity to compare the annual rainfall and recharge rate so that we can relate groundwater recharge variation with rainfall intensity. In this study only monthly rainfall data is considered for recharge.
- It is important to know base flow from the river to verify the groundwater balance in study area.
- It is recommended for the development and management of the existing temporary ponds. If existing large number of ponds get rehabilitated with depth, shape and size of the ponds so that it could store more water during monsoon season and which will finally help in dry season irrigation as well as recharge to the area.

Future Research

- A more comprehensive study on spatial specific yield and aquifer properties is recommended to arrive at guiding conclusive results.
- Although significant volume of water is available for use it would be better to account the economics of groundwater use for sustainable and profitable use of water resources.

References

- Alauddin M, Quiggin J (2008) Agricultural intensification, irrigation and the environment in South Asia: Issues and policy options. Ecological Economics 65: 111-124
- Ambast SK, Tyagi NK, Raul SK (2006) Management of declining groundwater in the Trans Indo-Gangetic Plain (India): Some options. Agricultural Water Management 82: 279-296 DOI http://dx.doi.org/10.1016/j.agwat.2005.06.005
- Baral T (2011) Evapotranspiration from natural and planted forest in the middle mountain of Nepal
- Basnet BMS (2009) Environment friendly technologies for increasing rice productivity. Journal of Agriculture and Environment 9: 34-40
- Bodach S, Lang W, Hamhaber J (2014) Climate responsive building design strategies of vernacular architecture in Nepal. Energy and Buildings 81: 227-242 DOI http://dx.doi.org/10.1016/j.enbuild.2014.06.022
- Dahal KR (2014) Assessment of Riverbed Excavation and its Effects on Ground Water Table of Shallow Aquifer of Tinau River NepalWater & Energy Proceedings of the Seminar on Water & Energy, pp. 46.
- Das B, Singh A, Panda SN, Yasuda H (2015) Optimal land and water resources allocation policies for sustainable irrigated agriculture. Land Use Policy 42: 527-537
- De Fraiture C, Fayrap A, Unver O, Ragab R (2014) INTEGRATED WATER MANAGEMENT APPROACHES FOR SUSTAINABLE FOOD PRODUCTION. Irrigation and Drainage 63: 221-231
- Duncan JMA, Biggs EM (2012) Assessing the accuracy and applied use of satellite-derived precipitation estimates over Nepal. Applied Geography 34: 626-638 DOI http://dx.doi.org/10.1016/j.apgeog.2012.04.001
- Duncan JMA, Biggs EM, Dash J, Atkinson PM (2013) Spatio-temporal trends in precipitation and their implications for water resources management in climate-sensitive Nepal. Applied Geography 43: 138-146 DOI http://dx.doi.org/10.1016/j.apgeog.2013.06.011
- Echhya K S (1992a) Shallow Groundwater Resources of the Terai Dhanusha District Nepal GWRDB HMG Nepal, Nepal.
- Echhya K S (1992b) Shallow Groundwater Resources of the Terai Saptari District of Nepal, March 1992 edn GWRDB HMG Nepal.
- FAO UN (2003) Grounwater Management the Search for Practical Approaches. Water Paper Water Reports 25: 42
- Frenken K, Faurès J-M (1997) Irrigation potential in Africa: A basin approach Food & Agriculture Organization
- Gami S, Ladha J, Pathak H, Shah M, Pasuquin E, Pandey S, Hobbs P, Joshy D, Mishra R (2001) Long-term changes in yield and soil fertility in a twenty-year rice-wheat experiment in Nepal. Biol

Fertil Soils 34: 73-78 DOI 10.1007/s003740100377

- Glendenning C, Van Ogtrop F, Mishra A, Vervoort R (2012) Balancing watershed and local scale impacts of rain water harvesting in India—A review. Agricultural Water Management 107: 1-13
- Golden Software I (2011) Surfer® User's Guide, Contouring and 3D Surface Mapping for Scientists and Engineers Golden Software Inc.
- Gurmu M (2010) Groundwater Recharge Estimation and Base Flow Analysis for the Mesoscale Chemoga Catchment,Upper Blue Nile (Abbay) River Basin, Ethiopia. M.Sc. Thesis, UNESCO-IHE
- Haefele SM, Bhattachan BK, Adhikari BB, Jr CCA, Shresta SM (2014) Spatial variability of fertilizer management and response in rainfed rice of Nepal. Agriculture, Ecosystems & Environment 189: 190-198 DOI http://dx.doi.org/10.1016/j.agee.2014.03.041
- Healy RW, Cook PG (2002) Using groundwater levels to estimate recharge. Hydrogeology journal 10: 91-109
- Heun JC (2001) Water for Agriculture -An Introduction for Water Resource Planners UNESCO-IHE
- Ichiyanagi K, Yamanaka MD, Muraji Y, Vaidya BK (2007) Precipitation in Nepal between 1987 and 1996. International Journal of Climatology 27: 1753-1762 DOI 10.1002/joc.1492
- Jon Cook, & ILK, Adhikari DL (2012) PREPARATION OF THE NEPAL AGRICULTURAL DEVELOPMENT STRATEGY, Kathmandu.
- Joshi NP, Maharjan KL, Piya L (2011) Effect of climate variables on yield of major food-crops in Nepal-A time-series analysis
- Kansakar SR, Hannah DM, Gerrard J, Rees G (2004) Spatial pattern in the precipitation regime of Nepal. International Journal of Climatology 24: 1645-1659 DOI 10.1002/joc.1098
- Kanzler A, Shrestha R (1989) Shallow Groundwater Explorations in TeraiSunsari District GWRDDB-UNDP Project NEP/86/025, Kathmandu.
- Laat PJMd (2015) Soil-Water-Plant-Relations UNESCO-IHE Institute for Water Education
- Machiwal D, Jha MK (2014) GIS-based water balance modeling for estimating regional specific yield and distributed recharge in data-scarce hard-rock regions. Journal of Hydro-environment Research
- Malik R, Kumar A, Dar S, Sharma R, Jat M, Singh S (2013) On-farm impacts of agronomic management optimization on wheat Productivity in a rice-wheat system of eastern Gangetic plains of South Asia. Experimental Agriculture (Submitted)
- Malla G (2008) Climate Change and Its Impact on Nepalese Agriculture. The Journal of Agriculture and Environment v9 (20090808): 62 DOI 10.3126/aej.v9i0.2119
- Malla G (2009) Climate change and its impact on Nepalese agriculture. Journal of Agriculture and Environment 9: 62-71
- Margat J, Van der Gun J (2013) Groundwater around the world: a geographic synopsis CRC Press
- McDonald AJ, Riha SJ, Duxbury JM, Lauren JG (2006) Wheat responses to novel rice cultural practices and soil moisture conditions in the rice–wheat rotation of Nepal. Field Crops Research 98: 116-126 DOI http://dx.doi.org/10.1016/j.fcr.2005.12.013
- Mishra HS, Rathore TR, Tomar VS (1995) Water use efficiency of irrigated wheat in the Tarai region of India. Irrig Sci 16: 75-80 DOI 10.1007/BF00189163
- Miyan MA (2014) Droughts in Asian least developed Countries: Vulnerability and sustainability.

Weather and Climate Extremes DOI http://dx.doi.org/10.1016/j.wace.2014.06.003

- Mohammadi Z, Salimi M, Faghih A (2014) Assessment of groundwater recharge in a semi-arid groundwater system using water balance equation, southern Iran. Journal of African Earth Sciences 95: 1-8
- Mudrakartha S (2013) Groundwater recharge management in Saurashtra, India: learnings for water governance
- Myint O (1999) Experience with Groundwater Irrigation in Nepal. WORLD BANK TECHNICAL PAPER: 125-132
- Obuobie E, Diekkrueger B, Agyekum W, Agodzo S (2012) Groundwater level monitoring and recharge estimation in the White Volta River basin of Ghana. Journal of African Earth Sciences 71:
- Ortega-Reig M, Palau-Salvador G, Cascant i Sempere MJ, Benitez-Buelga J, Badiella D, Trawick P (2014) The integrated use of surface, ground and recycled waste water in adapting to drought in the traditional irrigation system of Valencia. Agricultural Water Management 133: 55-64 DOI http://dx.doi.org/10.1016/j.agwat.2013.11.004
- Orzepowski W, Paruch AM, Pulikowski K, Kowalczyk T, Pokładek R (2014) Quantitative and qualitative assessment of agricultural water resources under variable climatic conditions of Silesian Lowlands (Southwest Poland). Agricultural Water Management 138: 45-54 DOI http://dx.doi.org/10.1016/j.agwat.2014.02.012
- Pariyar MP (2003) Water and poverty linkages in mountainous areas: A case study from Nepal. Water and poverty linkages: case studies from Nepal, Pakistan and Sri Lanka, International Water Management Institute, Sri Lanka: 5-50
- Pokhrel D, Bhandari BS, Viraraghavan T (2009) Arsenic contamination of groundwater in the Terai region of Nepal: An overview of health concerns and treatment options. Environment International 35: 157-161 DOI http://dx.doi.org/10.1016/j.envint.2008.06.003
- Pradhan Manik L, Maharjan Purna L, Tamang Damber B, Bahadur KCT (1966) Soil Survey of Sunasari DistrictReport.
- Rajmohan N, Prathapar SA (2013) Hydrogeology of the Eastern Gangetic Basin: an overviewIWMI Working Paper 157: 42 DOI 10.5337/2013.216
- Ram H, Dadhwal V, Vashist KK, Kaur H (2013) Grain yield and water use efficiency of wheat (Triticum aestivum L.) in relation to irrigation levels and rice straw mulching in North West India. Agricultural Water Management 128: 92-101 DOI http://dx.doi.org/10.1016/j.agwat.2013.06.011
- Regmi AP, Ladha JK, Pathak H, Pasuquin E, Bueno C, Dawe D, Hobbs PR, Joshy D, Maskey SL, Pandey SP (2002) Yield and Soil Fertility Trends in a 20-Year Rice–Rice–Wheat Experiment in Nepal. Soil Sci Soc Am J 66: 857-867 DOI 10.2136/sssaj2002.8570
- Salman SMA, World B (1999) Groundwater : legal and policy perspectives Proceedings of a World Bank seminar
- Sapkota P, Bharati L, Gurung P, Kaushal N, Smakhtin V (2013) Environmentally sustainable management of water demands under changing climate conditions in the Upper Ganges Basin, India. Hydrological Processes 27: 2197-2208
- Scanlon BR, Healy RW, Cook PG (2002) Choosing appropriate techniques for quantifying groundwater recharge. Hydrogeology Journal 10: 18-39
- Shamsudduha M, Taylor RG, Ahmed KM, Zahid A (2011) The impact of intensive groundwater abstraction on recharge to a shallow regional aquifer system: evidence from Bangladesh.

Hydrogeology Journal 19: 901-916

- Sharma BR, Rao K, Vittal K, Ramakrishna Y, Amarasinghe U (2010) Estimating the potential of rainfed agriculture in India: Prospects for water productivity improvements. Agricultural Water Management 97: 23-30
- Sharma PK, De Datta SK (1994) Rainwater Utilization Efficiency in Rain-Fed Lowland Rice. In: Donald LS (ed) Advances in Agronomy:85-120.
- Sherchan D, Karki K (2006) Plant nutrient management for improving crop productivity in Nepal. Improving plant nutrient management for better farmer livelihoods, food security and environmental sustainability: 41-57
- Shrestha ABWCPDJEMPA (2000) Precipitation fluctuations in the Nepal Himalaya and its vicinity and relationship with some large scale climatological parameters. JOC International Journal of Climatology 20: 317-327
- Shrestha N, Raes D, Sah SK (2013) Strategies to Improve Cereal Production in the Terai Region (Nepal) during Dry Season: Simulations With Aquacrop. Procedia Environmental Sciences 19: 767-775 DOI http://dx.doi.org/10.1016/j.proenv.2013.06.085
- Shrestha S, Adhikari S, Babel MS, Perret SR, Dhakal S (2015) Evaluation of groundwater-based irrigation systems using a water–energy–food nexus approach: a case study from Southeast Nepal. Journal of Applied Water Engineering and Research: 1-13
- Shrestha S, Bastola S, Babel MS, Dulal KN, Magome J, Hapuarachchi HAP, Kazama F, Ishidaira H, Takeuchi K (2007) The assessment of spatial and temporal transferability of a physically based distributed hydrological model parameters in different physiographic regions of Nepal. Journal of Hydrology 347: 153-172 DOI http://dx.doi.org/10.1016/j.jhydrol.2007.09.016
- Shukla A, Timilsina UR, Jha BC (2013) Wastewater Production, Treatment and Use in Nepal. UN Water Activity Information System Nd
- Singh N, AR R, Shekar M ea (2012) Rabi Maize Opportunities and Challenges Directorate of Maize Reserach, PUSA Campus. New Delhi.
- Synnott P (2012) Climate Change, Agriculture, & Food Security in Nepal pp. 42.
- Thapa U (2007) Water for Social and Economic Development of Nepal: The Case of Karnali Project ProQuest
- Udmale P, Ichikawa Y, Manandhar S, Ishidaira H, Kiem AS (2014) Farmers 'perception of drought impacts, local adaptation and administrative mitigation measures in Maharashtra State, India. International Journal of Disaster Risk Reduction DOI http://dx.doi.org/10.1016/j.ijdrr.2014.09.011
- UNESCO, WMO (1997) Water Resources Assessment. Handbook for Review of National Capabilities World Meteorological Organisation (WMO) and United Nations Educational Scientific Cultural Organisation (UNESCO), Geneva and Paris.
- Wang L, O Dochartaigh B, Macdonald D (2010) A literature review of recharge estimation and groundwater resource assessment in Africa
- WMO/UNESCO (1991) Report on Water Resources Assessment.
- World Meteorological O (2012) Technical material for water resources assessment World Meteorological Organization, Geneva

