

Initiation for information...

THE AGRINEER 2023

Volume 7



An annual publication of
Nepal Agricultural Engineering Students' Society
IOE, Purwanchal Campus
Dharan, Sunsari, Nepal



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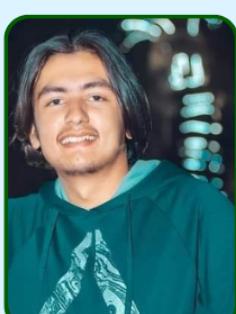
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Editorial

It is the moment of great pride and happiness to come with the seventh 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 stil-dent and related professionals, We aim to correct the short coming of sixth volume in this new edition.

Agricultural engineering are swiftly evolving fields that integrate the principles of Geological 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.



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Message

I am delighted to learn that the Nepal Agricultural Engineering Student's Society (NAESS) at the Institute of Engineering, Purwanchal Campus, is set to release the Seventh Edition of their esteemed journal 'AGRINEER' in 2023.

Agriculture holds immense significance in Nepal, serving as a vital sector that supports the majority of our population. With its diverse geography and favorable climate conditions, our country boasts enormous potential for agricultural activities. However, there exists a pressing need for agricultural modernization and commercialization, where crucial roles are played by farm mechanization, food processing, soil and water management, rural energy, and farmstead management.

The challenges of limited access to modern technology, inadequate irrigation facilities, insufficient agricultural knowledge and skills, and inadequate market infrastructure pose significant obstacles to the progress of Nepalese agriculture. However, the application of agricultural engineering knowledge and cutting-edge technologies can surmount these challenges.

In light of this, I would like to extend my heartfelt congratulations to NAESS and the entire AGRINEER team for their collaborative efforts in bringing forth this technical journal. Their dedicated work will undoubtedly make a valuable contribution to the agricultural sector and the overall Nepalese economy. I wholeheartedly wish them the best as they reach yet another milestone, marking a momentous achievement for Nepalese agriculture and engineering.

A handwritten signature in black ink, appearing to read "Hikmat Kumar Karki".

Hikmat Kumar Karki
Chief Minister



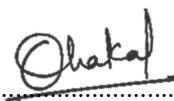
Message From Campus Chief

I am grateful to you and the entire team for the incredible achievement of having the seventh edition of the magazine "AGRINEER" of the Agricultural magazine published. Please accept my best compliments. In my official role as the Campus chief of Institute of Engineering Purwanchal Campus, I am immensely pleased of your excellent accomplishment.

By virtue of your tenacity, diligence, and dedication, you have significantly advanced the subject of agricultural sciences. Your research publication reflects the Campus commitment to funding the greatest agricultural research possible in addition to showcasing the depth of your knowledge.

I'd want to offer our appreciation for your excellent work on behalf of the Purwanchal Campus as a whole. Your success is proof of the excellent training and direction provided by our esteemed teachers. Do accept our sincere congratulations once more, and may this publication mark the beginning of an incredible scientific adventure for you and your team.

I wish you success and success in all of your future endeavors.


.....
Om Prakash Dhakal
(Campus Chief)



Message From Head of Department

I express my thank you and entire team for the amazing accomplishment of having Agricultural journal published as Seventh Edition of the journal "AGRINEER" offering my sincere congratulations. As the head of the agricultural engineering department, I am incredibly proud of your fantastic achievement.

You have made a major contribution to the field of agricultural sciences as a consequence of your persistence, hard work, and devotion. Your research publication not only demonstrates the breadth of your knowledge but shows the department's dedication to supporting the best agricultural research possible.

I'd want to express on behalf of the entire department how grateful we are for your outstanding job. Your achievement is evidence of the high caliber of instruction and guidance given by our respected teachers. Once more, please accept my heartfelt congratulations, and may this publication signal the start of an amazing scientific journey for you and your team.

I hope all of your future initiatives are fruitful and prosperous.

.....
Er. Aditya Roshan Dhakal
HOD, Agricultural Engineering
Purwanchal campus, Dharan



च.नं: ०२३/०७९-०८०

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Message From Free Student Union

We would like to express our sincere gratitude to the Institute of Engineering Purwanchal Campus, Agricultural Engineering students and entire Agrineer team for their amazing efforts in publishing an agricultural journal, Seventh Edition of Agrineer. Your commitment to conducting research in the area of agriculture is incredibly motivating. Keep up the good job and keep adding to the body of knowledge about sustainable farming methods.

I wish you success and success in all of your future endeavors.

Nabin Shrestha
President, Free Student Union
Purwanchal Campus, Dharan

Regd. No. 29/046/047



नेपाल कृषि इंजिनियर्स सोसाइटी

Nepalese Society of Agricultural Engineers



Date: 2080-02-25

Message from the President

We are delighted to announce the successful publication of Volume-7 of our esteemed technical journal, "**The Agrineer.**" As an organization dedicated to promoting Agricultural Engineering and its advancements, we take great pride in this accomplishment and would like to share our excitement with you.

"The Agrineer" has been a cornerstone of our efforts to disseminate cutting-edge research, innovative technologies, and best practices in the field of agriculture. Over the years, it has become a trusted source of knowledge and inspiration for professionals, researchers, academicians, and students across Nepal and beyond. We strive to provide a platform that fosters collaboration and encourages the exchange of ideas among agricultural engineers.

In conclusion, we would like to express our gratitude to you for your continued support and encouragement. We invite you to explore the latest volume of "The Agrineer" and encourage you to share it with your colleagues and networks who may benefit from its contents.

Thank you once again for your support and congratulations on this significant achievement.

Warm regards,

A handwritten signature in black ink, appearing to read "B.P. Shrestha".

Prof. Bim Prasad Shrestha, PhD
President
Nepalese Society of Agricultural Engineers



NEPAL AGRICULTURAL ENGINEERING STUDENTS' SOCIETY

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IOE Purwanchal Campus, Dharan

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Dharan-8, Sunsari, Nepal

MESSAGE FROM PRESIDENT



I hope this message finds you all in good health and high spirits.

I am writing to you with immense pride and gratitude for the publication of seventh volume of 'The Agrineer', the flagship journal of agricultural engineering in Nepal.

I want to start by expressing my sincere thanks and congratulations to the publication team of The Agrineer Volume 7 for the successful publication. Also, I appreciate the hardworking academic members and researchers who have tirelessly worked towards the publication of this journal. Your unwavering commitment to advancing the field of agricultural engineering is truly inspiring.

The research and articles presented within the journal will serve as a valuable resource for fellow scholars, professionals and students in the field. I hope this journal helps to mark a better recognition of Nepalese Agricultural Engineers and encourage the policy makers to provide career opportunities to agricultural engineers for the advancement of agro-based economy of Nepal.

I am also indebted to Department of Agricultural Engineering, Purwanchal Campus along with all the sponsors and helping hands during the journal publication.

Let us celebrate this success together and look forward to even bigger achievements in the future.

Warm regards,

President

Madhav Bashyal

Reg. No 1002/964



NEPAL AGRICULTURAL ENGINEERING STUDENTS' SOCIETY

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IOE Purwanchal Campus, Dharan

ई.आ.स. पुर्वाञ्चल क्याम्पस, धरान

Dharan-8, Sunsari, Nepal



Message from Co-ordinator

I am thrilled to share with you the joyous news of the successful publication of the latest issue of "Agrineer" journal, dedicated to the field of agricultural engineering. As the coordinator of this esteemed publication, it is my honor to extend my heartfelt gratitude to each and every one of you who has played a role in bringing this issue to fruition.

The release of this issue represents a significant milestone in our ongoing commitment to advancing agricultural engineering knowledge and innovation. Within its pages, you will discover a rich tapestry of research, insights, and best practices that collectively contribute to the growth and sustainability of the agricultural sector. Our passionate authors have delved into various aspects of agricultural engineering, offering novel solutions to contemporary challenges and shedding light on emerging trends.

I would like to express my deepest appreciation to the authors who have generously shared their expertise and discoveries in this issue. Your dedication to exploring new frontiers, developing cutting-edge technologies, and improving agricultural practices is commendable. Your contributions will undoubtedly inspire fellow researchers, industry professionals, and policymakers to embrace innovative approaches and make significant strides in the field.

Thank you for being an integral part of the "Agrineer" community. Together, we can create a brighter, more sustainable future for agriculture.

.....
Ram Prasad Adhikari
Coordinator Agrineer
Volume-7

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Watershed Prioritization of the West Rapti Basin based in Morphometric Parameters Using Geospatial Analysis

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ABSTRACT

Prioritization of watershed has picked up significance in watershed management. Morphometric analysis is being commonly applied to prioritize the watershed. The present study makes an effort to organize sub watersheds dependent on morphometric characteristics using GIS techniques in West Raptibasin, located in the Mid-Western region of Nepal. There are nine Sub watersheds under this. Various morphometric parameters namely Bifurcation ratio (Rb), Drainage density (Dd), Stream frequency (Ns), Texture ratio (T), Form factor (Rf), Circularity ratio (Rc), Elongation Ratio (Re), length of overland flow, shape factor (Bs), drainage texture, compactness ratio (Cc) has been determined for each sub-watershed and allotted position on premise of relationship as to arrive at a computed value for final ranking of watershed. The morphometric parameters range between Rb (1.682-2.240), Dd (0.8831.280), Fs (1.047-1.233), T (1.795-5.266), Rf (0.22-0.27), Rc (0.11-0.32), Re (1.061.18), C (0.781-1.132), Lof (0.391-0.566). The very important quantitative watershed aspects such as linear, relief and areal have been taken in consideration, and six morphometric parameters have been selected and used for ranking and prioritizing of sub-watersheds. In this regard, lower rapti Subbasin, lundri Subbasin and jhimruk Subbasin have categorized into very high priority, upper Rapti sub-basin has categorized into high priority, siban and dundungad Subbasin into medium priority and Arun and madi Subbasin have categorized into low priority. However, depending upon the weightage of morphometric parameters and mean raster values, lower rapti Subbasin has been ranked into the first priority due to higher drainage density as well as the bifurcation ratio.

Keywords: GIS, DEM, Morphometric analysis, Subbasin, Priority

INTRODUCTION

Watersheds play a vital role in the hydrological cycle, influencing the quality and quantity of water resources. However, they are often subjected to various geomorphological and topographical conditions that can impact their health and sustainability. In order to better understand and assess watersheds, morphometric analysis has emerged as a valuable tool in geomorphology. By quantifying the morphology of a river basin, morphometric analysis provides insights into its shape and hydrological characteristics.