STUDY OFPHYSICO-CHEMICAL PROPERTIES OF THE SOILAND METEOROLOGICAL CONDITION OF THE BISHNUPADUKA, DHARAN-20, SUNSARI : AN ASSESMENT FOR SUITABILITY OF GINGER/TURMERIC CULTIVATION

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ABSTRACT

Soil quality is the soil's fitness to support crop growth without becoming degraded or otherwise harming the environment. This research truly focusses on the study of status of soil through primary and secondary data. The quality of soil was assessed by analyzing physico-chemical properties of soil and the climatic condition &temperature was assessed by analyzing meteorological data obtained from the nearest meteorological station located at Dharan-8, sunsari.From the lab analysis of 15 soilsamples, it was found that pH value is 5.6 to 6.4, organic matter is 2.06%to 5.9%, available NPK value are 0.1% to 0.29%, 9 to 172 kg/ha and 186 to 582 kg/ha respectively which tells that use of proper dose of NPK suits the soil for cultivation of ginger/turmeric. While analyzing data of past five years, the average temperature, average annual rainfall and the average humidity of study area was 20.39 □ (minimum) to 30.02 □ (maximum), 1978.8 mm and 77.51% respectively. Hence, we can conclude that the overall parameters required for ginger/turmeric cultivation in Bishnupaduka was found to be suitable.

***Keywords**: soil quality, physico-chemical, meteorological, cultivation*

1. INTRODUCTION

Agricultural viability depends upon a healthy soil. Soil is a dynamic resource that supports plant life. It is made up of different sized mineral particles (sand, silt, and clay), organic matter, and numerous species of living organisms. Thus, soil has biological, chemical, and physical properties, some of which are dynamic and can change in response to how the soil is managed (USDA, 2001). Soil quality is the soil's fitness to support crop growth without becoming degraded or otherwise harming the environment. Soil quality should be evaluated based on soil function. It is governed by soil-forming processes (Karlen et al., 1997). Ginger can grow well at pH 5.5 to 6.5 (Casandra, 2012) and suitable pH range for turmeric is 4.5 to 7.5 (Kumar et al., 2012). The soil with rich organic matter is suitable for ginger/turmeric cultivation. Ginger/turmeric requires sandy or loam mixtures for best cultivation. Field investigation in India indicated that ginger/turmeric yield more in high nitrogen content soil. According to study done in Kerala state, India, in one crop period ginger/turmeric removed 31 kg/ha Phosphorous and removed 194 kg/ha Potassium(Nair, 2013).The required range of average annual temperature and average humidityare 20□ to 35□ and 70% to 90% respectively for ginger/turmeric cultivation (Sharifi-Rad et al., 2017).

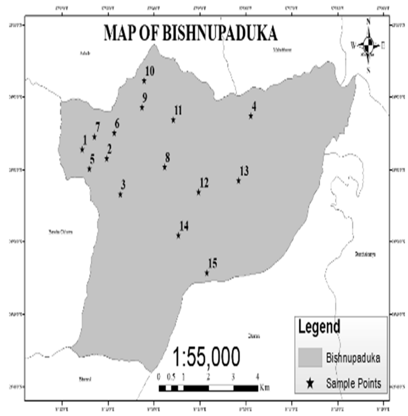
2. OBJECTIVES

- To study the physico-chemical properties of soil of existing ginger/turmeric field.
- To study the climatic condition and temperature of that belt.

3. METHODOLOGY

- **Sampling**

The selected area was plotted into GIS and 15 representative coordinates were located. With the help of GPS the representative sample for Soil analysis was located on the field. The surface soil samples (0-30 cm depth) were collected from our study area by using soil sampling auger during September, 2018. The random method based on the variability of the land was used to collect soil samples. The soil samples collected was fully representative as possible, and all precaution was taken to ensure that, as far as possible, the samples didn't undergo any changes in the interval between sampling and examination.



- **Sample Preparation**

Due to high moisture content, the collected sample were not ready enough to carry out the test. So, the collected samples were dried in the absence of sunlight for 10 days. Thus, obtained dried samples were taken to the lab for testing. The sample was prepared by process of drying, crushing, sieving, dividing and milling in laboratory for physical and chemical analysis.

- **Laboratory Analysis**

Different parameters of soil were determined by following methods:-

S N		Parameters		Methods
1		pH		pH meter
2		Texture		Hydrometer Method
3		Soil Organic Matter		Modified Walkley and Black Method
4		Nitrogen Content		Determined on the basis of OM content
5		Available Phosphorous		Modified Olsen Bicarbonate Method
6		Available Potassium		Flame Photometer Method

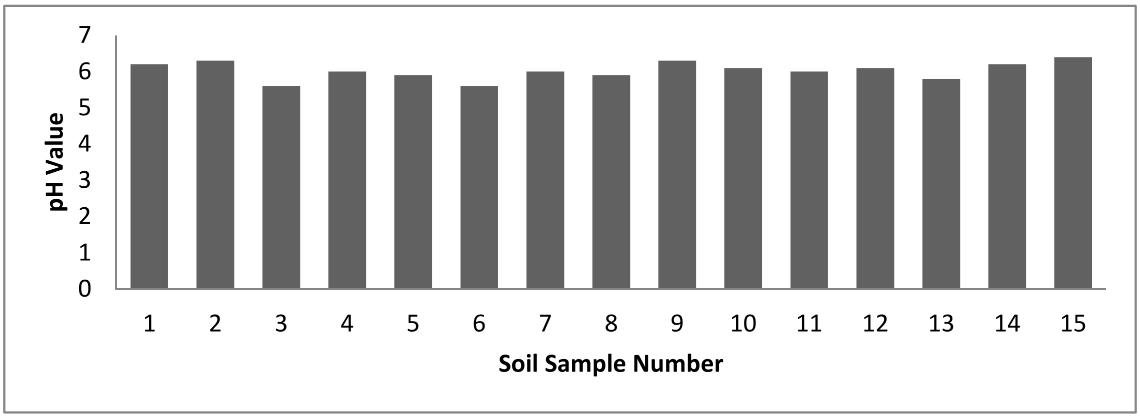
The collected soil samples were tested at Regional Soil Testing Laboratory, Jhumka, Sunsari.

- **Secondary Data**

The climatic conditions like temperature, rainfall, humidity, etc. of that place is collected from Eastern Regional Meteorological Station, Dharan which is the nearest meteorological station from our study area.

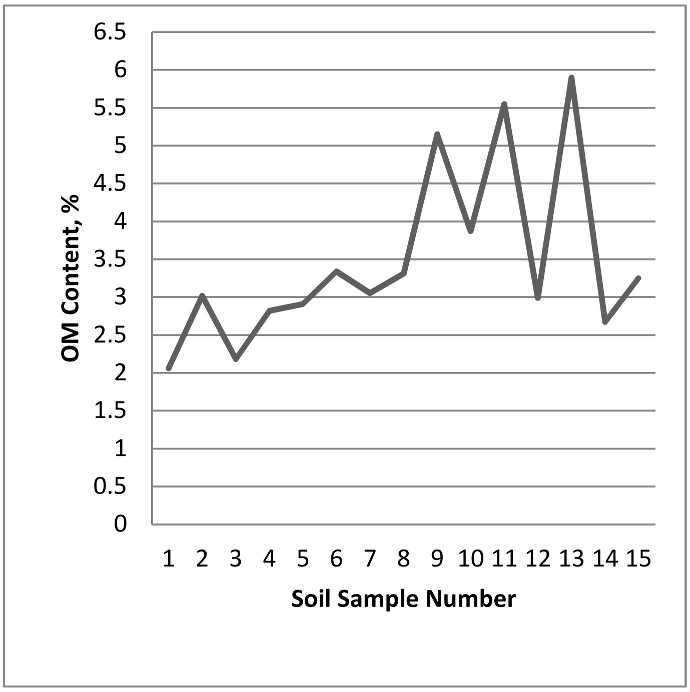
4. Soil Quality Analysis:

- Soil pH



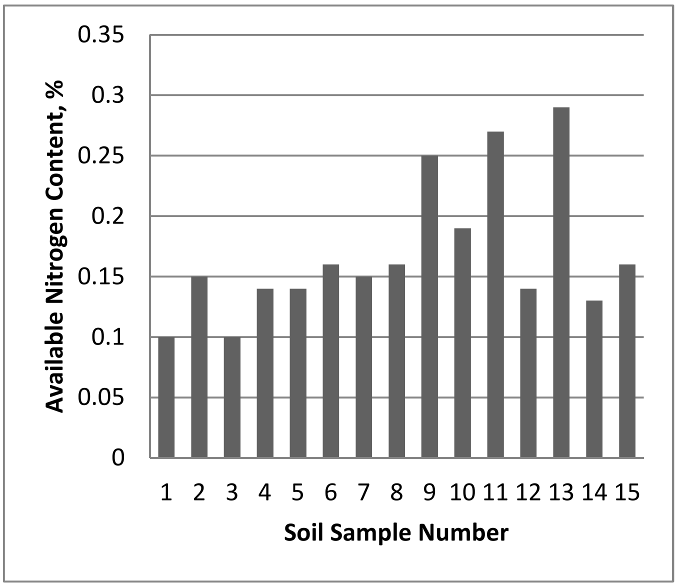
Soil pH is important chemical parameter of soil that affects nutrient availability and determines soil quality. According to soil analysis, sample number 3& 6 has lowest pH value i.e. 5.6 and sample number 15 has highest pH value i.e. 6.4.Average pH of soil sample is 6.03. Ginger can grow well at pH 5.5 to 6.5 (Casandra, 2012) and suitable pH range for turmeric is 4.5 to 7.5 (Kumar et al., 2012).Hence it concludes that the soil is suitable for cultivation of ginger and turmeric.

- **Soil Organic Matter**



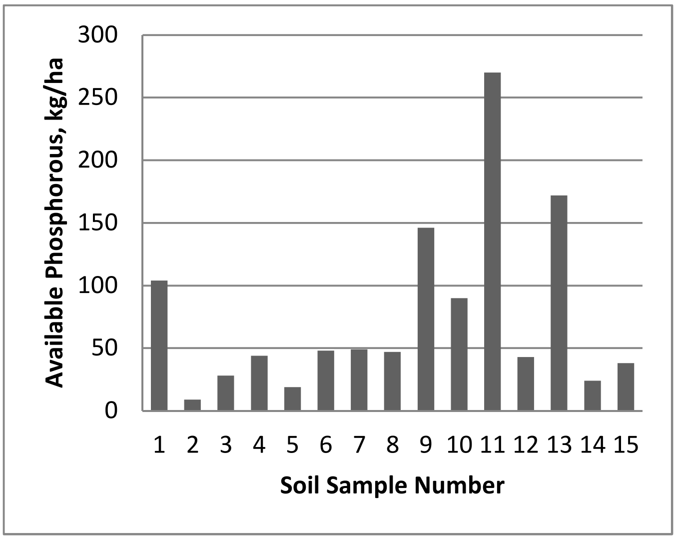
Soil organic matter is important source of soil essential nutrient. Thus, it is fundamental parameter for determining quality of soil. Following data shows that the soil with highest value of organic matter is sample number 13 (i.e. 5.9 %) and that with lowest value is sample number 1 (i.e. 2.06 %). The average value of organic matter is 3.47 %. The organic matter content of 1 to 2.5 % is low in rating, 2.5 to 5.0 % is medium in rating and 5 to 10 % is high in rating (Id, Maharjan et al., 2018).Hence it concludes that organic matter content for sample number 1 & 3 has low organic matter, sample number 2, 4, 5, 6, 7, 8, 10, 12, 14 & 15 has medium organic matter and sample number 9, 11 and 13 has high organic matter. Thus sample with rich organic matter is suitable for ginger/turmeric cultivation (Nair, 2013).