Morphometric parameters such as stream length ratio (Rl), bifurcation ratio (Rb), drainage density (Dd), drainage texture (Dt), stream frequency (Fs), elongation ratio (Re), circularity ratio (Rc), form factor (Rf), length of overland flow (Lg), and relief ratio (Rh) are commonly used to evaluate different aspects of watersheds. These parameters help in understanding the linear, areal, and relief features of a watershed and can provide valuable information for watershed management and conservation efforts. The stream length ratio (Rl) indicates the ratio of the total stream length of one order to the next lower order of stream segment. It reflects the maturity of the geomorphic status of the watershed. A higher stream length ratio

suggests a more developed watershed. Bifurcation ratio (R_b) measures the ratio of the number of stream segments of a specified order to the number of streams in the next higher order. It provides insights into the control of geologic structures on the drainage pattern. Drainage density (D_d) quantifies the total length of streams of all orders per unit area. It helps in understanding the density and interconnectedness of the stream network within a watershed. Drainage texture (D_t) is the total number of stream segments of all orders in a river basin divided by the perimeter of the basin. It provides information about the risk of soil erosion within the watershed. Stream frequency (F_s) measures the total number of channel segments of all stream orders per unit area. It can indicate the relief characteristics of a watershed. Elongation ratio (R_e) compares the diameter of a circle with the same area as the basin to the maximum basin length. It helps classify watersheds as elongated or circular. Circularity ratio (R_c) represents the ratio between the area of a watershed and the area of a circle with the same circumference as the watershed's perimeter. Form factor (R_f) assesses the ratio of the watershed area to the square of its length. It can provide insights into flood hydrograph characteristics. The length of overland flow (L_g) measures the average overland flow within a watershed. It helps assess the vulnerability to flash flooding. Relief ratio (R_h) quantifies the difference in elevation between the highest and lowest points in a watershed, indicating the relief characteristics.

In addition to morphometric analysis, watershed prioritization is crucial for effective conservation measures. It involves ranking different micro watersheds within a larger watershed based on their treatment and conservation needs. Prioritization takes into account factors such as soil erosion, drainage density, bifurcation ratio, land use, and land cover changes.

STUDY AREA:

The study area for this research project is the West Rapti River basin in Nepal. Situated in the mid-western region of the country, the West Rapti River basin offers an ideal setting to investigate the morphometric characteristics and prioritize conservation measures (Figure 1). The geographic coordinates of the study area span from $27^{\circ}56'50''$ to $28^{\circ}02'30''$ North latitudes and $81^{\circ}45'00''$ to **$81^{\circ}40'00''$ East longitudes**.

The main channel of the West Rapti River stretches for a length of 257 kilometers, originating from the middle mountains of Nepal. As it flows downstream, it traverses through diverse landscapes, including lowlands, before eventually joining the Ghagra (Karnali) River, a significant tributary of the Ganges River. Several tributaries contribute to the West Rapti River's flow, including the Jhimruk River, Madi River, Arun River, Lundri River, Sit River, Dundungad River, Sotiya, and Gandheli rivulets. Once the Jhimruk and Madi Rivers converge, the river assumes the name West Rapti River. The average slope of the West Rapti River basin is measured at 16.8%. This slope provides important insights into the terrain and topographical characteristics of the region. Understanding the slope of the basin can help in assessing the potential for water runoff, erosion, and the overall hydrological dynamics of the watershed. By focusing on the West Rapti River basin, this study aims to apply morphometric analysis and watershed prioritization techniques to gain a comprehensive understanding of the basin's features and identify areas that require conservation measures. The unique geographical attributes and diverse landscapes of the West Rapti River basin make it an ideal case study for examining the effectiveness of these approaches in managing and preserving watershed.

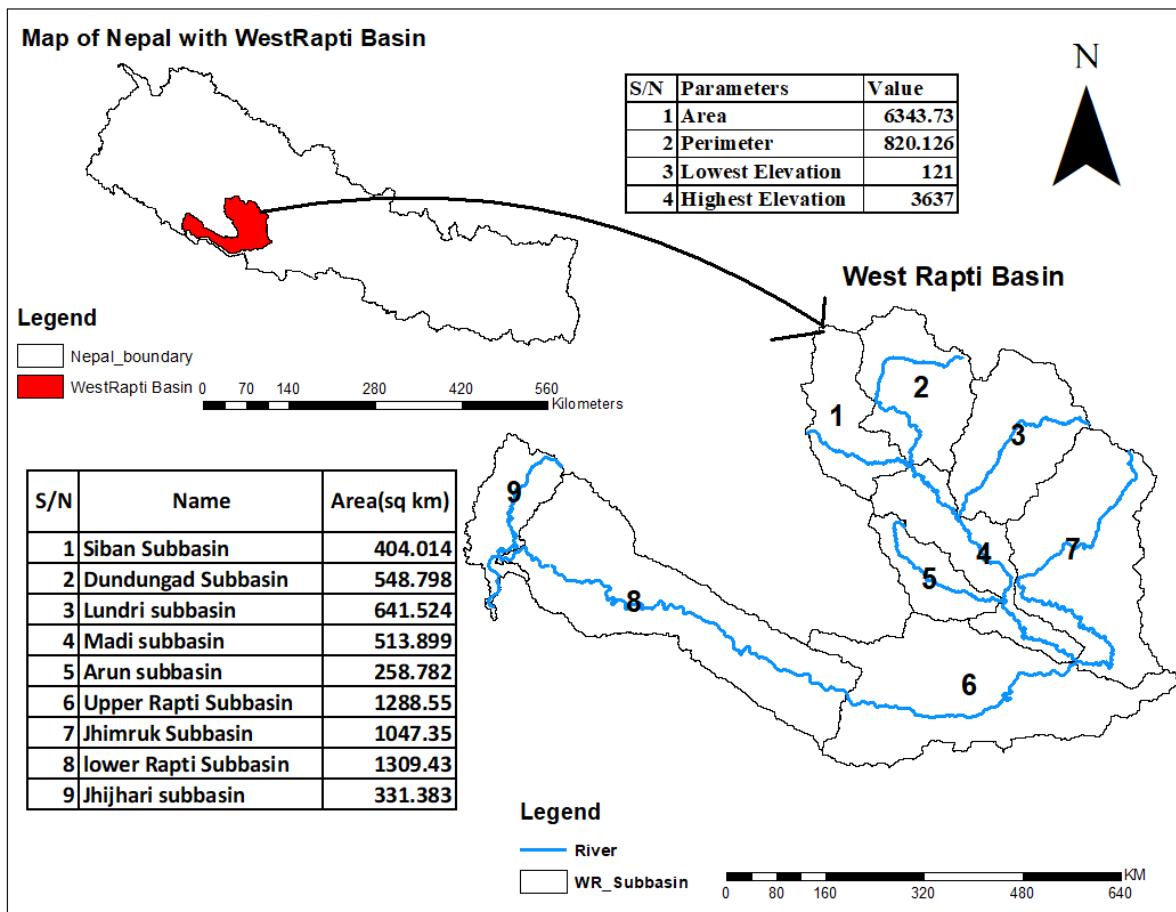


Figure 1: Map of the study area

MATERIALS AND METHODOLOGY

In the present study an integrated use of satellite data SRTM (Shuttle Radar Topography Mission) DEM (Digital Elevation Model) was utilized for generation of database and extraction of various drainage parameters. DEM of spatial resolution 30 m and spectral resolution 1 was used.

4. RESEARCH DESIGN

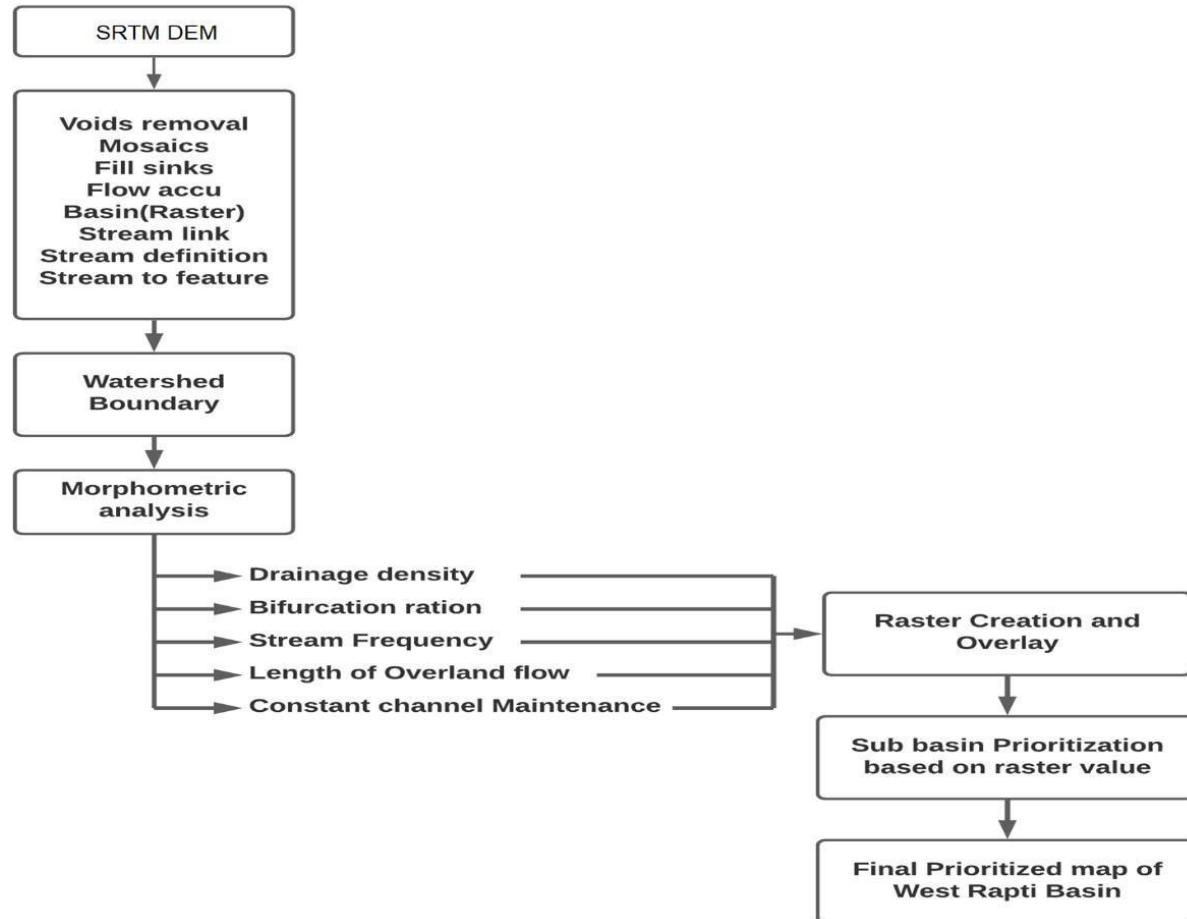


Figure 2: Flow chart for Watershed Delineation and Prioritization of West Rapti Basin.

For the prioritization by the morphometric analysis, the raster image of morphometric parameters such as drainage density, bifurcation ratio, stream frequency, texture ratio, length of overland flow and constant channel maintenance was created. After this, the raster overlay with certain weightage was done to obtain the final image. The weightage for individual raster is mentioned in the table 2 (Rekha, 2015):

$$\text{Prioritized map} = \text{Drainage density} \times 0.3 + \text{Bifurcation ratio} \times 0.25 + \text{Stream frequency} \times 0.2 + \text{Texture ratio} \times 0.1 + \text{Length of overland flow} \times 0.1 + \text{Constant channel maintenance} \times 0.05$$

Table 2: Morphometric parameters weightage

S/N	Parameters	Weight
1	Drainage density	0.3
2	Bifurcation ratio	0.25
3	Stream frequency	0.2
4	Texture Ratio	0.1
5	Length of Overland flow	0.1
6	Constant channel maintenance	0.05

RESULTS AND DISCUSSION

1. Watershed delineation of the West Rapti Basin

The watershed delineation was done to determine the information of the West Rapti Basin such as area, perimeter, highest and lowest elevation, length as well as the number of drainage lines with the stream order and the information of the sub basin. The detail of West Rapti sub basin is shown in the table 3.

Table 3: Details of West Rapti Basin

S/N	Parameters	Value
1	Area	6343.73
2	Perimeter	820.126
3	Lowest Elevation	121
4	Highest Elevation	3637

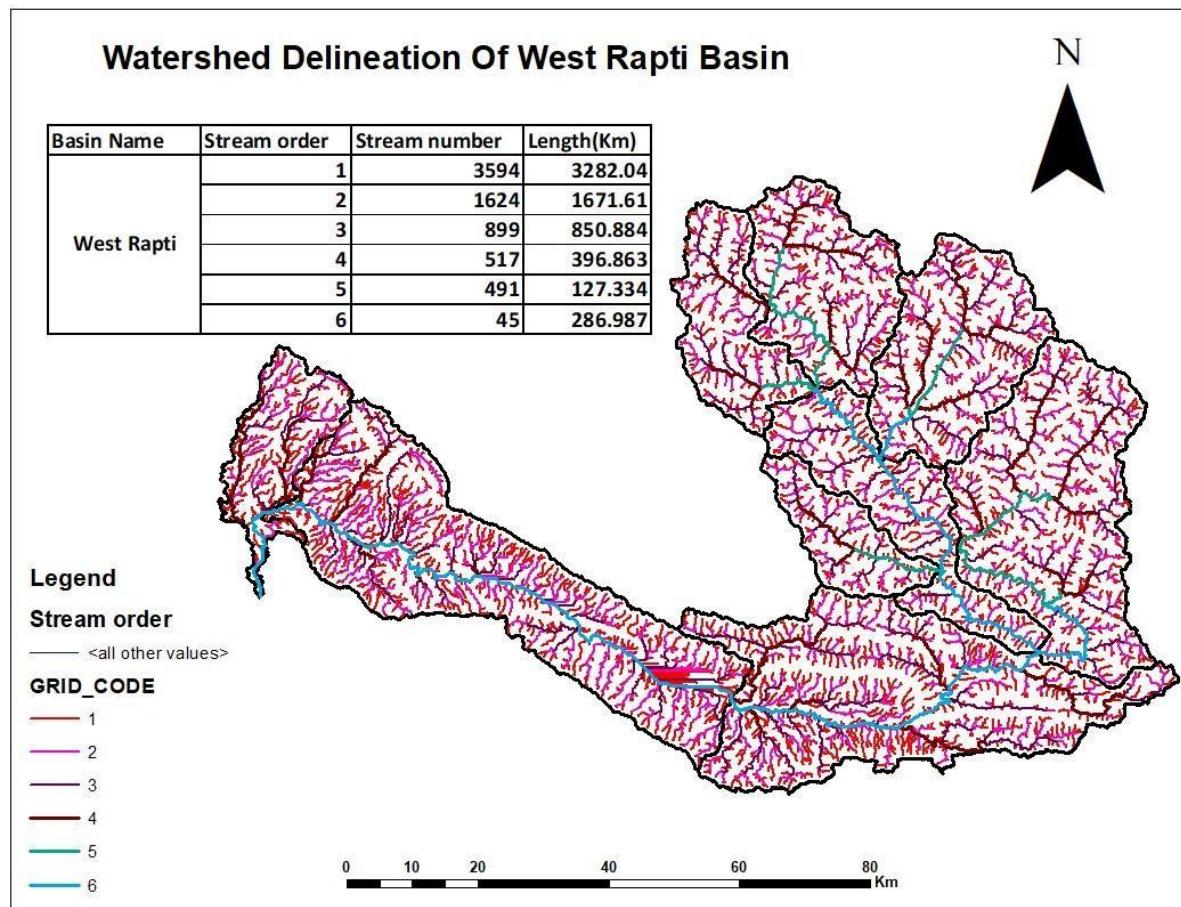


Figure 3: Watershed Delineation of West Rapti Basin

The watershed delineation of the West Rapti basin shown in the figure 3 clarified that, the stream order of the basin varies from 1st to 6th order. Stream ordering of the West Rapti basin was computed using ARC GIS software by applying the law proposed by [Horton, 1945](#). It is found that the total length of streams segment is maximum in first order streams and decreases as the stream order increases. This change in stream orders may indicate flowing of

streams from high altitude and lithological variations. The understanding of streams in a drainage system constitutes the drainage pattern, which in turn replicates mainly structural controls of the underlying rocks. The study area possesses dendritic drainage patterns, despite stream lengths and other hydrological properties. They are generally characterized by a treelike branching system, which indicates the homogenous and uniformity. While the dendritic drainage pattern suggests a lack of significant structural controls on the overall river network, it is important to note that other hydrological properties, such as stream lengths and morphometric parameters, contribute to the comprehensive understanding of the basin's hydrological dynamics. characteristics and identify potential areas of concern for conservation and management efforts.

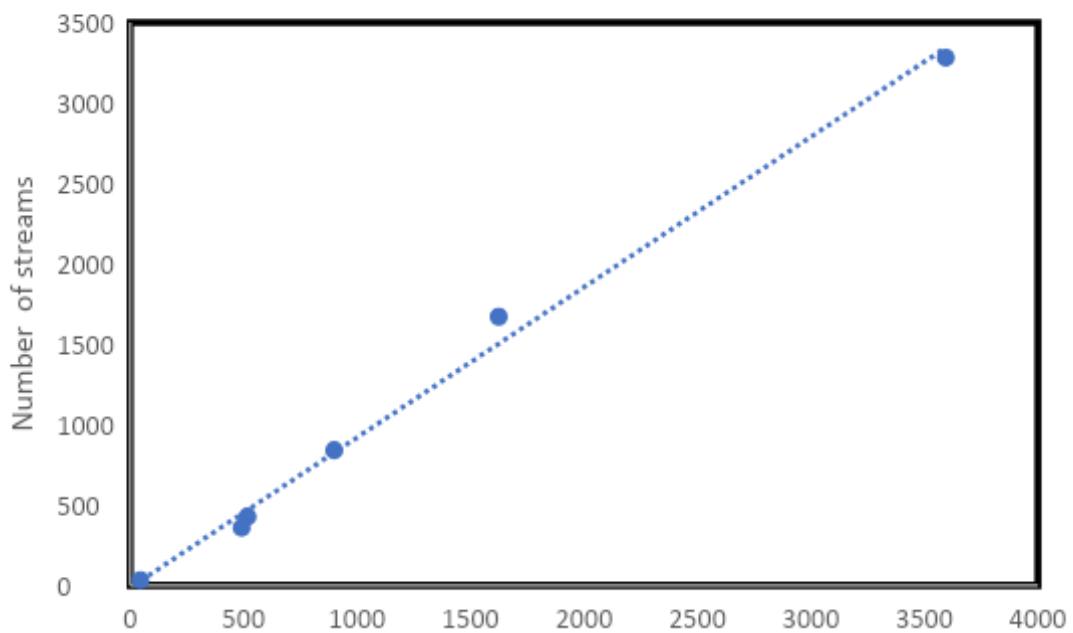


Figure 4: Regression analysis between number of streams and the length of drainage lines of West Rapti basin

From the graph shown in figure 4, it can be concluded that there are six stream orders with different lengths and numbers. The regression analysis of the stream and length showed the positive linear behavior with the value of $R^2 = 0.944$. Here, the number of streams are considered as independent variables and length of drainage lines are considered as dependent variables.

2. Morphometric Analysis

Designation of Stream order is the first step in morphometric analysis of a drainage basin, based on the hierachic making of streams proposed by Strahler (1964). In the study area sb1, sb2, sb4, sb5, sb6 sb8 and sb9 are of fifth order whereas sb3, and sb7 are of sixth order streams. The morphometric parameters were calculated, its shows that Bifurcation ratio (R_b) ranges from

1.628 to 2.240, sb5 have low R_b whereas sb9 have high R_b . Stream frequency (F_s) varies from 1.047 to 1.233 with sb9 having low and sb5 has high value. Texture ratio (T) ranges from 1.795 to 5.266 with low in sb9 and high in sb7. Form factor (R_f) is low in sb6 and sb8

and high in sb5, it ranges from 0.22 to 0.27. Length of overland flow varies from 0.391 to 0.566, sb8 have low value whereas sb5 have high LoF. Constant channel maintenance (C) shows wide variation across the sub watershed it is more in sb5 and less in sb8, it varies from 0.781 to 1.132. Elongation ratio (Re) varies from 1.06 to 1.18 with sb6 and sb7 has low and sb5 has high value. Circularity ratio (Rc) of Subbasin ranges from 0.11 to 0.32 with low in sb9 and high in sb3. The details of these values are shown in the table 4.