➢ Available Nitrogen Content



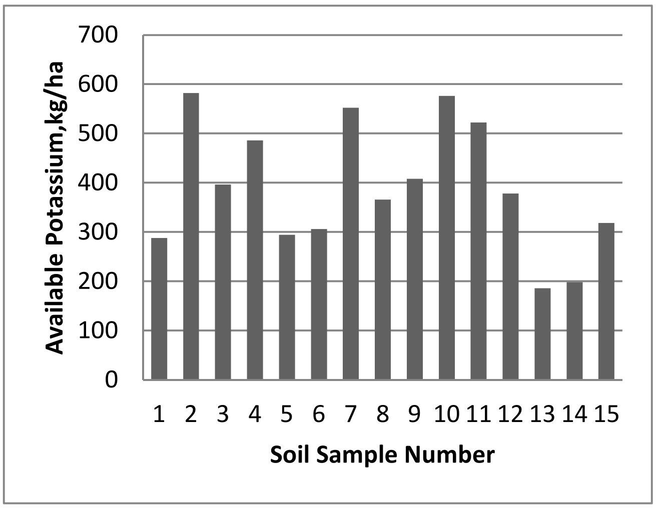
Usually, N has a greater effect on crop growth, crop quality, and yield. Following data shows that the soil with highest value of Available Nitrogen is sample number 13 (i.e. 0.29 %) and that with lowest value is sample number 1 & 2 (i.e. 0.1 %). The average value of Available Nitrogen is 0.17 %. The Nitrogen content of 0.05 to 0.10 % is low in rating, 0.10 to 0.20 % is medium in rating and 0.20 to 0.40 % is high in rating (Id et al., 2018).Hence it concludes sample number 1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 14 and15 has medium Nitrogen content and sample number 9,11 and 13 has high nitrogen content. Field investigation in India indicated that ginger/turmeric yield more in high nitrogen content soil so that in our study area, wecan easily grow ginger/turmeric (Nair, 2013).

➢ Available Phosphorous



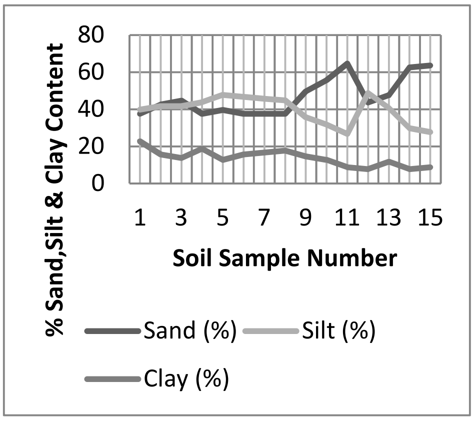
Phosphorous plays a role in photosynthesis, respiration, energy storage and transfer, cell division, cell enlargement and several other processes in plant. Thus, it is fundamental parameter for determining quality of soil. The above figure is the graphical representation of Available Phosphorous of soil samples. From the figure, it is clear that sample number 11 has highest amount of available phosphorous (i.e.270 Kg/ha). Similarly, sample number 2 has lowest amount of available phosphorous (i.e.9 Kg/ha). The average amount of available phosphorous was found to be 75.4 Kg/ha. The available phosphorous of less than 10 Kg/ha is very low in rating, 10 to 30 Kg/ha is low in rating, 30 to 55 Kg/ha is medium in rating, 55 to 110 Kg/ha is high in rating and of greater than 110 Kg/ha is very high in rating (Id et al., 2018). Hence it concludes sample number 2 has very low available phosphorous content and sample number 2, 3, 5 and 14 has low available phosphorous content. Similarly, sample number 4, 6, 7, 8, 12 and 15 has medium available phosphorous content and sample number 9, 11 and 13 has very high phosphorous content. According to study done in Kerala state, India, in one crop period ginger/turmeric removed 31kg/ha Phosphorous which is sufficiently available in the soil of study area (Nair, 2013).

➢ **Available Potassium**



Potassium is the essential element that limits plant productivity. From the figure, it is clear that sample number 2 has highest amount of available potassium (i.e.582 Kg/ha). Similarly, sample number 13 has lowest amount of available potassium (i.e.186 Kg/ha). The average amount of available phosphorous was found to be 390.4 Kg/ha. The available potassium of less than 55 Kg/ha is very low in rating, 55 to 110 Kg/ha is low in rating, 110 to 280 Kg/ha is medium in rating, 280 to 500 Kg/ha is high in rating and of greater than 500 Kg/ha is very high in rating (Id et al., 2018). Hence it concludes sample number 12 & 13 has medium available potassium content and sample number 1, 3, 4, 5, 6, 8, 9, 12 and 15 has high available phosphorous content. Similarly, sample number 2, 7, 10 and 11 has very high phosphorous content. According to study done in Kerala state, India, in one crop period ginger/turmeric removed 194 kg/ha Potassium which is sufficiently available in the soil of our study area (Nair, 2013).

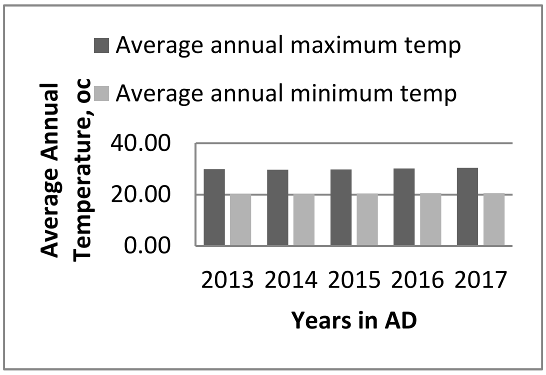
➢ **Soil Texture**



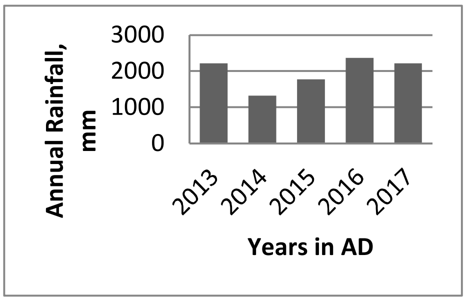
Soil texture affects soil sustainability. The sand, silt and clay are the three components of soil texture. The % sand of soil sample were ranged from 37.6 to 64.6 % with an average value of 46.8 % and that of % silt were 26.7 to 48.7 % with an average value of 39.5 % while the range of % clay were 7.7 to 22.7 % with an average value 13.7 %. Sample number 1 to 9 and 12 &13 were found loam, sample number 10, 11, 14 and 15 were found sandy loam.Ginger/turmeric requires sandy or loam mixtures for best cultivation (Nair, 2013).Hence it concludes all soil sample are suitable for ginger/turmeric cultivation.

5. Meteorological Data Analysis

➢ **Average Annual Temperature**



Above chart shows that there was maximum average annual temperature i.e. 30.46 □ in 2017 AD and minimum average annual temperaturei.e. 20.14 □ in year 2014 AD. While analyzing data of past five years , the average temperature of study area was 20.39 □ (minimum) to 30.02 □ (maximum). Hence this average annual temperature was within required range (20 □ to 35 □) for ginger/turmeric cultivation (Sharifi-Rad et al., 2017)



➢ **Annual Rainfall**

Above chart shows that there was maximum annual rainfall i.e. 2362.2 mm in 2016 AD and minimum annual rainfall i.e. 1321.8 mm in year 2014 AD. Hence the average annual rainfall of study area was 1978.8 mm while analyzing data of past five years. Hence, this average annual rainfall was sufficient for ginger/turmeric cultivation (Sharifi-Rad et al., 2017).

➢ **Average Humidity**

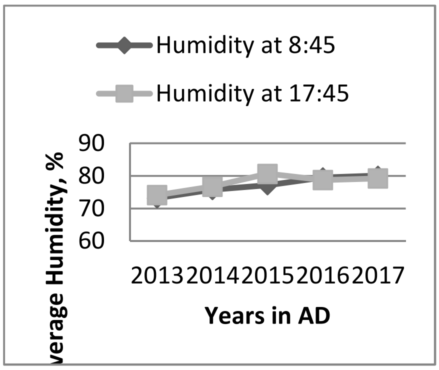


Chart shows that at time 8:45 there was maximum average humidityi.e. 80.08% in 2017 AD and minimum average humidity i.e. 73.17% in year 2014 AD. At time 17:45 there was maximum average humidityi.e. 80.64% in 2015 AD and minimum average humidity i.e. 74.11% in year 2013 AD. Hence the average humidity of study area was 77.51% while analyzing data of past five years. Hence this average humidity was within required range (70-90%) for ginger/turmeric cultivation (Sharifi-Rad et al., 2017).

6. CONCLUSION

Based on research conducted on soil of Bishnupaduka, Dharan following conclusions were made:

- By the study of physical properties i.e. Soil Texture, it was found that the overall soil texture of Bishnupaduka is good for Ginger/Turmeric cultivation, it is loam or sandy loam.
- Similarly, Soil pH is slightly acidic in nature i.e. within the range of (5.6-6.4).
- The macronutrient contents of soil are within the range of 0.1-0.29% for available nitrogen content, 9-270 kg/ha for available phosphorous and 186-582 kg/ha for available potassium.
- Overall Organic Content is within the range of 2.06-5.9%.
- The average temperature of study area was 20.39□ (minimum) to 30.02□ (maximum) while analyzing data of past five years. Average annual temperature was with in required range for ginger/turmeric cultivation.
- The average annual rainfall of study area was 1978.8 mm while analyzing data of past five years which was sufficient for ginger/turmeric cultivation.
- The average humidity of study area was 77.51% while analyzing data of past five years which was within required range for ginger/turmeric cultivation.

So, we can conclude that the quality of soil and meteorological condition of Bishnupaduka is good and is best suited for ginger/turmeric cultivation.

7. ACKNOWLEDGEMENT

We feel extremely privileged to express our deep sense of reverence and indebted to our advisor Er. Sameer Shakya for his valuable effort, unflagging enthusiasm, constructive criticisms and inspiring advices throughout the period of research works and thesis writing.

8. REFERENCES

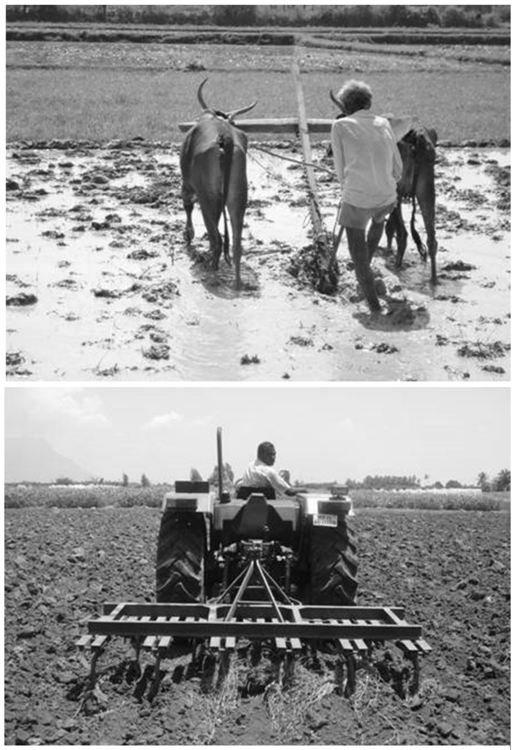
- Casandra, M. (2012). What Kind of Soil Does Ginger Like? | Home Guides | SF Gate. Retrieved February 11, 2018, from http://homeguides.sfgate.com/kind-soil-ginger-like-42476.html
- Id, D. P., Maharjan, B., Chalise, D., & Shrestha, R. K. (2018). Digital Soil Mapping in the Bara District of Nepal Using Kriging Tool in ArcGIS Digital soil mapping in the Bara district of Nepal using kriging tool in ArcGIS, (October). https://doi.org/10.1371/journal.pone.0206350
- Karlen, D. L., Mausbach, M. J., Doran, J. W., Cline, R. G., Harris, R. F., & Schuman, G. E. (1997). Soil Quality: A Concept, Definition, and Framework for Evaluation (A Guest Editorial). *Soil Science Society of America Journal*, *61*(1),4.https://doi.org/10.2136/sssaj1997.03615995006100010001x
- Kumar, S. C., Bhai, S. R., Editors Lijo Thomas, T. C., & Publisher Director, R. P. (2012). Contributors Jayashree. *Turmeric*, 671–672.
- Nair, P. P. (2013). *The Agronomy and Economy of Turmeric and Ginger*. *The Agronomy and Economy of Turmeric and Ginger*. https://doi.org/10.1016/C2011-0-07514-2
- Sharifi-Rad, M., Varoni, E. M., Salehi, B., Sharifi-Rad, J., Matthews, K. R., Ayatollahi, S. A., … Rigano, D. (2017). Plants of the genus zingiber as a source of bioactive phytochemicals: From tradition to pharmacy. *Molecules*, *22*(12), 1–20. https://doi.org/10.3390/molecules22122145
- USDA. (2001). Soil Quality - Introduction. *Usda*, (June),1–2.https://doi.org/10.1088/0022-3727/39/1/032

Conservation Tillage

-Shreemat Shrestha

What is tillage?