Table 4: Morphometric parameters of West Rapti Sub-basin

Subbasin	Name	Rb	Dd	Fs	T	Lof	C
1	Siban Subbasin	2.134	0.909	1.198	3.243	0.550	1.100
2	Dundungad Subbasin	1.688	0.927	1.159	4.165	0.539	1.078
3	Lundri Subbasin	2.137	0.899	1.163	4.693	0.556	1.113
4	Madi Subbasin	1.698	0.965	1.164	2.640	0.518	1.036
5	Arun Subbasin	1.682	0.883	1.233	2.782	0.566	1.132
6	Upper Rapti Subbasin	1.774	1.089	1.114	4.668	0.459	0.918
7	Jhimruk Subbasin	1.797	0.893	1.101	5.266	0.560	1.120
8	Lower Rapti Subbasin	2.020	1.280	1.108	4.688	0.391	0.781
9	Jhijhari Subbasin	2.240	1.175	1.047	1.795	0.426	0.851

Raster Of Morphometric Parameters Of West Rapti Basin

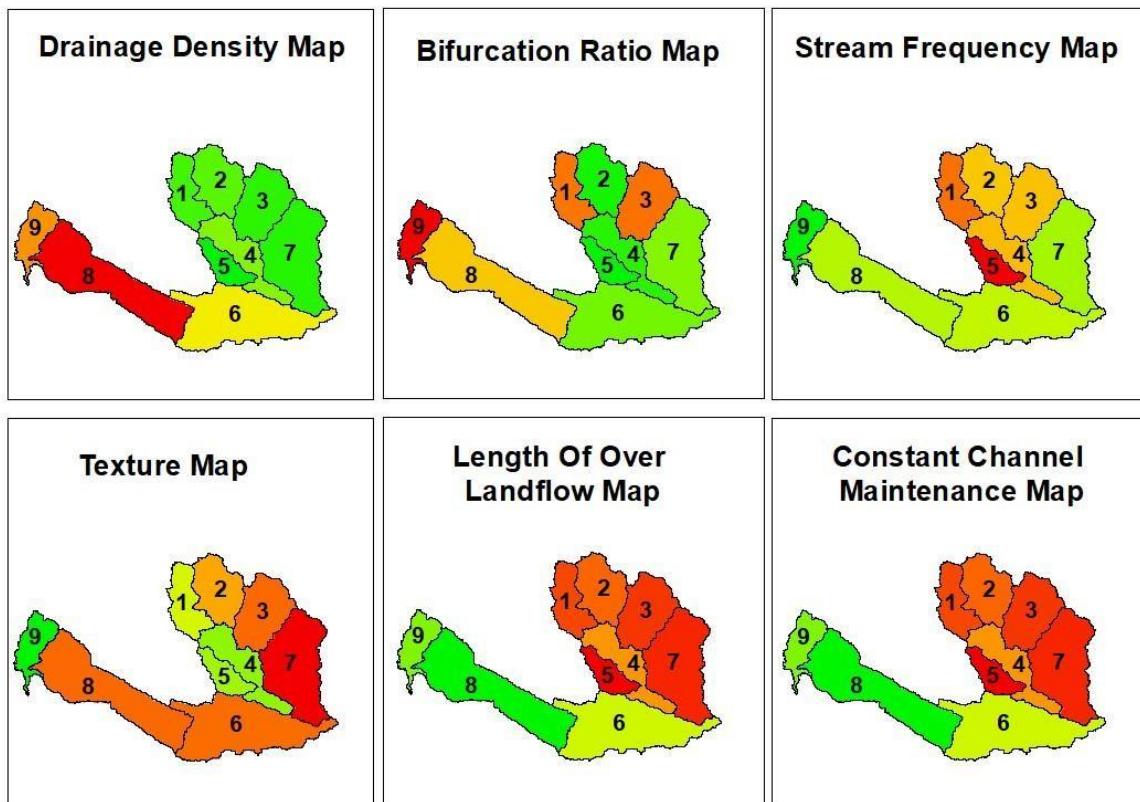


Figure 5: Raster of Morphometric Parameters of West Rapti Basin.

Raster of the different morphometric parameters are shown in the figure 5. The map shows that the Subbasin which lies in the red zone has the highest value and the Subbasin which lies in the dark green zone has the least value. On this basis it clarifies that, Drainage density (Dd) has its highest value in sb8 which is Lower Rapti Subbasin. similarly, bifurcation ratio (Rb) was found to be highest in Jhijhari sub basin, Stream frequency (Fs), length of overland flow (Lof) and

Constant channel maintenance© was found to be highest in the Arun sub-basin and lastly, the texture was found to be highest in the Jhimruk sub-basin. The maximum and minimum values of these morphometric parameters are shown in table 4.3

Table 5: Maximum and minimum values of morphometric parameters of subbasins of West

Morphometric Parameters	Values	
Bifurcation Ratio	Maximum	2.24
	Minimum	1.682
Drainage density (Dd)	Maximum	1.28
	Minimum	0.883
Stream frequency (Fs)	Maximum	1.233
	Minimum	1.047
Texture ratio (T)	Maximum	5.266
	Minimum	1.795
Length of overland flow(Lof)	Maximum	0.566
	Minimum	0.391
Constant channel maintenance (C)	Maximum	1.132
	Minimum	0.781

3. Prioritization of sub watersheds

Morphometric aspects such as Bifurcation ratio (Rb), Drainage density (Dd), Stream frequency (Ns), Texture ratio (T), Form factor (Rf), Circularity ratio (Rc), Elongation Ratio (Re), length of overland flow, Basin Shape (Bs), drainage texture, compactness ratio (C) is also termed as erosion risk assessment parameters and have been used for prioritizing Subbasin (Biswas et al 1999). The parameters such as Bifurcation ratio (Rb), Drainage density (Dd), Drainage Texture, Stream frequency (Ns), Texture ratio (T), have a direct relationship with erodibility, higher values of all these have been rated as rank 1 second largest is rated as rank 2 and so on with the least ranked last. Parameters such as Form factor (Rf), Circularity ratio (Rc), Elongation Ratio (Re), Basin Shape (Bs) have inverse relationship with the erodibility, higher the value less is erosion lower the value high is erodibility.

In this manner least estimations of this are appraised as rank 1 and second least been rated as rank 2 and so on and the highest values is given last rank. After the ranking has been done

based on every single parameter of each Subbasins were added up for each of the nine Subbasins to arrive at compound value. Based on the average value of these parameters.

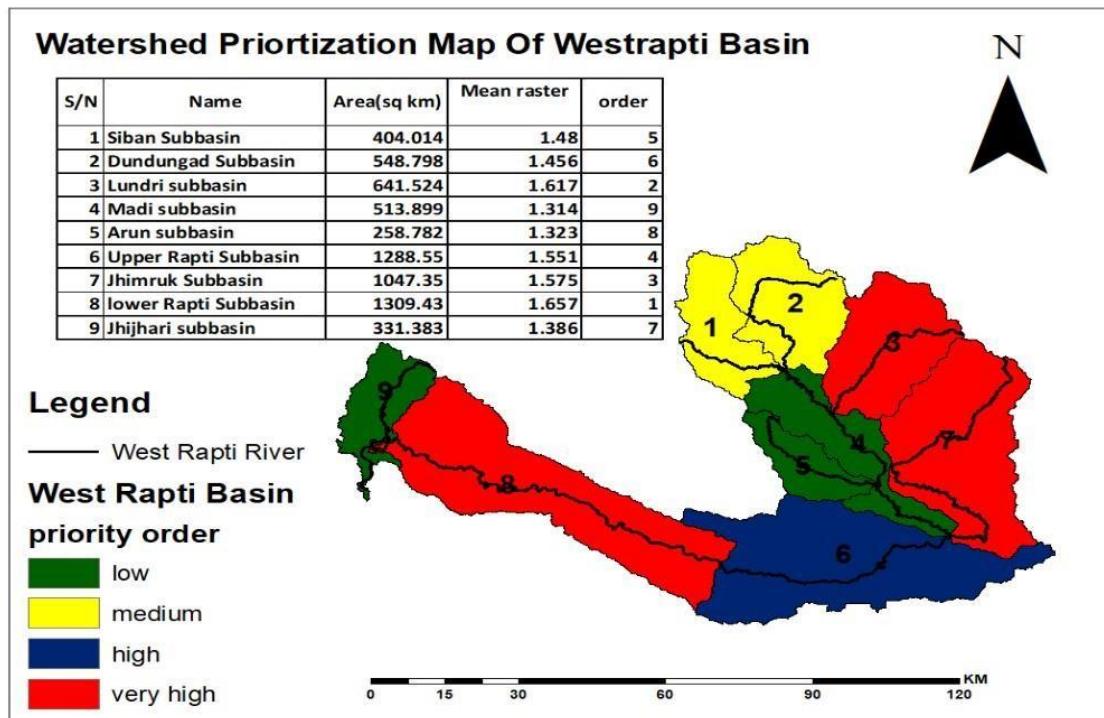


Figure 6: Priority Map of West Rapti Basin

Subbasin with least rating was assigned highest rank next value was assigned second rank and so on and the Subbasin with highest compound value was assigned last rank. Hence on basis of the weightage of morphometric parameters and raster values, the priority map shown in the figure 4.4 justifies that, Subbasin 8 is highly erosive which is Lower Rapti Subbasin and given first priority and the Subbasin 4 is given the last priority which is Mardi Subbasin. The priorities and the ranking of different Subbasin in shown in the table 6.

Table 6: Priorities of Subbasins and their ranks

Sub basin	Name	Rb	Dd	Fs	T	Lof	C	Area (sq km)	Value	Rank
1	Siban Subbasin	2.134	0.909	1.198	3.243	0.550	1.100	404.014	1.48	5
2	Dundungad Subbasin	1.688	0.927	1.159	4.165	0.539	1.078	548.798	1.456	6
3	Lundri Subbasin	2.137	0.899	1.163	4.693	0.556	1.113	641.524	1.617	2
4	Madi Subbasin	1.698	0.965	1.164	2.640	0.518	1.036	513.899	1.314	9
5	Arun Subbasin	1.682	0.883	1.233	2.782	0.566	1.132	258.782	1.323	8
6	Upper Rapti Subbasin	1.774	1.089	1.114	4.668	0.459	0.918	1288.55	1.551	4
7	Jhimruk Subbasin	1.797	0.893	1.101	5.266	0.560	1.120	1047.35	1.575	3
8	Lower Rapti Subbasin	2.020	1.280	1.108	4.688	0.391	0.781	1309.43	1.657	1
9	Jhijhari Subbasin	2.240	1.175	1.047	1.795	0.426	0.851	331.383	1.386	7

The graphical representation of priority map is shown in the figure 7 which was plotted based on the values of different morphometric parameters and their corresponding raster values. Here, the thin black line shown at the top of bar chart clarifies that Lower Rapti Subbasin should be ranked first on the basis of priority. Similarly, Madi Subbasin should be ranked last on the basis of priority. Moreover, the graph shows that Jhimruk Subbasin has the highest texture value in comparison to the other sub basins.

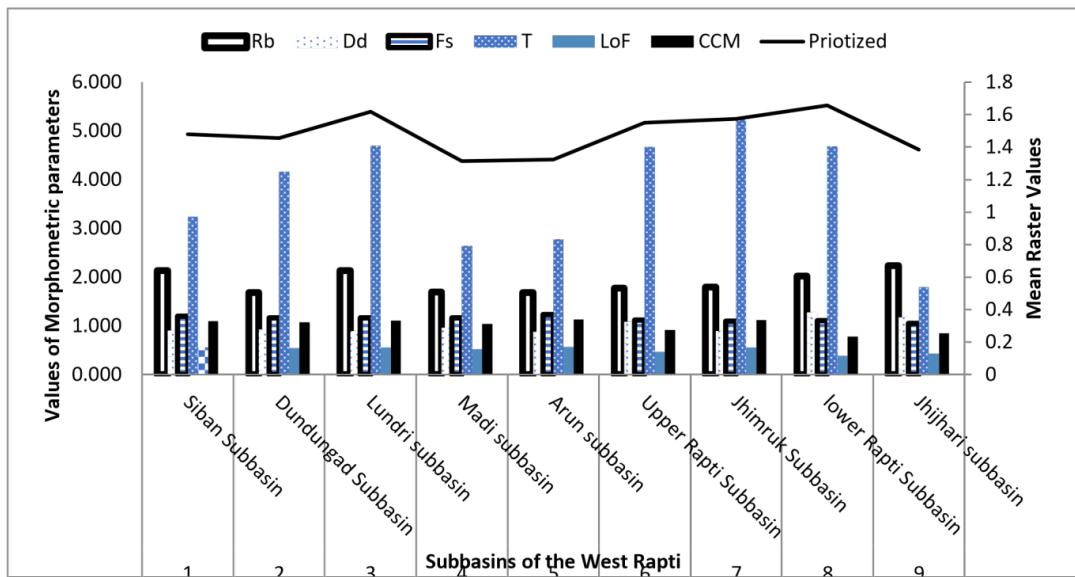


Figure 7: Graphical representation of priority map of west Rapti basin

6. CONCLUSION

The present study gives a thought regarding the basin characteristics in terms of slope, topography, soil condition, runoff characteristics, surface water potential etc. Lower Rapti Basin should be prioritized on top and least priority goes to Madi Subbasin. The higher priority in the lower Rapti basin happens due to higher drainage density as well as the bifurcation ratio. The higher drainage density attributes to greater drainage lines in the river system that can carry massive discharge as well as the sediment in the peak period. The higher values of the bifurcation ratio mean the ability of the river to divert the river path away from the river lines. This results the river path to meander and sometimes flow across the bank and cut the fertile land. To avoid such problem, the river training works such as construction of guide bund, spur or levee should be constructed at the vulnerable sites of the lower Rapti basin. For the basin at the middle or upper reaches, the bio engineering principles should be adopted for the watershed management.

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Determination of the Change Detection in the Land Use/Land Cover by Supervised Image Classification Technique using RS and GIS: A Case Study of Chitwan District

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Abstract:

Due to the increasing rate of population and unmanaged way of urbanization there arise many problems like degradation of cultivable land, deforestation and poorly maintained marginal land, landslides in Narayanghat-Mugling Highway. These problems can be managed using RS and GIS in which we analyze different land satellite images of the district for past 20 year in a interval of 10 years. After analyzing the land satellite images, we have idea to assess the pattern of changes in population, industrial development, and the area covered by agricultural and vegetation, as well as how these factors interact through time and the consequences on surface water supplies. The project's output aids in educating the public about deforested areas and in the development of the concepts of agroforestry, communal forests and managing related organization to make proper decision. After analysis it was found that between 1992 to 2002, there was a expansion of built up land and grassland from 0.74% to 1.02% and 1.16% to 2.8% followed by barren area from 0.81% to 2.67%, however forest area, crop land and water bodies shows a reduction from 66.8 % to 63.83%, 28.6% to 28.36% and 1.1% to 1.1% aerial coverage. On the other hand, in between 2002 to 2012, water bodies, forest and built up area shows increase in the aerial coverage from 1.1% to 2.7%, 63.83% to 64.9% and 1.02% to 1.6% respectively and there is decrease in cropland, barren land and grassland from 28.36% to 28.1%, 2.67% to 0.91% and 2.8% to 2.17% respectively. And at last in between 2012 to 2022, water bodies, forest and built up area shows increase in the aerial coverage from 2.7% to 4.09%, 64.9% to 67.7% and 1.6% to 3.44% respectively and there is decrease in cropland, barren land and grassland from 28.1% to 23.24%, 0.91% to 0.078% and 2.17% to 1.34% respectively. The major possible driving forces for these changes were natural factors such as mostly flat slope, drought and climate change. The possible human driving factors include population growth and density, over intensification of land use, farm size, land tenure status, and policies on land use. These factors results in various forces and strong effect to change the quantity and quality of land use.

Keywords: Urbanization, Satellite images, RS, GIS,

INTRODUCTION:

The physical characteristics of the surface of the land, such as vegetation, water, crops, and urban infrastructure, are referred to as land cover (LC). LU is the adjustment of LC according to human needs and behaviors. The most accurate LU indicator is land cover (LC). Land use (LU) is the modification of land cover (LC) in response to human needs and actions. Land cover (LC) defines the physical properties on the surface of the land, such as forest, water, crops, and urban infrastructure. In environmental science and geography, the phrases land use and land cover (LULC) are used to refer to how people utilize and manage the land. The phrase "land use" describes the unique activities and procedures that are carried out on a

given plot of land, such as farming, mining, or urban growth. The physical and biological elements that make up the land's surface, such as forests, grasslands, and water bodies, are referred to as land cover. In order to maintain biodiversity, support ecosystem services, and provide resources for human communities, LULC is a critical component of our planet's ecology. The best way to measure LU is through land cover (Mallupattu and Sreenivasula Reddy, 2013a). Changes in land use and land cover are acknowledged to be significant contributors to global environmental change and to the socioeconomic development of local communities. The term "Land Use and Land Cover" (LULC) refers to the physical and biological components of the earth's surface, such as the soil, water, plant, and man-made structures. For a variety of applications, such as environmental monitoring, natural resource management, urban planning, and disaster management, it is crucial to comprehend LULC and its changes through time (Hasen M.C, Potapov, 2013). On regional to global dimensions, changes in land use and land cover (LULC) have a significant impact on ecosystem functioning, ecosystem services, and biophysical and human factors like climate and governmental policies (Hussain et al., 2020).

LULC can be categorized and analyzed in a variety of ways, from straightforward visual interpretation of satellite imagery to sophisticated machine learning algorithms that can automatically recognize and map various land use and land cover patterns. Remote sensing, geographic information systems (GIS), and field surveys are some of the most used techniques for LULC analysis. A comprehensive overview of LULC patterns at regional or global scales can be obtained using remote sensing techniques like satellite and aerial imaging, while a more in-depth examination of LULC changes over time and space can be performed using GIS. To verify and improve the results of remote sensing and GIS, field surveys, such as vegetation sample or soil analysis, can give ground-truth data. An important technique for studying and increasing our understanding of the earth's physical processes is remote sensing. The mapping and monitoring of LULC has been made much easier thanks to remote sensing tools like satellite images and aerial photography. These methods make it possible to recognize and categorize different forms of land cover, including woods, wetlands, croplands, and urban areas, as well as to quantify changes in land use, such as logging, urbanization, and agricultural growth. Utilizing the growing amount of geographic data made available by GIS in conjunction with satellite data is a recent trend in the usage of satellite data. GIS is an integrated system of computer hardware and software that can collect, store, retrieve, manipulate, analyze, and display spatially referenced information in order to support management and decision-making procedures that are geared toward advancing growth. Agriculture, the environment, and integrated eco-environment evaluation are just a few of the areas where remote sensing and GIS have a wide range of applications. Due to the negative consequences that LU/LC studies have on the local ecosystem and plants, many researchers have concentrated on them. (Mallupattu and Sreenivasula Reddy, 2013b)

Bharatpur, its largest metropolis, is one of Nepal's fastest-growing cities. The city has not been managed well as a result of this rapid population growth. There are haphazard settlements and unplanned places due to the rising rate of migration from mountainous areas, which results in the degradation of cultivable land. There are numerous rivers such as the Narayani and Rapti, as well as lakes like Bishajari, Sorahajari and Nandavauju Lake. The perennial river Narayani has a lower rate of soil and water conservation, which contributes to land cutting, bank erosion, and soil erosion.

The scope and character of LULC changes in the Chitwan district throughout time have been recorded by numerous research. For instance, Paudel et al.'s (2019) analysis of LULC trends from 1990 to 2016 using remote sensing and GIS methodologies revealed that agricultural land rose by 12.9% while forest cover dropped by 26.1%. Devkota et al. (2021) examined the drivers of LULC changes in the Chitwan district and found that infrastructure development, agricultural expansion, and population growth were the key causes of these changes. Changes in land use and land cover have a substantial impact on the environment on a local, regional, and international level. Regional and worldwide loss of biodiversity, disturbances in hydrological cycles, an increase in soil erosion, and increased sediment loads are all severe effects of these changes (Mzuza et al., n.d.). It also has Chitwan National Park. The Chitwan district is mostly covered with forests, grasslands, marshes, and hilly terrain. Due to the increase in the population of the area resulting in the maximum use of the forest area so there is an imbalance between the wild animals and humans, and the attacks of the wild animals have increased (Ruda et al., 2018).

OBJECTIVES

General objective:

- To analyze the land use land cover change in the Chitwan district from 1992 to 2022.

Specific objectives:

- To prepare map from satellite image using ArcGIS 10.5.
- To assess the trajectory of changes in human habitation and the area used for agriculture and vegetation, as well as how these variables interact through time and what consequences there are for surface water supplies.
- To make conclusions about how to manage the surface of the water resources.
- To identify densely populated area and urban area.
- To perform accuracy assessment of classified image

SIGNIFICANCE OF STUDY

The study of the comparison provides ideas on:

- Systematic planning of urban areas in an appropriate manner,
- Main priority to improve in the affected areas.
- Educating people about deforested areas and creating concepts for community and agroforestry
- Judicious use of natural resources and management of those resources

LIMITATION OF STUDY

Some limitations are listed below:

- Ground validation cannot be performed so that accuracy of change obtained is not completely accurate.
- Due to more percentage of cloud cover, it is difficult to obtain clear Landsat images.
- The area of different land cover classes obtained is not completely accurate because of pixel based classification system.