Tillage is a basic operation for the crop cultivation. Tillage is the manipulation of soil to obtain favorable conditions for the germination of seed, plant establishment and growth. Tillage operation includes ploughing, harrowing, mechanical destruction of weeds and soil crusts etc. and it prepares agricultural land with good filth appropriate for seeding/ transplantation. Tillage is performed by using different tillage implements, viz. animal drawn plough, Power tiller drawn plough/cultivator, tractor drawn plough, manually operated implants. (Fig. 1) For example, a mustard seed requires a seedbed consisting of fine particles, since the seed itself is very small.



FFig1:- Tillage operations by using animal drawn plough and tractor drawn implements.

Functions of tillage:

- To prepare a seedbed of good filth.
- To destroy weed and prevent its growth
- To incorporate organic matter, manure and fertilizer in soil
- To improve aeration in the soil
- To improve infiltration and water retaining capacity of soil and reduce water loss. Precision leveling/ grading and shaping for irrigation and other operations.

Drawbacks of excessive tillage:

Traditionally preparation of very fine seedbed by multiple operation of tillage implements were considered to be prerequisite for enhanced crop production. It is observed that soil erosion is accelerated due to excessive tillage, which is presented in fig. 2. After realizing the negative effects of continuous excessive tillage, it is realized that the present practice of excessive tillage in crop production is not economical as well as not sustainable. Annual average nutrient loss from sub-Saharan African soils is estimated at 24kg/hectare and rising. In South Asia, the cost of different forms of land degradation - such as loss of soil structure leading to erosion, compaction and formation of surface crusts, is estimated at US$10 billion a year. (FAO, 2000)

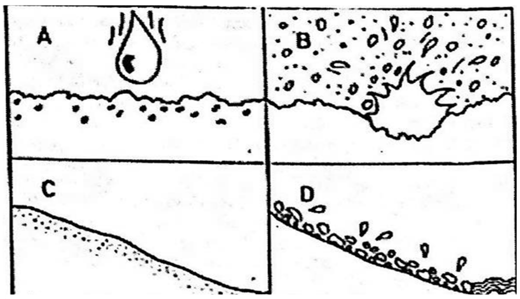


Fig 2:- Phases of soil erosion: The impact of rain drops on the bare soil surface. (A) Causes the detachment of small soil particles. (B) That clogs the pores and forms a surface sealing (C) The water that runs off carries soil particles, which are deposited down slope when the runoff velocity is reduced (D) Soil slides down from its original position.

The flow chart of drawback of tillage is soil 75 to 80% of rainwater left the plots as explained in the fig. 3. The major consequences run off (Figure 4). Similar results have been of excessive tillage operations are reduction in obtained by researchers in many parts of the crop yield, increase erosion, high cost of cultivation and increased air and water pollution. The major drawbacks of tillage operations are listed below.

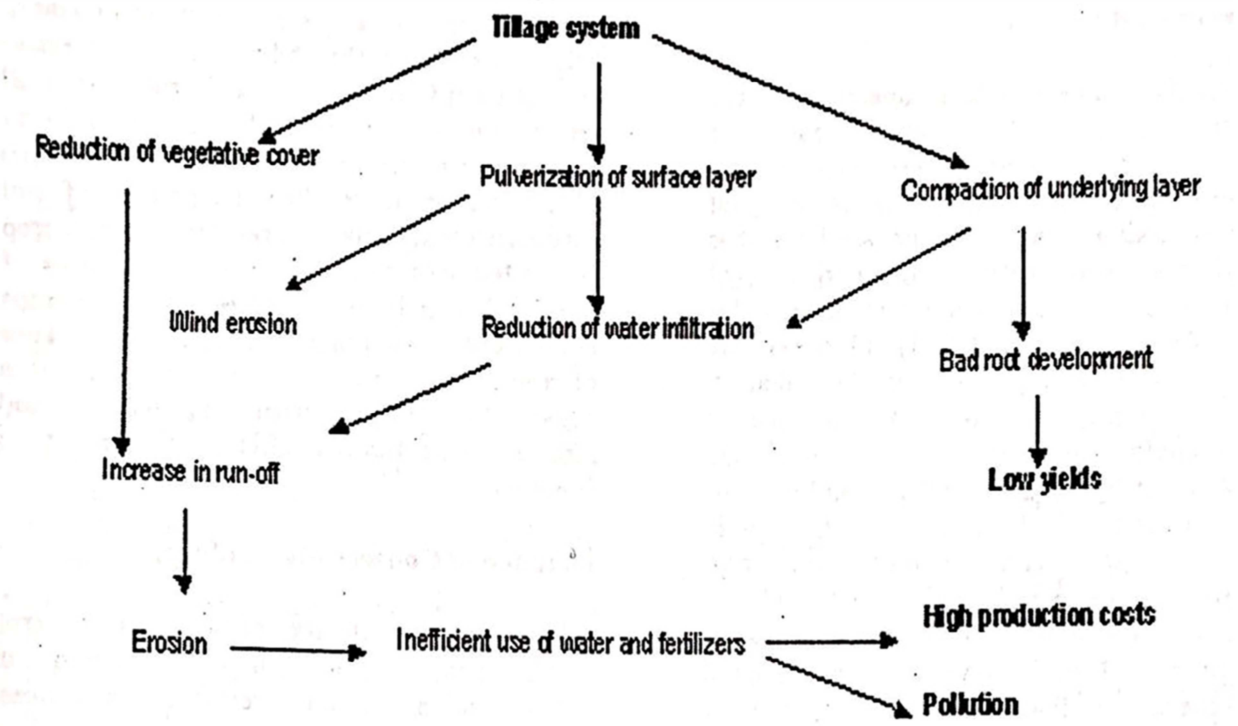


Fig. 3: Flow chart of drawbacks of tillage

- Timely planting is not possible due to long turnaround time due to number of tillage operations (viz. primary, secondary etc.)
- Increase in production cost due to number of passes
- Loss of soil moisture due to exposure of moist soil underneath
- Loss of soil in rainy season mainly in *bari* land
- Destruction of soil structure
- Limits water infiltration through surface sealing
- High demand on power, time and equipment
- Causes tillage erosion

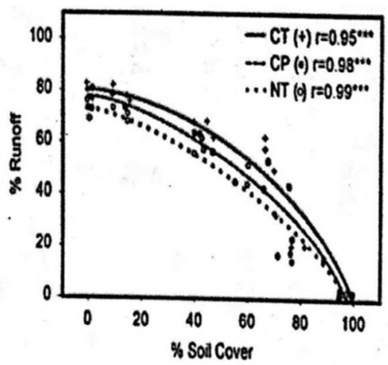


Figure 4: Total runoff after 60 minutes of simulated rainfall as affected by % soil cover and tillage system (CT: conventional tillage, CP chisel plough, NT: no-tillage).

Research conducted in Brazil (Roth, 1985) also shows, that the percentage of soil covered with plant residues is the most important factor that influences water infiltration into the soil. While virtually all water from a simulated rainfall of 60 mm/hour infiltrated when the soil was 100% covered with plant residues, in the case of bare soil 75% to 80% of rainwater left the plots as runoff (Figure 4). Similar results have been obtained by researchers in many parts of the world.

Conservation tillage:

Traditionally multiple tillage operations were considered essential to create a favorable seedbed, to achieve good soil-seed contact, and to ensure rapid, uniform crop emergence. But due to excessive tillage for fine seed bed has resulted more soil erosion, increased cost of cultivation, more environmental threats etc. After World War II, Melsted (1954) addressed the effects of tillage on filth and suggested that by substituting capital for labor, the science of farming could replace the art of fanning. He suggested that by using fertilizer N and reduced tillage, erosion could be controlled, organic matter increased, and optimum soil tilth developed. Hence to address the negative effects of excessive tillage, new dimension of tillage i.e. conservation tillage is developed and adopted around the world. Permanent no-till is now used on 45% of cropland in Brazil, 50% in Argentina, and 60% in Paraguay, with Paraguay now leading the world in percentage of no-tillage adoption. Access to adequate herbicides and seeding machines, as well as sufficient knowledge ofno-tillage methods, were necessary in each instance for widespread adoption of the system. (Derpsch, 2004)

In conservation tillage, crops are grown with minimal disturbance of soil. When the amount of tillage is reduced, the stubble or plant residues are not completely incorporated, and most or all remain on top of the soil rather than being plowed or incorporated into the soil. In this tillage system more than 30 percent of soil surface is covered by crop residue. The new crop is planted into this stubble or small strips of tilled soil. Weeds are controlled with cover crops or herbicides rather than by tillage. Increased use of crop residue and organic matter in the soil in conservation tillage system improves the soil tilth and soil fertility after few years of its adoption.

Fig 5:- Conservation tillage

Function of Conservation Tillage:

- Minimum disturbance of the soil for crop cultivation is the major function of conservation tillage resulting significant reduction in soil erosion.
- Covering the soil surface by crop residue (at least 30 percent) is an integral component of conservation tillage to conserve soil moisture as well as add organic matter in the soil and suppress weed.
- In contrast to conventional tillage system the major focus of conservation tillage system is creation of favorable condition of soil environment for better crop establishment and growth through biological processes rather than physical and chemical process.

Limitations:

- In the soils with poor drainage capacity the conservation tillage may not provide favorable result for few years.
- Weed control is critical in conservation tillage.
- For the few years the crop yield may be less than conventional tillage system in some cases.
- In general mindset of farmers, extension agent, and even scientists are based on agricultural production on conventional tillage system. Hence there is need of mindset change of farmers & technicians through training and demonstrations on conservation tillage system.
- Unavailability of appropriate bullock drawn zero till/ minimum till drill for small/ narrow hill terraces.

Advantages:

- The operation cost of planting is significantly reduced due to single pass of bullock/ tractor compared to multiple pass of primary and secondary tillage before sowing. Timely planting is possible in minimum tillage system in contrast to delayed planting due to long turnaround time in conventional tillage system.
- Due to minimum disturbance of soil and use of cover crop and crop residue on soil surface, the air and water erosion is significantly reduced in conservation tillage system.
- In the rained situation residual soil moisture is critical. Due to minimum disturbance of soil, soil moisture is conserved and efficiently used by the crop for its germination and establishment. • In conservation tillage system the quality of soil is enhanced due to cover crop, crop residue mulching and addition of organic matter in soil.
- A continuous no-till system increases soil particle aggregation (small soil clumps) making it easier for plants to establish roots. Improved soil tilth also can minimize compaction. Compaction is also reduced by reducing trips across the field.

- Intensive soil tillage accelerates organic matter mineralization and converts plant residues in carbon dioxide, which is liberated into the atmosphere contributing to the greenhouse effect and to global warming. Conservation tillage reduces the releases of CO2 into the atmosphere because of minimum disturbance of soil and surface cover by agricultural residue. Moreover, reduced number of hours on use of tractors/ machines in conservation tillage in contrast to conventional tillage also significantly reduces the emission.

Disadvantages:

Conservation tillage system involves a long-term process to enhance the quality of soil to enhance the agricultural productivity in sustainable manner. Hence, it is not possible to attain immediate quantum jump of agricultural production by adoption of conservation tillage.

Types of Conservation Tillage:

Zero tillage, minimum tillage and contour tillage are major conservation tillage system practiced.

Zero Tillage:

In zero tillage system, soil is opened (narrow slit or small pit) only for placing seed and fertilizer and then covered. This tillage system includes dibbling by using dibble stick, sowing by using zab seeder and using zero till drill. The dibble stick and zab seeder is used to sow bold grained seeds such as maize, soya bean etc. The zero till drill can sow small as well as bold grain seeds depending upon its metering device.

A **dibble stick** (Fig. 6) is a stick to make holes in the soil. Its conical point requires less force to penetrate the soil than a blunt stick. A farmer makes a hole with a dibble stick and drops few maize kernels in to the hole by other hand. As the fanner steps forward to plant next hill he covers the seed and firms the soil with his foot. It is especially helpful for larger seeds, such as bean or pea seeds and for transplanting young seedlings.

Fig 6:- Dibble stick in operation

A **Zab Seeder** (Fig. 7) is manually power machine of weight about 3-6 kg weight with 1 kg of maize seed and fertilizer. At the bottom of seed and fertilizer box there is seed plate and fertilizer metering device. A typical zab planter makes 2 rectangular adjacent holes about 2X3 cm and 5 cm deep and drops metered maize seed and fertilizer in those 2 holes. Like in dibble stick the farmer covers the seed and fertilizer and firms the soil with his foot while in operation.

Fig 7:- Jab Seeder in operation

A **Zero till drill** (Fig 8) (Fig 9) consists of narrow furrow opener which makes a narrow slit in the soil. It also consists of seed and fertilizer box which is metered by the metering device and dropped to the narrow slit. A chain or a press wheel is attached to cover and firm the soil. Depending upon the power source the zero till drill is further classified as animal drawn zero till drill, power triller drawn zero till drill and 4-wheel tractor drawn zero till drill the narrow slit is made by the straight blades of the rototiller. Zero till planter/seed drill have either all or some of the following components:

Fig 8:- Zero trill drill

Fig 9:- Zero trill drill in operation

- Hoppers for seed and, if applicable, for fertilizer with the respective metering mechanisms and delivery tube.
- Row cleaner, if necessary, to remove excess mulch from the plant row.
- Cutting disc to cut through residue cover.
- Furrow opener for fertilizer.
- Furrow opener for seeds.
- Seed press wheel.
- Furrow closing wheel (often in combination with depth control).
- Furrow press wheel.