- It is difficult to obtain Landsat data of same time period by which we cannot obtain more accurate result due to more difference in land use pattern.

METHODOLOGY

1. Study Area

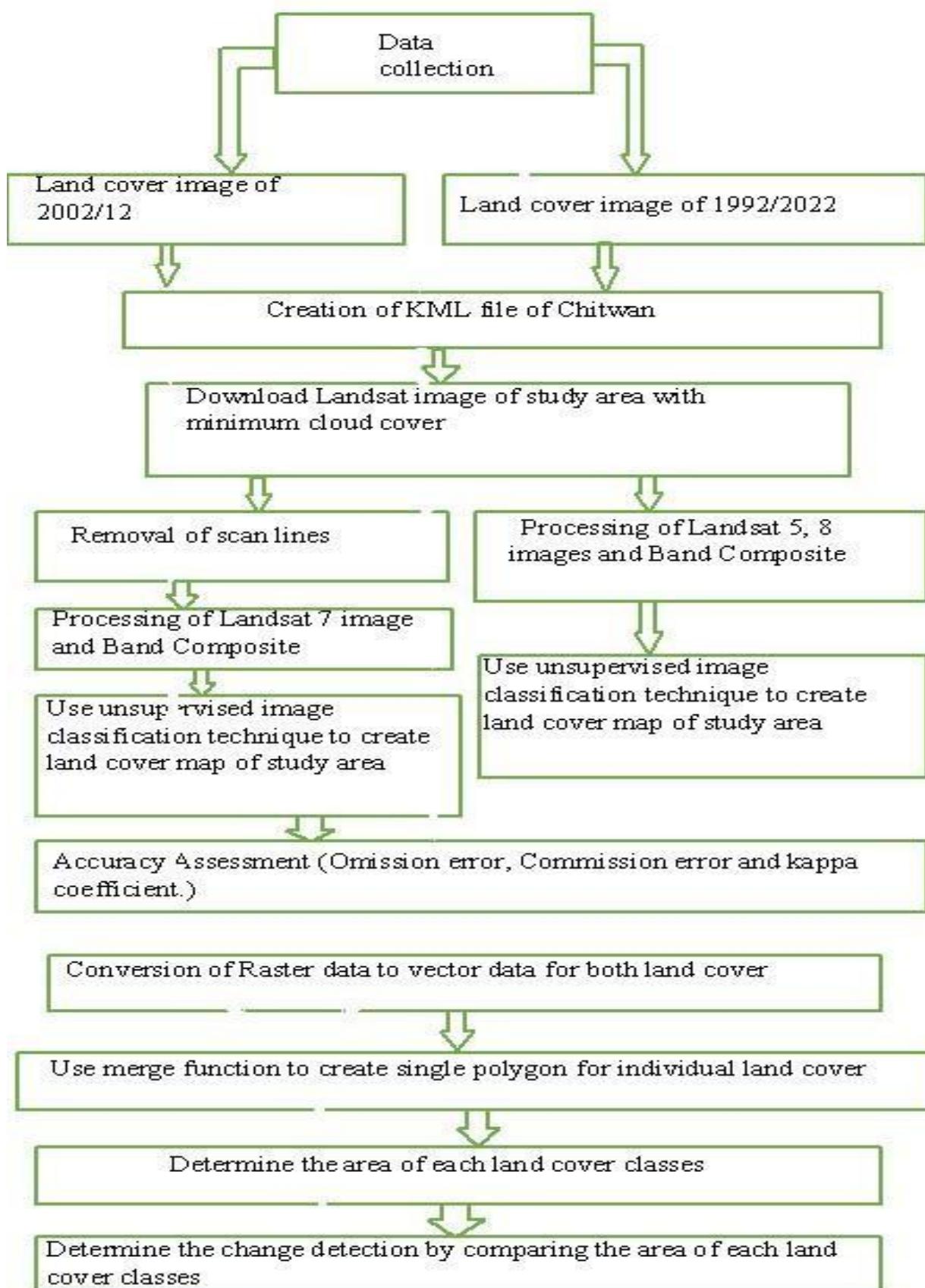


Study Area	Chitwan District
Location	27°36'21.60"N 84°22'47.28"E
Area	2238.39 Km ²

Figure 1. Map of study area

Using remote sensing and unique metrics approaches, data from primary and secondary sources were processed and evaluated to quantify LULC. This study, as previously stated, employs remote sensing and spatial metrics methodologies to measure land use and land cover change and patterns. Remote sensing image classification is a useful tool for determining the amount and pace of land use and land cover change, whereas spatial metrics are derived using the remote sensing image classification results to quantify land use and land cover change. Both are thought to improve understanding of land use and land cover change. The methods are also quick ways to obtain useful information when spatial data is lacking.

2. Research Design



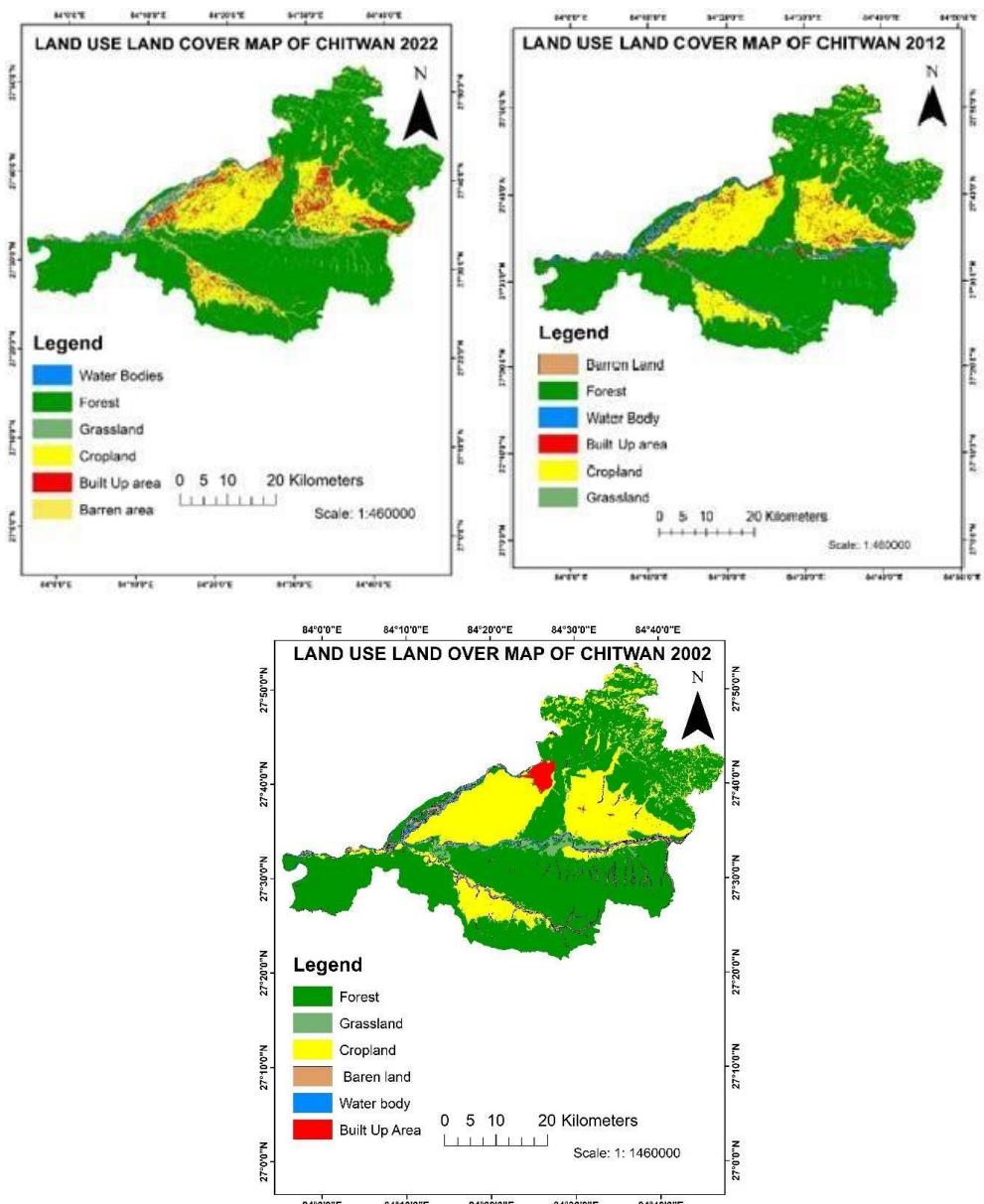
RESULT

A classification system was devised for the study region based on prior knowledge of the area that dates back more than 30 years, a quick reconnaissance assessment, and additional data from earlier studies in the area. The LULC was identified by a single number under the categorization system, which provides a rather broad classification included. A computer application can compare the area of various land uses cell by cell by superimposing them on maps. Six distinct land use and land cover categories were discovered using supervised classification tools. These consist of bodies of water, forests, shrubs, cropland, and barren areas.

S.N	Land cover classes	Characteristics
1	Forests	Dense vegetation areas with dense shrubs inner recreational areas, River line plantation, Tall Dense trees, fairly dense Sal Jungles
2	Cropland	Agricultural area or cultivated area planted or irrigated area, fallow land and paddy crops
3	Water bodies	River, Lakes, Check dams, permanent open water, reservoirs
4	Built up area	Area like town, village, populated with residential, commercial, industrial and transportation facilities
5	Barren area	Unfertile and empty area ,river sand
6	Grassland	Plain green vegetation, grazing area, small dense forest area and shrub

Table: Estimation of Landcover

LULC classes	Area in square kilometres				Area in percentage			
	1992	2002	2012	2022	1992	2002	2012	2022
Water body	42.65	26.49	50.9	91.6	1.9	1.1	2.27	4.09
Forest	1493.2	1427.4	1452	1516	66.8	63.83	64.9	67.7
Built up area	14.62	22.86	35.85	77	0.74	1.02	1.6	3.44
Cropland	640	634.24	628.89	519.65	28.6	28.36	28.1	23.24
Barren land	18.28	59.84	20.53	1.75	0.81	2.67	0.91	0.078
Grassland	26	62.59	48.68	30	1.16	2.8	2.17	1.34
Total	2236	2236	2236	2236	100	100	100	100



CONCLUSION

This study focuses on LULC analysis of Chitwan district over past four decades. Four-year 1992, 2002, 2012 and 2022 are taken for image analysis and the data obtained from USGS website were pre-processed and analyzed using supervised classification. After the analysis of data into different land cover classes, accuracy assessment of the data was done by calculating error matrix presented above. From 1992 to 2002, there is decrease in forest from 66.8% to 63.83%, the forest area from 2002 to 2012 increases in % from 63.83 to 64.9 and trends shows there is increase in forest area from 64.9% to 67.7% in between 2012-2022. There is increase in forest area because of concept of community forest and agro-forestry especially on the northern belt of Terai areas. For water body, there is decrease in % from 1.9 to 1.1 from 1992-2002, increase in % from 1.1 to 2.67 from 2002-2012 and again increase in % from 2.67 to 4.09 from 2012 to 2022 as shown in figure above. This may be due to increase in rainfall in northern belt according to LULC map presented above which abruptly increases level of water.