Zero tillage is successfully adopted by a farmer Jaya Kisor Yadav in Parsa in wheat cultivation since last 12 years.

Minimum Tillage:

In minimum tillage system consists of following tillage systems in which there is significantly less tillage operation than the conventional tillage system.

Minimum tillage by depth:

In conventional tillage system there is several pass of tillage tilling the soil of depth more than 10 cm. In minimum tillage by depth system minimum till drill (fig 10) is used which till the soil depth of about 2-4cm, meters the seeds and drops the seed and covers and press by roller simultaneously in a single press.

Fig 10:- Min till drill on operation

Minimum tillage by tillage area:

In conventional tillage system whole land is ploughed where as in minimum tillage area system only a part of the land along the contour is ploughed and prepared a seed bed rather than ploughing entire plot.

Strip tillage:

In strip tillage only a narrow strip is tilled and seed is sown along the strip. In between the strips the land is not tilled at all. There are also strip till drill (Fig 11) to perform strip tillage.

Fig 11:- Strip till drill on operation

Contour Tillage:

The tillage is performed across the slope and along the contour (Fig 12) and the plants are also planted along the contour. The contour tillage will enhance the infiltration and reduce the runoff and soil loss. Moreover contour tillage will reduce variation in tillage depth and speed and consequently reduce tillage erosion (Lobb et.al 2000)

Fig 12:- Contour Cultivation

Surface Seeding:

Surface seeding is adopted for wheat crop after rice harvest in the field if there is very high soil moisture (if there is clearly visible foot prints while walking on the field). In this case the wheat seed is mixed with cow dung and kept for 24hrs then it is broadcasted in the field without any tillage at late hours at the time of sun set. The seed is mixed with cow dung to facilitate easy germination and to prevent from birds eating wheat seed (Fig 13).

Fig 13:- Surface Seeding

Controlled Traffic Farming (CTF):

In controlled traffic farming, all the field traffic is restricted to permanent traffic lanes (of tractor), which are normally untilled and unplanted, to optimize traction and traffic ability (Fig 14). The untrafficked soil of the crop beds can be managed for optimum crop performance, uncompromised by traffic or unnecessary tillage. Furthermore, controlled traffic can make field operation timely precisely, which is in accordance with precision farming trends in the near future. Controlled traffic with zero tillage provides better protection for both surface and subsurface soil, resulting in reduction of runoff and improvement of crop production. With CTF, the need for tillage is often minimal and it is synonymous with and enhances the performance of conservation and zero tillage systems. The concept of controlled traffic farming separates crop areas and traffic lanes permanently providing optimal conditions for crop growth (no traffic) and traction (compacted). Even through 20% of the field was occupied by wheel tracks without planting, no yield decrease was observed in controlled traffic treatment when compared with conventional tillage. Power requirements and fuel consumption were lower in controlled traffic.

Conservation Tillage Period:

Conservation tillage and sowing is performed just after harvesting the previous crop, this will not only result timely planting but conserves residual soil moisture. In conservation tillage system, the field is not kept fallow. If the major crop is not possible cover crop is sown in fallow period. Leuminous and grass are the major cover crops.

Precautions:

- Check there should be at least 30% of field area covered by the crop residue.
- Do not adopt zero till at poor drainage condition.
- Adopt appropriate weed management practice in conservation tillage system
- Harvest the cover crop at least 15 days before planting main crop in water deficit areas.
- Never burn the crop residue in the field

Scope:

- Zero tillage can be well adopted in medium to coarse textured soil with periodic drought prone area.
- Minimum tillage and contour tillage can be well adopted in silty clay and loam soil as well • as in sloppy area.
- Surface seeding in the area where there is excess soil moisture for wheat cultivation especially in low lands with drainage problems.

References:

Derpsch, R.2004:*History of crop production with and without tillage. Leading edge Journal of no till agriculture, March 2004.*

Derpsch, R.2006:*Frontiers in Conservation Tillage and Advances in Conservation Practice. No-Tillage, Sustainable Agriculture in the New Millennium, CC 13223, Shopping del So lAsunciOn-PARAGUAY*

FAO, 1976:*Farm Implements for arid and tropical regions. Food and Agriculture Organization of united states. Rome, 1969.*

FAO, 2000:*Conservation tillage: the end of the plough? www.fao.orgi Melsted, S. W. 1954. New concepts of management of Corn Belt soils. Adv. Agron. 6121-142.*

Roth, C.H.1985: *Infiltmbilitat von Latossolo-Roxo-B6den in _Nordparana, Brasilien, in Fel dv ersuchen air ErosionskontrollemitverschiedenenBodenbearbeitungs-systemen and Rotationen. GottingerBodenkundlicheBerichte, 83, 1 -104.*

RWC, 2003:*Addressing resource conservation issues in rice wheat system of south Asia. A resource books. Rice Wheat Consortium for Indo Gangetic plains, -CIMMYT, New Delhi, India*

Lobb, D A. Lindstrom, M J and Quine, T A 2000:*Tillage at the Threshold of the 21st Century: New Directions in Response to Tillage Translocation and Tillage Erosion. Paper presented in ISTRO — 2000: 15th Conference of the International Soil Tillage Research Organization Forth Worth, Texas, July 2000*

Food Deficit: Challenge for the Modern World

-Arun Kumar Sharma
062-BAE-01

Abstract
World's population exceeds seven billion, but the land for agriculture is decreasing day by day due to infrastructure and other uses. Some countries are doing huge investment on wars while some countries facing severe food shortage. Millions of peoples are dying due to hunger every week. The most challenging issue for the modern world is to provide a food for increasing population from decreasing agricultural lands. This article intends to analyze the causes and consequences of food deficit and tries to provide some solutions to fight with it.

Introduction

The food deficit is a widespread scarcity of food caused by several factors including crop failure, population unbalance or government policies. Nearly every continent in the world has experienced a period of food deficit throughout the history. Some countries, particularly in sub-Sahara Africa, continue to have extreme cases of food deficit.

Food shortage occurs when food supplies within a bounded region do not provide the energy and nutrients needed .by that region's population. Food shortage is most easily conceptualized as a production problem - not enough food is grown to meet regional needs - but constraints on importation as well as storage can also cause or contribute to food shortage. Food shortage is also created where food is exported from areas where production is adequate or even abundant.

Food sufficiency or deficit always depends upon the population to be feed. Availability of food is determined by domestic production, import capacity, existence of food stocks and food aid. Access to food depends on levels of poverty, purchasing power of households, prices and the existence of transport and market infrastructure and food distribution systems.

Despite a general decline in fertility rates, world population is still growing rapidly. United Nations predictions of global population increase to the year 2025 require an expansion of food production of about 40-45% (Stockle, 2002). According to an FAO report released on 9 October 2006, forty countries are facing food emergencies and require external assistance (FAO, 2006).

Nepal occupies the 16th position among 31 countries that are reeling from a food deficit with 40 districts facing a food shortage. Food insecurity is growing in Nepal as well as in the world despite improvements in technology in food production and processing. In addition rising prices is aggravating the food crisis. On the other hand, natural calamities such as winter droughts and floods have had a severe impact on food security in the country (The Kathmandu Post, 2010-04-01). In Nepal Humla, Mugu and Bajhang are the districts having extremely food deficit where less than 4 month food sufficiency occurs. Similarly 7 districts have severely food deficit (less than 6 months food sufficiency), 18 districts have moderate food deficit (less than 10 months food sufficiency), 14 districts have mild food deficiency, 9 districts have food sufficiency and 21 districts have food surplus (WFP,1998). According to Nepal Agricultural Research Council, in 2005 Nepal had 213,027 MT foods was sufficient, but in Mountain and Hilly region of Nepal had 64,683 MT and 287,923 MT foods was deficit respectively (Manandhar, 2005).But according to Water and Energy Commission Secretariat, Nepal was self sufficient in food grain production until 1990. Due to drought condition in 2005/06, production fell short by 21,553 MT and by 179,910 MT in 2006/07 due to drought and natural calamities (WECS, 2011).

Causes of food deficit

The different stakeholders related to food deficit issues blame each other for its causes. On the world food day (October 16) of 2010 foreign minister of Canada said that developed countries are responsible • for the food deficit. He identifies following three reasons that the developed countries are responsible for food deficit:

1) Developed countries are gradually decreasing the investment in agriculture and increasing in the industrial sector.
2) Developed countries have technology so that they convert edible product into non edible product (Eg :- Biodiesel from maize), whereas millions of people are dying of hunger.
3) Developed countries are more responsible for the global warming and it affects most in developing countries (floods, landslides drought etc.) which adversely affects on the food production (Nepal is 4th most vulnerable country in South Asia due to climate change) (Thapa, 2010)

Food deficit in Nepal is mainly the result of insufficient inputs in the production process, conversion of food grain into animal feed, erratic rainfall, delayed monsoon and poor land husbandry. The crop yield data show big yield gaps (the gap between attainable yield and the national average yield). The gap is three tons per hectare for wheat, three tons per hectare for maize and two tons per hectare for rice. Thus, over a million hectares of cultivable land yield below average (Sapkota, 2011). Agro scientists in Nepal often complain that there is not enough money for research and awareness programs aimed at farmers, which would be of enormous help in reducing these gaps. Unavailability of quality seeds, fertilizers and plant-protection chemicals for the crops are other important factors. Moreover, the government does not have enough space to store all of the food grain produced in the country; instead traders across the border store Nepali harvest, thus leading to seasonal shortages. According to the statistics of the Ministry of Agriculture and Cooperatives, wheat production was down 17 percent due to drought. Similarly, drought brought down paddy production by 11 percent and corn by 4 percent. The fall in production is likely to affect prices. A study done by the Department of Industry revealed that the price of coarse rice was up 41 percent in February compared to the same month in 2009. Similarly, the price of lentil increased 25 percent, flour 25 percent and black gram 44 percent compared to previous year. Sugar rose by 60 percent (The Kathmandu Post, 2010).

Even when production shortfall is the primary cause of insufficient supply, the ecological and political reasons for production problems vary widely. They range from natural disasters such as drought, flood, or fungus, to political disasters such as civil conflict, to misguided economic policies such as price controls- all of which discourage production of essential foods.

Increased demand for meat is a particular 'concern, since livestock conversions, usually calculated in terms of food energy grain-to-livestock ratio is high. In a feedlot, it takes two kilos (kilograms) of grain to produce one kilo of chicken or fish, four kilos to produce one kilo of pork, and seven to produce one kilo of beef. Some suggest the ratios may he even higher: 3:1, 6:1, and 16:1. In the 1990s, it was calculated that some 4.3 billion large domesticated animals and 17 billion poultry eat 40 per cent of the worlds grain supply (Messer &Dr. Rose 2009). In general causes of food deficit can be listed as follows:-

1. Social Causes	2. Political Causes
i. Inequality ii. Dependency iii. Exploitation iv. Discrimination v. Disparities vi. Lack of Participation	i. Lack of appropriate policies ii. Lack of commitment iii. Lack of good governance (transparency, accountability, responsibility) iv. Poor decentralization
3. Economic Causes	**4. Environmental Causes**
i. Poverty ii. Unemployment iii. Lack of capital formation iv. Lack of appropriate agricultural inputs(seeds, fertilizers, pesticides, irrigation et.) v. Lack of infrastructures (road, communication, transportation etc) vi. High population growth rate	i. Global warming and climate change ii. Pollution iii. Natural Calamities (flood, fire, landslide, drought etc) iv. Deforestation

Consequences of food deficit

The phenomenon of food deficit is usually accompanied or followed by regional malnutrition, starvation, epidemic and increased mortality. From the perspective of state security, food insecurity would also have implications on the political stability of states, both as a cause and effect. Food security can be jeopardized by the lack of political or social stability. Likewise, food insecurity can lead to political and social instability and, in turn, a regime's survival.

Apart from its implications on domestic stability, food insecurity could destabilize regional security. The policy to curb food export in order to secure national food supply in one country could have a negative impact on other countries. Food security has gained more political weight and become the focal point for discussion and cooperation as a non-traditional security issue.

Areas of famine are almost exclusively found in areas of armed conflict and food wars - the use of hunger as a weapon in active conflict and the consequential food insecurity (Khorid, 2000).Social consequences of food deficit are under nutrition, slow growth rate, begging, conflict, migration etc. Political consequences are instability and refuges, while rise in prices, low production and unemployment are common economic consequences and deforestation, climate change, soil erosion are some common environmental consequences.

How to decrease food deficit?

1) Developed countries should increase their investment in agriculture and they should stop converting edible food into non edible product.
2) The irrigated land was, on average, more than twice productive as rain-fed land (Stockle, 2002). Irrigation agriculture will be an essential component of any strategy to increase the global food supply. Much effort will be needed to increase the efficiency of existing irrigation systems.
3) In the case of food grains, some estimates suggest that in developing countries as much as 1/4th to 1/3rd of the total crop -may be lost, as a result of, inefficiencies in the postharvest system (Ojha &

Michael, 2010). It is essential that a major centralized effort be made to provide research and development capability in the field of postharvest technology and to expand or develop joint programs with national organization.

4) Agricultural protection should be granted to developing countries that have food shortage and large availability of good land.
5) Land, seeds, fertilizers and chemicals should be available in sufficient quantities to sustain the required production.
6) International trade rules need a new framework in order to ensure enough food to the poor.
7) There is no quick fix for the underlying cause of the food crisis, but urgent interventions are needed to address immediate food shortages for the countless people facing hunger and malnutrition. The High-Level Conference on World Food Security, held in Rome in June 2008, identified a number of concrete steps to mitigate hunger (Cecchi, 2009). The most urgent is to increase emergency food aid and to assist poor people in obtaining the maximum yield from the next season's crops. Etc.
8) If the farmers are supported with proper inputs in time and storage facilities are improved, we can attain the goal of food sufficiency in a not too distant future.. Also, if the farmers could store rainwater during monsoon for its use in the dry season, millions of tons of additional yield can be achieved. None of these measures require genetic manipulation of seeds, which is Monsanto's forte.
9) An integrated livelihood improvement approach will be required to ensure food security at the local level. In addition increasing access to markets, capacity building of farmers and developing entrepreneurship for high-value cash crops and commodities will be needed to cope with such emerging problems.
10) In developed countries, higher consumption of animal foods and fat is being discouraged to make more food available to meet global food needs, and to encourage sustainable agricultural practices. 11) A food shortage is likely to impact most heavily on women and girls, who are often the last fed in poor households. So the knowledge about gender equity and social inclusion is also related with food deficit (UNDP, 2008) etc.
11) A food shortage is likely to impact most heavily on women and girls, who are often the last fed in poor households. So the knowledge about gender equity and social inclusion is also related with food deficit (UNDP,2008) etc.

Conclusion

There are no hard and fast rules and no fixed methods to reduce food deficit. Process and methods used to reduce food deficit mainly depends on the causes of it. This problem is not only for developing countries. Some steps should be moved within the country and developed countries also assist to developing countries. For the developing countries reducing the postharvest losses, maximum utilization of available resources, gradually moving towards the modern farming system may be major solutions. Whole world should be concern about the food deficit. Lastly every people should be aware about "if we save food from wasting, it can save another lives."

References

Cecchi, C. (2009)*Millennium Development Goals MDO 1 and the International Food Crisis, SPES - Development Studies Research Centre at SAPIENZA University of Rome.*

Khorid, M.M.Z.A. (2000) *THE EFFECTS OF FOOD SHORTAGE ON THE SOUTHEAST ASIAN REGION FROM A STRATEGIC PERSPECTIVE*

Manandhar, G.B. (2010)*Presentation on Status of agricultural mechanization, food chain management and Agro based enterprise development in Nepal.*

Ojha, T.P. & Michael, A.M. (2010)*Principles of Agricultural Engineering, Volume I, Jain Brothers, East Park Road, Karol Bagh, New Delhi.*

Stockle, C.0. (2002) *Environmental Impact of Irrigation: A Review, State of Washington Water Research Center, Washington State University.*

Thapa, P.K. (2010)*Sahakarya, Working Together to Build Self Reliant Communities in the Hills of Nepal, A presentation on AGM of CECI Nepal.*

UNDP, (2008)*United Nations Conference on Trade and Development, Addressing the global food crisis.*

WECS, (2011)*WATER RESOURCES OF NEPAL IN THE CONTEAT OF CLIMATE CHANGE, Government of Nepal, Water and Energy Commission Secretariat Singiu2 Durbar, Kathmandu, Nepal.*

http://archive.unu.edu/unupress/unupbooks/uu22we/uu22we09.html

htpp://www.fao.org/newsroom/en/news/2006/1000416/index.html

http://www.ekantipue.com/the-kathmandu-post /2010/03/31/Business/40-districts-in-Nepal-facing-food-deficit/206744/

http://sapkotac.blogspot.com/2011/11/food-deficit-in-nepal-is-mainly-result.html

Hydrogen as Energy Source

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What is Hydrogen?

-<u>It's Simple! Light!! Everywhere!!!</u>

Hydrogen is the simplest, lightest element in the universe. Because of its simplicity, it is believed by some that hydrogen is the root of all elements. When hydrogen escapes into the atmosphere, it is so light that it scatters immediately upward in the air (it's 14 times lighter than air). This means that a hydrogen spill won't pool on the ground, pollute groundwater, or soak into clothing it removes itself Hydrogen is the most abundant element in the universe, making up more that 90% of all matter. On Earth, it is the third most abundant element in the Earth's surface, found in water and all organic matter.

What's Its Nature?

In its normal gaseous state, hydrogen is colorless, odorless, tasteless, and is nontoxic, which makes it different from every other common fuel we use.

What Happens When Hydrogen Burns?

Hydrogen burns readily with oxygen, releasing considerable energy as heat and producing only water as exhaust. When hydrogen burns in air (which is mostly nitrogen), some oxides of nitrogen (NOx, contributors to smog and acid rain) can be formed, but much fewer pollutants are formed than when normal hydrocarbon fuels such as gasoline and diesel are burned. Because no carbon is involved, using hydrogen fuel eliminates carbon monoxide, carbon dioxide, and does not contribute to global warming.

Sources of Hydrogen

Hydrogen is now made from natural gas (methane), petroleum, coal, various chemical reactions, and from biomass (landfill waste, wastewater sludge, and livestock waste). It can also be made from water by electrolysis. Hydrogen can be made from renewable resources, such as methane and hydrocarbon. Hydrogen is currently made primarily from natural gas (methane), which is non-renewable. Methane is a-recycled fuel (and therefore renewable) when made by anaerobic digestion of biomass. Hydrogen production from hydrocarbons can also produce carbon, which in some forms has ten times the strength of steel. With some research this carbon could be used for automobile bodies and structural members.

❖ Advantages of Hydrogen
- Hydrogen can be totally non-polluting (water is the exhaust).
- Hydrogen can be economically competitive with gasoline or diesel.
- Hydrogen is safer than gasoline, diesel, or natural gas.

- Hydrogen can help prevent the depletion of fossil fuel reserves.
- Hydrogen can be produced in any country.

Interval of ignitability

The hydrogen has a wide interval of ignitability in comparison with other fuels; therefore, the hydrogen engines can operate with a higher efficiency and a leaner mixture than the petrol engines; an ignitable mixture is formed as soon as it contains 4% of hydrogen.

Ignition energy

The hydrogen requires lower ignition energy than other fuels; its disadvantage is the risk of themixture getting ignited from hot places in the cylinder, and in the equipment serving for the outside formation of the mixture.

Anti-detonation resistance

Up to now not known to a creditable degree; the results of the tests on the engines and in the research differ.

Burning velocity

The velocity of combustion of the mixture is higher than with petrol, in the level of orders; it allows for its effective and thorough combustion, even if the burning velocity decreases with leaner mixtures.

Mixture formation

Concerning the formation of the mixture, the gas fuels are more advantageous than the liquid ones, because it is easier to mix two substances of the same state; a more perfect use of the air in the combustion, and therefore, a better cleanness of the combustion products.

Density

The density of hydrogen is very low, which brings about problems with its storage; another disadvantage consists in insufficient filling of the cylinder with the fresh mixture.

Hydrogen Production

The simplest and most common element, hydrogen is all around us, but always as a compound with other elements. Nearly all hydrogen production today is by steam reformation of natural gas. For high purity needs, a small amount of hydrogen is produced by electrolysis, but this again is only as good as the energy source used to produce the electricity used. There are, however, many possible ways to produce hydrogen with renewable energy. Some of the most promising are the following:

Steam reformation:

Heating biomass (or fossil fuels) with limited or no oxygen present can gasify it to a mixture of Hydrogen and carbon monoxide known as synthesis gas or syngas or liquefy/pyrolyze it to a liquid known as pyrolysis oil or bio-oil. Syngas can then be catalytically converted to increase the amount of hydrogen with a "water-gas-shift reaction." Pyrolysis oil can be converted to hydrogen using steam reformation and the water-gas-shift reaction.

Electrolysis

Electrolysis can electrochemically split water into hydrogen and oxygen in essentially the reverse of the reaction in a fuel cell. To make sense for large-scale use, this process must use an inexpensive source of electricity. Because wind energy is currently the lowest cost renewable energy, it is the leading candidate. It is also an intermittent source that would benefit from being able to produce hydrogen when its electricity is not needed and to add fuel-cell generation when electricity demand exceeds what the wind turbines can provide. The combination also benefits because electrolyzes require direct current and wind turbine power must be converted to direct current before conversion back to alternating current suitable for the electric grid.

Photo electrochemical (PEC)

Photo electrochemical (PEC) hydrogen production replaces one electrode of an electrolyze with photovoltaic (PV) semiconductor material to generate the electricity needed for the water-splitting reaction. The efficiency loss of separate steps is done away with, as is the cost of the other components of a solar cell. PEC is elegantly simple, but finding PV materials both strong enough to drive the water split and stable in a liquid system presents great challenges for researchers. Another way to directly tap solar energy for hydrogen production is to take advantage of ways in which naturedoes so.

Biological and photo biological

Certain micro algae and photosynthetic bacteria do sometimes use photosynthesis to make hydrogen instead of sugar and oxygen. Among challenges here is the fact that the algal enzyme that triggers the hydrogen production is inhibited by oxygen, which of course, the organism also normally produces. Another biological research avenue is to develop microorganisms that will ferment sugars or cellulose to Hydrogen Storage.

Hydrogen Storage

On the one hand, hydrogen's great asset as a renewable energy carrier is that it is storable and transportable. On the other hand, its very low natural density requires storage volumes that are impractical for vehicles and many other uses.

- Pressurized tanks
- Liquefying the hydrogen
- Metal hydrides
- Chemical compounds
- Carbon nano tubes

How do you turn hydrogen into electricity?

A fuel-cell is made of two plates sandwiched together with a plastic membrane coated with a catalyst (a substance that speeds the reaction). Hydrogen fuel and oxygen are fed through channels in the plates on either side of the membrane. The hydrogen and oxygen atoms are attracted to each other; however, only the proton part of the hydrogen atom can pass through the membrane to reach the oxygen. The electron has to take the long way around the membrane to reach the oxygen atom, creating energy in the process. The hydrogen electron is eventually united with the proton and oxygen atom to create water (H20). Or, more simply put: Hydrogen + Oxygen = Electricity, Heat, and Water.

Why you use hydrogen in a fuel-cell? What are the benefits of using hydrogen?

Hydrogen is the most abundant element on earth, and can be found in water, fossil fuels, and other sources. As a fuel source, hydrogen creates much smaller quantities of greenhouse gases that contribute to global warming and none of the air pollutants that create smog and cause health problems. In fact, if pure hydrogen is used as a fuel, only heat and water are emitted.

According to the U. S. Department of Energy, advancing hydrogen fuel-cell technologies offers a cleaner, more efficient alternative to the combustion of gasoline and other fossil fuels. Also, hydrogen can be derived from a variety of domestically available primary sources, including fossil fuels and nuclear power. This flexibility would make us less dependent on oil from foreign countries.

Is hydrogen safe?

When handled properly, hydrogen is a very safe fuel source. For many decades, hydrogen has been produced and used for commercial and industrial purposes with an exemplary safety record. Like all fuels, however, hydrogen is an energy source and must be handled with care.

One of the attributes of hydrogen is that it is the lightest element in the universe. As a result, if it does escape from its container, hydrogen dissipates quickly into the air - it does not "pool" into a flammable hazard on the ground. Contrary to common misconceptions, hydrogen is not highly explosive in cannon use. Like gasoline and other fuels, it is flammable, but hydrogen would need to be highly concentrated to be explosive. Because it dissipates so rapidly in the air, this level of concentration is highly unlikely to occur if it should be released.

Another important point is that hydrogen is not toxic, so if it is released, hydrogen does not present a health hazard to humans and its effect on the environment is benign.

References:

http://www.nrel.gov/hydrogen/pdfs/42834.pdf
http://www.nrel.gov/hydrogen
http://www.nrel.gov/hydrogen/projects.html

Solar Photovoltaic

The word "photovoltaic" combines two terms: "photo" meaning light and "voltaic"meaningvoltage. Together the terms describe a cell, which generates electricityfrom the light, which strikes it. Solar energy is harnessed using solar cells(photovoltaic or PV cells)made of panels of semiconductor material (usuallysilicon), which generate electricity when illuminated bysunlight. Photovoltaic(PV) devices generate electricity directly from sunlight via an electronicprocessthat occurs naturally in certain types of material. Electrons in certain types of crystals are freed by solar energy and can be induced to travel through an electrical circuit, powering any type of electronic device or load. PV devices can be used to power small devices e.g. road signs, calculators or phone call boxes, homes, or even large stores or businesses.