Due to the decrease in water body, there is increase in grassland from 1992-2002 from 1.16% to 2.8%, the grassland from 2002 to 2012 decreases in % from 2.8 to 2.17 and there is decrease in grassland from 2.17% to 1.34% in between 2012- 2002. Similarly for crop land, the crop land remains almost same from 1992 to 2002 and there is decrease in cropland in % from 28.36 to 28.1 in between 2002-2012. And again, there is decrease in crop land from 28.1% to 23.24% in between 2012-2022.

For built-up area, there is increase in built up area in % from 0.74 to 1.02 from 1992 to 2002, again there is increase in built up area in % from 1.02 to 1.6 in between 2002-20012. And there is again increase in built up area in % from 1.6 to 3.44 in between 2012-2022. The increase in built up area because of migration of people from rural area to urban area. In Chitwan district there are two main area where the population density has increased randomly i.e Bharatpur and Ratangar. For the barren area there is increase in barren area from 0.81% to 2.67% in between 1992-2002, the barren area from 2002 to 2012 decreases in % from 2.67 to 0.91 and again there is decrease in barren area from 0.91% to 0.078% in between 2012-2022. This change is due to agro-forestry and community forest development.

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Renewable Energy Development in Nepal: Potential, Policies and Challenges

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ABSTRACT

This research article provides a comprehensive analysis of the renewable energy sector in Nepal, focusing on its potential, policies, and challenges. The study explores the current energy landscape in Nepal, highlighting the dominance of hydropower and the untapped potential of solar, wind, biomass, micro-hydro, and geothermal energy sources. It examines various strategic plans and policies that aim to promote renewable energy in the country and achieve sustainable development goals. Additionally, the article identifies the challenges hindering the growth of renewable energy, including outdated technologies, limited access to finance, ambiguous policies, and inadequate infrastructure. Finally, the article proposes strategic recommendations for advancing renewable energy development in Nepal, including leveraging climate and energy funds, strengthening donor relationships, fostering public-private partnerships, collaborating with local governments, and promoting e-cooking initiatives.

INTRODUCTION

As of mid-March 2022, an impressive 94.0 percent of Nepal's population had achieved access to electricity. The Economic Survey, 2021/22 by the Ministry of Finance reveals that the electricity generation breakdown comprised 2,033 Megawatts (MW) from hydroelectricity, 49.73 MW from solar plants, 53.4 MW from thermal plants, and 80 MW from various other sources, encompassing renewables and co-generation¹. Nepal's geographical and topographical characteristics position it as an auspicious site for the development of renewable energy. At present, hydropower stands as the primary energy source in Nepal, contributing to over 90% of the nation's electricity production. Furthermore, Nepal demonstrates potential for diversifying its energy portfolio through the utilization of other renewable sources, including solar, wind, biomass, and micro-hydro.

Solar Energy

Nepal possesses a remarkable potential for harnessing solar energy, characterized by an average of 300 sunny days and 6.8 hours of sunshine. The specific solar photovoltaic (PV) electricity output capacity in the country falls within the range of 1400 kWh/kWp to 1600 kWh/kWp, resulting in an average daily total ranging from 3.8 to 4.4 kWh/kWp. The mountainous regions, with their higher elevations and cooler air temperatures, exhibit even greater potential for PV energy yield. In light of these favorable conditions, the World Bank identified the hills and lower-elevation mountains with optimal Global Horizontal Irradiance (GHI) and lower temperatures as the most suitable areas for solar PV system development in Nepal in 2017.

According to the Solar and Wind Energy Resource Assessment (SWERA) report by the Alternative Energy Promotion Center (AEPC), the estimated commercial potential for on-

grid solar PV systems in Nepal is 2,100 MW, as cited by UNEP/GEF in 2008. Moreover, approximately 25% of Nepal's land area is deemed suitable for Concentrated Solar Power (CSP) systems, which, even with just 2% utilization of the best solar irradiance, can generate 1829 MW of electricity. The initiative to employ solar PV systems for electrifying rural households in Nepal was launched after the establishment of AEPC in 1996. As of mid-2021, AEPC had successfully facilitated the installation of over 961 thousand solar home systems ranging from 10Wp to 100 Wp capacities throughout the country. Additionally, around 3,000 institutional solar power systems were implemented in schools and health posts, along with approximately 2,300 PV pumping systems for small-scale irrigation and 200 systems for drinking water supply. AEPC also implemented 30 off-grid solar and solar-wind hybrid mini-grids, cumulatively contributing a capacity of 1,262 kW across Nepal². In Nuwakot, the Nepal Electricity Authority (NEA) operates a utility-scale solar PV power plant with a capacity of 25 MW. As of May 2023, 47 solar PV projects in Nepal have obtained survey licenses, indicating a projected production capacity of 1248.59 MW. Furthermore, construction licenses have been granted to 21 solar projects, collectively contributing to a total capacity of 133.56 MW³.

Wind Energy

Nepal possesses a significant and untapped potential for harnessing clean wind energy. A report published by the Solar & Wind Energy Resource Assessment in Nepal (SWERA) in 2008 identifies a promising area spanning over 6000 square kilometers, characterized by a wind power density exceeding 300 watts/m². If only 10% of this region is considered suitable for wind energy production, Nepal has the capacity to generate up to 3000 MW of wind energy, translating to a rate of 5 MW per square kilometer. The study highlights the high and middle mountainous areas of Nepal as the most promising locations for wind energy development. However, the commercially viable wind energy potential of the country is currently estimated at a modest 448 MW. Nonetheless, efforts have been made to explore and utilize wind energy resources in Nepal. The Asian Development Bank has provided support for the installation of two wind turbines with 5 kW capacities each, accompanied by a 2 kW solar hybrid system in Nawalparasi, Dhaubadi VDC. Additionally, several pilot projects focusing on small wind-solar hybrid systems have been implemented in various locations across the country. Notably, the largest wind-solar hybrid power system in Nepal, boasting an installed capacity of 20 kW, has been successfully completed and is providing electricity to 90 rural households. As of the fiscal year 2020/2021, the cumulative installation of solar and wind mini-grid systems, according to estimates by the Alternative Energy Promotion Center (AEPC), has reached 1262 kW.

Micro and Pico Hydro

Micro-hydro and pico-hydro power systems, which generate electric power below 100 kW and 1 kW respectively, have emerged as practical and cost-effective solutions to address the electricity needs of rural and remote areas in Nepal, where expanding the national grid has been challenging. Leveraging its vast hydropower potential, Nepal has actively promoted the development of micro-hydropower as a means of rural electrification since the government initiated subsidization for such projects in 1981. As of 2018, the installed capacity of micro-hydropower plants, including pico-hydropower plants, reached up to 38 MW, while the country's untapped potential for hydroelectricity from these small-scale plants exceeds 50 MW.

Integrating micro and pico-hydropower systems into the national grid would enhance their sustainability and economic viability. By 2020, four micro-hydropower plants with a total capacity of 253 kW have been successfully integrated into the national grid, with several more projects currently under evaluation. The Alternative Energy Promotion Center (AEPC) collaborates closely with various stakeholders, including local communities, to facilitate and promote the development of micro and pico-hydro projects throughout the country.

Biomass

According to the Ministry of Finance (2021), Nepal's agricultural sector plays a crucial role in the country's economy, employing 60.4% of the total population⁴. The substantial biomass generated from farming and livestock activities presents an excellent opportunity for utilizing biogas technology, particularly for cooking purposes, given the country's sizable population. Around 1.9 million households, accounting for 42% of all households in Nepal, have the potential to adopt household biogas systems. The Government of Nepal (GoN) has actively promoted various capacities of biogas plants under the domestic category, ranging from 2 cubic meters to 8 cubic meters, while biogas plants exceeding 12 cubic meters are classified as Large Biogas Plants. As of 2021, approximately 435,000 household biogas plants have been successfully installed across Nepal, with a majority of these installations located in the Terai region. Additionally, there are 343 large-scale biogas plants implemented throughout the country, with over half of them also situated in the Terai region. These initiatives demonstrate the government's commitment to expanding the adoption of biogas technology and harnessing its benefits for sustainable energy and rural development.

Geothermal Energy

Geothermal energy refers to the thermal energy that is generated from the sub-surface of the Earth, where water and/or steam are responsible for carrying this energy to the surface. In the Nepalese context, geothermal energy can be employed for an array of applications, including agriculture drying, fish farming, greenhouse heating, snow-melting, and bio-digestion. Despite the many potential benefits of geothermal energy in Nepal, its use has thus far been limited to recreational and tourism-related activities such as balneotherapy. Nepal remains in the early stages of exploring the potential of geothermal energy, and the country's only source of information regarding hot springs and geothermal resources comes from two research papers authored by Mahendra Ranjit (2005, 2015). There are 31 major geothermal springs scattered throughout Nepal, but the government's "Alternative Energy Perspective Plan" (2002-2017) identifies geothermal energy as a promising alternative energy source for the country. In 2001, the Government of Nepal initiated geothermal programs through the Alternative Energy Promotion Centre, which conducted field surveys at two accessible geothermal locations: Kodari and Singha Tatopani. However, the study was limited to preliminary chemical analysis of the thermal water. While isotopic studies conducted by Mahendra Ranjit (2010) suggest the possibility of a vast geothermal reservoir in the Sadhu Khola - Jomsom area of central Nepal, these qualitative estimates must be confirmed through geophysical investigations.