A typical silicon PV cell is composed of a thin wafer consisting of an ultra-thin layer of phosphorus doped (N-type) silicon on top of a thicker layer of boron-doped (P-type) silicon coated with special additives. An electrical field is created near the top surface of the cell where these two materials are in contact, called the P-N junction. When sunlight strikes the surface of a PV cell, light particles called photons penetrate the cell and knock electrons free from the silicon atoms, creating an electric current.This electrical field provides momentum and direction to light-stimulated electrons, resulting in a flow of current when the solar cell is connected to an electrical load. As long as light flows into the cell, electrons flow out of the cell. The cell does not use up its electrons and lose power, like a battery it's a converter that turns one kind ofenergy (sunlight) into another (flowing electrons).

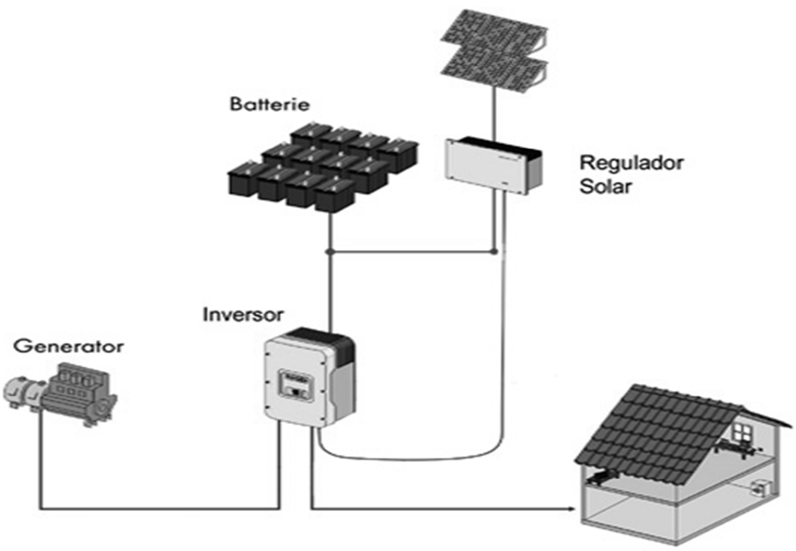

Fig. Major components Photovoltaic system

Advantages

- Lifetime, 15-20 years for systems, upto 30 years for modules.
- No pollution, no waste products (for UK, each K Wp of PV reduces C02 emission byabout 1 ton per year).
- Energy from the sun is free and abundant; energy input from the sun is several thousand times higher than consumption.

Disadvantages

- High initial cost (although it is recovered by fuel savings over the lifetime ofthe product)
- Area intensive can besolved by utilizing roofs and surfaces in Urban areas, deserts, etc.).
- Intermittence and seasonality ofsunlight need for storage.

- **Photovoltaics' Applications**

PV is best suited for remote site applications that have small to moderate power requirements, or small consuming applications even where the grid is in existence. A few power companies are also rooting limited grid-connected PV systems, but the large market for this technology is for stand-alone (Offgrid) applications. Some common PV applications are as follows:

1. **Rural electrification**
    - Lighting and power supplies for remote building (mosques, churches, temples, schools, mountain refuge huts) - low wattage fluorescent lighting is recommended
    - Power supplies for remote villages street lighting
    - Individual house systems
    - Battery charging
    - Mini grids
2. **Water pumping and treatment systems**
    - Pumping for drinking water
    - Pumping for irrigation
    - Dewatering and drainage
    - Ice production
    - Saltwater desalination systems
    - water purification

3. **Health care systems**
    - Lighting in rural clinics
    - UHF transceivers between health centers
    - Vaccine refrigeration
    - Ice pack freezing for vaccine carriers
    - Blood storage refrigerators
4. **Communications**
    - Radio repeaters
    - Remote TV and radio receivers
    - Remote weather measuring
    - Mobile radios
    - Rural telephone kiosks
    - Data acquisition and transmission

For example, river levels and seismographs

5. **Transport aids**
   - Road sign lighting
   - Railway crossings and signals
   - Hazard and warning lights
   - Navigation buoys
   - Road markers
6. **Security systems**
   - Security lighting
   - Remote alarm system
   - Electric fences

7. **Miscellaneous**
   - Ventilation systems
   - Calculators
   - Pumping and automated feeding systems on fish farms
   - Solar water heater circulation pumps
   - Boat / ship power
   - Vehicle battery trickle chargers
   - Earthquake monitoring systems
   - Emergency power for disaster relief.

❖ Environmental Impacts

1. **Impacts from production of the components of PV system:**

   1.1 Purified silicon is the most common solar cell material
   - In manufacturing, purification and solar cell manufacturing involve many steps and different chemicals.
   - All these steps are tightly controlled and no accidents have ever occurred in solar cell manufacturing.
   - No environment impacts form the production of PV systems

   1.2 Energy expenditure and carbon emission by production of PV systems
   - The energy consumed for its production can be recovered by operation
   - The time for this recovery is called Energy Payback time

2. Impacts from the daily operation of the PV systems:

   2.1 No effect on the environment from their operation.
   - Do not emit noise, solid waste, or gases that could harm environment.

   2.2 PV systems make an important contribution to the protection of the environment.
   - Each KWh generated by PV plants avoids an output of the greenhouse gas carbon-dioxide.

The solar technology has a great potential to provide clean energy to the rural as well as urban settlements of the region. The potential for SPV technology is obvious in the rural electrification, especially of inaccessible villages where grid connection is techno- economically not feasible. There are several direct and indirect impacts of SPV on socio-economic development of any community. They indirectly help to improve social indicators like standard of living, health, education, drudgery, etc. A major impact on the local economy can be realized by the creation of income generating activities through SPV electrification. Although, it is recognized that PV systems are vital in meeting basic electricity requirements of rural and remote areas, the technology has remained out of reach to many people due to a variety of reasons such as high system cost, lack of reliable after-sale service, lack of overall user confidence regarding the technology etc. These barriers can be overcome through demonstration, reduction in the system's cost, and improving its reliability through producing accessories locally.

On the same way for the applications of solar thermal technologies for the rural development the attractive subsidy policy through government and awareness for the rural people is the most important task. Although, there are some limitations with solar technologies, the solar systems have made the significant changes in the socio-economic status of the rural people. They are accessing with drinking water, irrigation water, electrification, telecommunications facilities and providing vaccine refrigeration for rural health centers. Direct income generation through solar dryers and green houses are the solar thermal applications. Water heating for different purposes and space heating for the cold climates help the people to save the wastage of wealth.

To fully exploit the potential of solar energy will require several institutional changes in the energy sector:

- Rural and agricultural development banks must make solar energy systems eligible for loans.
- The systems must be made more attractive to private investors.
- Above all, the energy, agriculture, education and health sectors must work together to promote solar technology, improve maintenance and servicing infrastructure and create sustainable markets for the creation, use and funding of solar energy systems.

Though the limitations and constraints for solar technologies remain very great, the future is hopeful and bright. One day the hurdles and obstacles will certainly be overcome and the rural community of the entire earth will live in the brightness.

Some Modern Technologies in Agricultural Engineering

1. Zero till seed cum fertilizer drill

Seed Cum Fertilizer Drill

Seed cum fertilizer drill is used for wowing different crop seeds such as wheat, barley peas, lentils, etc in the land. It will become very useful and important agricultural machine for the farmer. It helps them to seed a crop directly into the cultivated field just after the harvest of previous crop. It eliminates or reduces time and energy intensive conventional tillage operation reducing cultivation cost apart from improving crop yields and profits.

These machines continuously show the seed in row by maintain the recommended spacing between row to row. There is present of seed and fertilizer metering mechanism which maintain the recommended sowing rate (kg/ha) of seeds and fertilizer rate (kg/ha) for a specified crop. Seed-cum fertilizer drill having 7-13 times and has a field capacity of 0.4-0.8 ha/hr. AS the one experiment conducted in India, for the wheat uses conventional method (Broad casting method) of sowing and by the seed cum fertilizer drill in sandy loam soil.

Table 1. : Comparison of farmers practice and recommended practice

Technology Assessed	*Production per unit	Net Return (Profit) in Rs./unit	BC Ration
T1-Farmers Practice-Seed sowing in dry soil with broadcast method and seed rate 100 kg/ha.	8.0 q/ha	2038	1.46
T2-Recommended practice-Sowing of wheat using tractor operated seed cum fertilizer drill sedd rate 40 kg/ha	16.4 q/ha	8798	2.50

(Source: International journal of innovative of science, Engineering and Technology, VOL 2, June 2015)

From the above table, we finally assured that production rate of crops is much higher by using of this machine than conventional method so that this machine is suitable for the sowing above type of crops.

2. Rice transplanter

Rice transplanter is used to transplant seedlings in the paddy field. Mainly there are two types of rice transplanter:

(i) Riding type of rice transplanter

It is also called self-propelled rice transplanter. It can usually transplant 6-8 line in one pass. It has field capacity of 0.19-0.245 (ha/hr). Seedling is prepared by mat type method. The production rate of paddy using rice transplanter is similar to conventional method while transplanting but only difference in operation is time and labour which minimizes the cost of production.

Fig:- Self-Propelled rice transplanter

(ii) Walking type rice transplanter

It includes the manually operated rice transplanter which transplants 2-4 line in one pass. It is generally two types:

Fig:- Mat type seedling transplanting manual transplanter

Type 1:

It transplant mat type paddy seedling. By pressing the handle the fork pick up the seedling and plant them in 2-4 rows. It can cover the 0.25 ha/day. It saves the time and money.

Type 2:

It is manually operated and backward type of rice transplanter. It is transplants the seedlings which is conventionally prepared. It is also called Hand cranked rice transplanter. Especially 2 rows rice transplanter have field capacity of 0.22-0.33 ha/day.

Fig:- Transplanting the seedlings by hand cranked rice transplanter

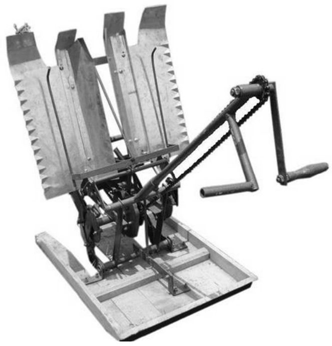

Fig:- Hand Cranked rice transplanter

3. **Vertical Conveyer Reaper**

A machine called vertical conveyer reaper-cum windrower can cut the crop and lay it in the form of windrow for easy picking. It consists of a conventional cutter bar assembly, crop row dividers with star wheels, covers, pressure springs and vertical conveyor belts/ Cutter bar is given reciprocating motion by crank wheel. Crop row dividers with star wheels enter the standing crop, help in lifting, gathering and guiding the crop towards the cutter bar. After the crop is cut, held in a vertical position during its passage by means of pressure springs and star wheels.

Fig :- Power tiller mounted vertical conveyer vertical conveyer

Fig :- Harvesting paddy using vertical conveyer vertical

Fig :- Harvesting paddy using tractor mounted vertical conveyer reaper

Vertically held crops are then delivered towards right side of the machine in a windrow perpendicular to the direction of movement of machine with the help of lugged conveyor belt. The gearbox and windrower is coupled to the drive shaft of the prime mower. A front mounted vertical conveyor reaper is the most common reaper, to harvest wheat and paddy crops. It can also be used for harvesting of soybean and other similar crops. Engine operated reaper can be operated with a 5-6 hp engine. Whereas, tractor operated reapers can be operated with 25-35 hp tractor. Width of cut is about 1.6m in power tiller a reaper, and about 2.05 in tractor operated reapers. Stroke per min of cutter bar is 1225 and 1550 in case of power tiller and tractors operated reapers, respectively. Power tiller and tractors-front mounted vertical conveyer reaper windrower can conveyer about 0.2 ha/h and 0.4 ha/h respectively.

4. Disc harrow

A disc harrow is a farm implement that is used to till the soil where crops are to be planted. It is also used to chop up unwanted weeds or crops remainders. It consists of carbon steel and sometimes the longer-lasting boron discs, which have many varying concavities and disc blades sizes and spacing.

Fig:- Off Setdic harrow

5. Multi-crop thresher

A threshing machine or thresher is a farm equipment that threshes grain, that is, removes the seeds from the stalks and husks. Multi crop threshers are used in Nepal due to its good field performance. It threshes paddy, wheat, and other crops such as lentils etc.

6. Rotavator

Rotavator is an excellent secondary tillage implement which is effectively used in dry land as well as wet land condition for the seed bed preparation. For wet land, it churns mixes and disperses the finer particle in muddy conditions so that slit and clay particles are settled on the surfaces and restricts the infiltration of irrigation of irrigation water. Thus, it provides the conducive to the growth of wet land plants. Similarly for dry land, it gives excellent pulverization of soil and land mixes the thrashes crop residues, weeds, etc into the soil for their rapid decay.

The planking attachment given behind the equipment ensures breaking of big clods, levelling of field and packing of soil moisture that can make a very fine seed bed suitable for the effective planting of crops. It is available as tractor mounted tillage implement. It takes its drive from tractor PTO.

Fig:- Tractor mounted Rotavator

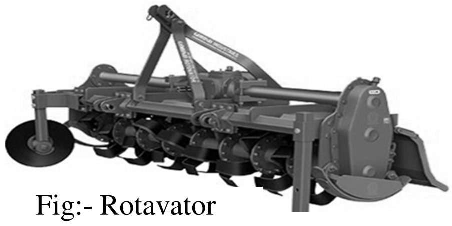

Fig:- Rotavator

7. **Green house technology**


Fig:- Growing crops under the green house

Greenhouse technology is the technique of providing favourable conditions to the plants. Even in extreme adverse climatic conditions where no crops can grow, green house can be used to grow high value crops. This method is used to protect the plants from adverse climatic conditions, such as cold wind, precipitation, excessive radiation, extreme temperatures, insects and disease, etc. In Greenhouse technology, the environmental conditions are modified to favourable conditions for plant.

Greenhouses are framed or inflated structures covered with transparent or translucent materials large enough to grow crops under partial or full controlled environmental conditions to get optimum growth and productivity. There is increase in yield from 10% to 12% depending upon the type of greenhouse, type of crop, environmental control facilities. Reliability of crop increases in green house cultivation. It expands the growing season, the variety among the produce and minimizes the external threats of the crop.

8. **Drip irrigation**

Drip irrigation is a type of irrigation which saves water by allowing water slowly to the roots of plants, either onto the soil surface or directly into the root zone, through a network of valves, pipes, tubing and emitters. It is done through narrow tubes that deliver water directly to the base of the plant. It is chosen instead of surface irrigation for various reasons, often including concern about minimizing evaporation. Drip irrigation is used in farms, commercial greenhouses, and residential gardeners. Drip irrigation is adopted extensively in areas of acute water scarcity and especially for crops and trees. A drip irrigation system with plastic mulching directs the water at the root systems of plants and effectively reduces pests, weeds and harmful fungal growth. With a properly installed drip irrigation system, one can save up to a 50% of irrigation water annually.


Fig:- Growing Crops using drip irrigation and plastic mulching

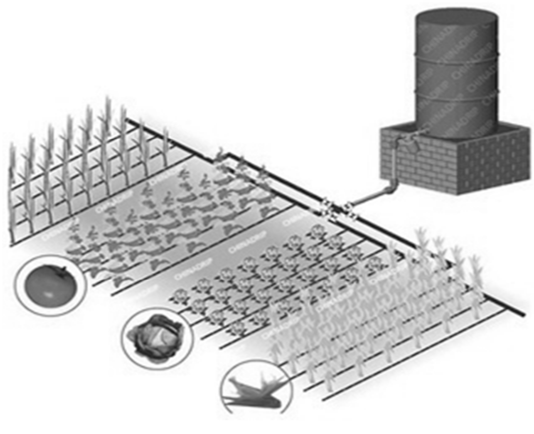
Fig:- Growing crops using drip irrigation

9. Hydroponic System

Hydroponic is a system where plants are grown in growth media other than natural soil. All the nutrients are dissolved in irrigated water are supplied at regular basis to plants. We can grow virtually any time of the year.

Advantages

- Hydroponically produce vegetable can be high quality and need little washing.
- Soil preparation and weeding is reduced or eliminated.
- It is possible to produce very high yields of vegetable on small area because an environment optimal for plant growth is created. All the nutrients and water that plants need are available at all times.
- One does not need good soils to grow vegetables.

Basically high value crops such as tomato, cucumber, lettuces and herbs are grown by this method.

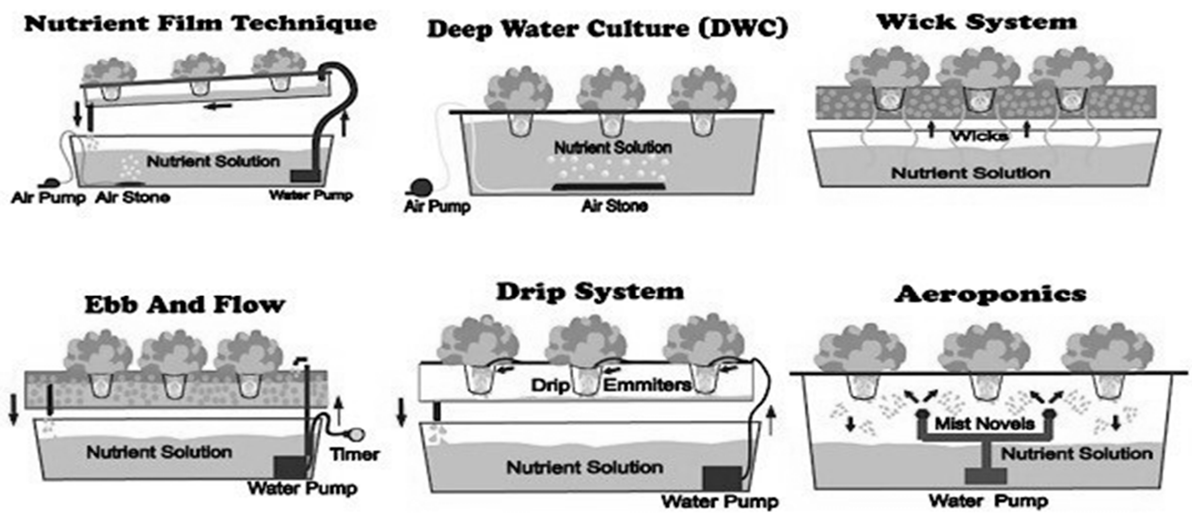

Fig:- Different Method of Hydroponic System

10. Ram Pump

A hydraulic ram pump is cyclic water pump which is operated by kinetic energy of following water. It takes water at one hydraulic head and flow rate and outputs water at a higher hydraulic head and low flow rate. The device uses water hammer effect to develop pressure that allows a portion of input water that power than pump to lift to a point higher than where the water originally started. There is no need of fuel or external power to operate this type of pump.

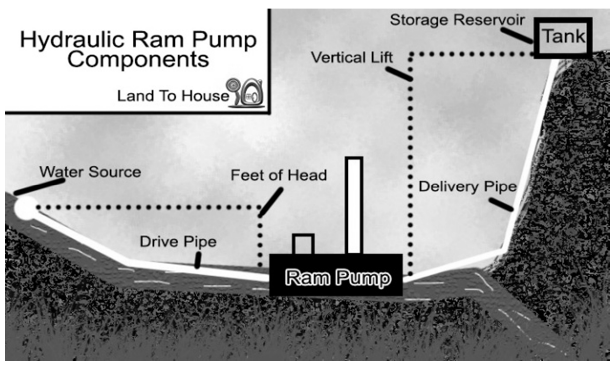

Fig:- Pumping of water using ram pump

11. Plastic Mulching

Plastic mulching is used in a similar fashion to mulch, to suppress weeds and conserve water in crop production and landscaping. Crops grow through slits or holes in thin plastic sheets. Plastic mulch is often used in conjunction with drip irrigation. This method is predominant in large-scale vegetable growing, with millions of acres cultivated under plastic mulch worldwide each year. Disposal of plastic mulch is cited as an environmental problem, however, technologies exist to provide for the recycling of used/disposed plastic mulch into viable plastic resins for re-use in the plastics manufacturing industry.

Fig:- Growing Crops using plastic mulching

Advantages

- The use of plastic mulch alters soil temperature. Dark mulches and clear mulches applied to the soil intercepts sunlight warming the soil allowing earlier planting as well as encouraging faster growth early in the growing season. White mulch reflects heat from the sun effectively reducing soil temperature. This reduction in temperature may help establish plants in mid-summer when cooler soil might be required.
- Plastic mulches reduce the amount of water lost from the soil due to evaporation. This means less water will be needed for irrigation.
- Plastic mulch prevents the growing of weeds.
- The use of drip irrigation in conjunction with plastic mulch allows one to reduce leaching of fertilizers.
- This reduced contact with the soil decreases fruit rot as well as keeps the fruit and vegetables clean.

12. Power Tiller

Power tiller is designed mainly for tilling of seedbed in small farms and in hill farming. The adoption of power tillers by the farmers for carrying out farming operations is low when compared to tractors. Power tiller is also used as a power source for other agricultural operations such as seed bed preparation, sowing and fertilizer application. Power tillers are also useful in intercultural operations in wide spaced row crops (more than 1.0 m row to row spacing) and

harvesting of cereals under upland conditions including transportation of farm products and power source of stationary farm operations.

As the land holding capacity is low and the economic condition of farmers do not support for having large farm power source, its seems to be economical to introduce power tiller in Nepalese agriculture and its matching equipment whose initial cost, running cost is low and which could be made busy throughout the year. There are various models of power tiller in the market with the various capacities such as 5-12 hp, versatile power tiller which is suitable for the all operations in the farm should be chosen.

References

I. R.P. Murumkar Usha, R. Dongarwar, D.S. Pisalkar, Dr. Panjabrao Deshmuukh, Krishi Vidyapeerth, Akola (M.S) Assessment of seed cum fertilizer drill for wheat sowing after paddy harvesting **"International Journal Of Innovative Science, Engineergin & Technology, Vol 2 Issue 6, June 2015"**.

II. O.N.Sharma, S.Mukesh (2013) **farm machinery design third edition Jain brother**, Delhi.

III. What is hydroponic growing (http://www.growthtechnology.com/growtorial/what-is-hydroponic-growing/)

IV. Basic hydroponic system and how they work (http://www.simplyhydro.com/hydrou.html)

V. Rice transplanter searched (http://en.uk.wikipedia.org/wiki/Rice-transplant)

VI. Advangate and Disadvantages of Greenhouse technology searched (http://agriculturalinformation4u.blogspot,com/2015/09/advantage-and-disadvantage-if.html)

VII. Drip irrigation (https://en.wikipedia.org/wiki/Drip-irrigation)

VIII. Pressure ram pump searched (https;//en.wikipedia.org/wiki/Hydraulic-ram)

IX. Plastic mulching searched (https://en.wikipedia.org/wiki/Plastic-mulch)

Agricultural Engineering for Socio-Economic Transformation

Agricultural engineers can be employed in the following fields:-

1. Irrigation
2. Soil & Water Conservation
3. Appropriate & Intermediate Technology Development
4. Farm Management
5. Farm Power & Machinery
6. Alternative Energy Development
7. Rural Infrastructure Development
8. Solid Waste Management
9. Environment Protection
10. Industries Management especially related to food, forestry & agriculture.
11. Research & Development, Innovation and Technology Management
12. Project Management
13. Food & Dairy Industries
14. Greenhouses,Hydroponic & Controlled Farming
15. Hydropower
16. Underground Water Exploration & Utilization
17. Weather Forecasting especially related to agriculture
18. Agro-forestry
19. Technology Transfer & Extension
20. Acquaculture

Agricultural engineers are armed with multiple skills and knowledge. They need to be managed and mobilized for socio-economic transformation of the country. Country's resources remain idle without being beneficial to the country unless engineers especially agricultural engineers are given the opportunities to mobilize them. Resources of interest for agricultural engineers are :

1. Soil
2. Water including underground water
3. Medicinal Plants
4. Traditional Technologies
5. Forest
6. Solid Wastes including Agriculture Wastes
7. Climate
8. Traditional Skills

Small industries can't afford to employ engineers of different disciplines like civil engineers, mechanical engineers, electrical engineers and even computer engineers. Agricultural engineers are appropriate for such industries because of their multiple skills. Local governments can't afford to employ engineers of different disciplines like small industries and agricultural engineers are boon for them as they can help such governments to address their engineering needs. R & D managers need to supervise and manage engineers and technologists of different disciplines. Agricultural engineers are most suited as R & D managers as they have the basic knowledge and skills of different disciplines. Just like medical doctors for sports and mountaineering teams are expected to take care of varied medical needs of the sportsmen and mountaineers respectively, agricultural engineers are expected to meet the varied engineering needs of the rural communities, local governments and small industries. Our country is a country of rural life with more than 65 % of the population engaged in agriculture which gives the message that the country needs agriculture engineers for her socio-economic transformation.Our country is a country with overwhelming number of local governments which is as many as 753 and such governments' engineering requirements are the requirements of agricultural engineers.Even our industries are mostly small industries and such industries ' engineering needs are the needs of agricultural engineers. Industries related to food, feed, fertilizer, dairy,forestry and agriculture, no matter whether they are big or small, need agricultural engineers to get the most from the least. Agricultural engineers are agents of positive challenges and such changes are for country 's socio-economic transformation. Let's get the most of such engineers for the speedy development of the country.Let country mobilize them who,in turn,mobilize country's resources for country 's development which are otherwise going waste.

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