RENEWABLE ENERGY IN VARIOUS STRATEGIC PLANS AND POLICIES

Nepal is resolutely dedicated to achieving net-zero emissions by 2045, as detailed in its comprehensive Long-term Strategy for Net-zero Emissions. The strategy presents two scenarios: the With Existing Measures (WEM) scenario, which evaluates the impact of intervention measures implemented up to 2020, and the With Additional Measures (WAM) scenario, which encompasses additional feasible mitigation actions. The strategy's sectoral approach emphasizes maximizing power generation from renewable energy sources. Key strategic actions include the development of hydropower plants, integration of variable renewable energy into power systems, expansion of distributed energy resources, and the establishment of policies on regional power sector integration, renewable energy integration, and grid flexibility. For both the WEM and WAM scenarios, the Long-term Strategy establishes targets for energy generation capacity and investment. By 2050, the WEM scenario aims for 34 GW of hydropower, 2.1 GW of grid-connected solar PV plants, and 1.1 GW of off-grid and isolated renewable energy power systems. The more ambitious WAM scenario sets targets of 50 GW of hydropower, 2.1 GW of grid-connected solar PV plants, and 1.1 GW of off-grid and isolated renewable energy power systems. The estimated investment required to achieve these targets is \$9.85 billion for the WEM scenario and \$15.05 billion for the WAM scenario by 2050. Additionally, according to IFC statistics, Nepal has the potential to attract \$46 billion in green and climate-friendly foreign investments from 2017 to 2030.

The Sustainable Development Goal (SDG) Baseline Report for 2030 outlines Nepal's objectives for increasing electricity access, reducing reliance on firewood for cooking, raising per capita electricity consumption, and decreasing commercial energy use per unit of GDP⁵.

Nepal's Second Nationally Determined Contribution (NDC) aims to expand clean energy generation from 1,400 MW to 15,000 MW by 2030, with 5-10% coming from mini and micro-hydro power, solar, wind, and bio-energy. This is intended to ensure that 15% of the total energy demand is met from clean energy sources⁶.

The 15th National Plan sets targets for augmenting the share of renewable energy in the country's overall energy consumption and fostering an investment-friendly environment for renewable energy projects. By 2023/24, Nepal aims to increase the share of renewable energy in total energy consumption from 7% to 12%. The plan also includes targets for renewable energy generation, starting from a baseline of 67.8 MW in 2018/19 and reaching 216.6 MW by 2023/24, 4,000 MW by 2029/30, and 5,000 MW by 2043/44⁷.

In conclusion, these documents underscore Nepal's steadfast commitment to increasing the proportion of renewable energy in its energy mix. While hydropower remains a focal point, Nepal is also actively pursuing the development of other renewable energy sources such as solar, wind, and biomass.

CHALLENGES

The development of renewable energy in Nepal is a multifaceted endeavor that entails addressing various complex challenges. One of the foremost obstacles is the imperative to phase out outdated technologies that still dominate the energy sector. Traditional biomass sources like firewood and agricultural waste persist as the primary energy sources in Nepal. To forge ahead, it is essential to foster a new technology ecosystem by investing in solar and

wind technologies and constructing the requisite infrastructure to support their deployment. However, this endeavor necessitates substantial investment and a skilled workforce, which are not readily available within Nepal.

Effective coordination with local and provincial governments assumes paramount importance in renewable energy development, as these entities play a critical role in identifying local energy needs and prioritizing renewable energy projects. Nevertheless, the centralized nature of Nepal's energy sector poses challenges to effective coordination with these regional authorities. Another significant challenge lies in accessing finance, as renewable energy projects entail substantial upfront investments, while financing options remain limited. Innovative financing models, such as public-private partnerships, are indispensable to overcome this hurdle. Gender, equity, and social inclusion (GESI) considerations are vital in the development of renewable energy. The sector must strive for inclusivity and equity, addressing the specific needs of women, youth, and other marginalized groups. Nepal also has a considerable number of households that will permanently remain off-grid. In this regard, the development of innovative solutions, such as community-based microgrids and decentralized renewable energy systems, is crucial to ensure that these households have access to renewable energy. Given Nepal's challenging terrain and underdeveloped infrastructure, developing renewable energy infrastructure necessitates substantial capital investment. Consequently, improving road and transport infrastructure becomes imperative to ensure that renewable energy services can reach remote communities. Moreover, the presence of ambiguous policies and regulations creates uncertainty and hampers investment in renewable energy development. Establishing clear and consistent policy directions becomes pivotal to attract investment and support the growth of the sector.

WAY FORWARD

The following strategies can be explored to facilitate the advancement of renewable energy in Nepal:

- Facilitating Climate and Energy Funds: The government should establish and implement a comprehensive approach to effectively utilize climate funds such as the Green Climate Fund (GCF), International Renewable Energy Agency (IRENA), and Global Environment Facility (GEF) to support the development of renewable energy projects in Nepal. Mobilizing resources from these funds will require well-crafted project proposals, stakeholder engagement, and sound financial management to ensure timely disbursement of funds.
- Strengthening Donor Relationships: The government should enhance its partnerships with donors such as the German Agency for International Cooperation (GIZ) and the UK Foreign, Commonwealth & Development Office (FCDO), while also diversifying funding sources by engaging with other key donors active in the energy sector, including the United States Agency for International Development (USAID), Swiss Contact, Japan International Cooperation Agency (JICA), and Korea International Cooperation Agency (KOICA). These engagements can be conducted through bilateral and multilateral approaches.
- Public-Private Partnership with the Private Sector: Explore and develop project banks on a public-private partnership (PPP) model in collaboration with private sector companies to attract private sector investment and scale up renewable energy projects in

Nepal. Ensuring the inclusivity of these projects in line with the principles of Gender Equality and Social Inclusion (GESI) is essential to promote equity and sustainability.

- Collaboration with Local and Provincial Governments: The federal government should collaborate with local and provincial governments, as stipulated in the new constitution, to facilitate efficient resource allocation and strengthen the development of renewable energy projects in Nepal.
- Engaging Local Governments in MSW-to-Energy Projects: Engage local governments in Municipal Solid Waste (MSW) to Energy projects, which can promote clean energy and waste reduction. Local governments can contribute by conducting public awareness programs on waste segregation and facilitating private sector involvement in addressing local issues. Strategic engagement with multiple stakeholders, including local governments, government agencies, and private sector partners, is crucial.
- Promoting E-cooking: The government should actively promote e-cooking as the primary cooking method, which can mitigate indoor air pollution and improve health outcomes. Effective awareness campaigns, targeted marketing, and sustained advocacy efforts are required to encourage the adoption of e-cooking technologies.
- Transitioning from Coal to Biomass Fuel: Prioritize the replacement of coal with biomass fuel, a cleaner alternative that reduces greenhouse gas emissions and improves air quality in Nepal. This will necessitate the development of comprehensive biomass fuel supply chains, strategic partnerships with local communities, and robust regulatory frameworks to incentivize the use of biomass fuels.
- Encouraging Green Hydrogen: Nepal should promote the use of Green Hydrogen, produced from renewable energy sources, as a clean and sustainable energy solution. This entails establishing robust research and development programs, forging partnerships with private sector companies, and implementing targeted policy interventions to stimulate the adoption of Green Hydrogen technologies.
- Private Sector Engagement in Micro-Hydro through RESCO Model: Engage private sector companies in the development of micro-hydro projects using the Renewable Energy Service Company (RESCO) model. This approach will facilitate access to clean energy in rural areas and attract private sector investment for the expansion of renewable energy projects. It requires the formulation of robust business models, strategic partnerships with local communities, and effective stakeholder engagement to ensure the long-term viability of micro-hydro projects.

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Managerial Aspects of Irrigation Systems in Nepal

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ABSTRACT

A review is carried out based on the available literatures and reports about the managerial aspects of irrigation systems in Nepal. Attempts are made to generalize the findings from different previously studied published and unpublished reports. From this review, it is concluded that Farmer Managed Irrigation Systems (FMIS) and Jointly Management Irrigation Systems (JMIS) cover the larger portion of irrigated agricultural land of Nepal. Similarly, Agency Managed Irrigation Systems (AMIS) are under the process of management transfer. Although the discourse of intervening private management in irrigation systems are underway, they have not taken any shape.

INTRODUCTION

Contribution of agriculture in the GDP of Nepal has declined to 23.9 percent and provides employment opportunities to 57.3 percent of the total population (National Statistics Office, 2023). Among the different variables in agricultural production, irrigation plays a vital role. Irrigation facilities in Nepal are provided through small, medium and large scale projects. The management of these projects is always a challenging issue, failure of which leads to great loss in terms of economic investment and affects the farmer's livelihood. In this context, small scale irrigation projects in general are constructed and managed by farmers themselves, medium scale projects are also managed by farmers with technical support from the government and the large ones are managed jointly by farmers and the government agency.

HISTORY OF IRRIGATION DEVELOPMENT IN NEPAL

Irrigation development in Nepal can be identified as: pre-modern period, where farmers were largely responsible for development and management of irrigation; construction period between 1960 and 1990, where huge investments were made by the government in infrastructure development and construction of new facilities which is still in progress; and a period from 1990 to present, where besides new construction, efforts have been placed on better management of infrastructure (Prasad, P, & Molden, 2000). The development phases of the irrigation systems in Nepal can be categorized as follows:

i. Primary Phase

Irrigation facilities constructed in the Kathmandu valley during Lichhvi period and Malla period such as Raj Kulos of which the traces are still found, are the oldest ones under primary phase. King Ram Shah of Gorkha had special contribution in irrigation management aspect by empowering local people in irrigation related dispute resolution. During the Rana regime, Chandra Shumsher, with the assistance of British engineers, had developed Chandra Canal System in 1928. The other irrigation facilities during primary phase are- Juddha Canal in Sarlahi district, Jagadishpur

Irrigation system in Kapilvastu district, Pardi Irrigation system in Pokhara, etc. In addition to these, the irrigation systems developed with the involvement of the State within this period covered 6,228 ha.

ii. Infrastructure Development Phase

Irrigation facilities developed in 1st, 2nd and 3rd Periodic Plan periods fall under infrastructure development phase. Nepal developed different irrigation facilities with the cooperation from India and USA in this phase. Tika Bhairav, Mahadev Khola and Budhanilkantha irrigation systems in the Kathmandu valley and Vijayapur irrigation system in Pokhara were developed. Likewise, Sirsha, Dudhaura and Tilawe irrigation systems were developed by the Indian engineers under the financial aid of the USA. Khageri (Chitwan), Kamala and Hardinath (Dhanusha), Kodku-Godavari (Lalitpur), Pashupati (Kathmandu), Jhanjh (Rautahat) and Tinau (Rupandehi) are the examples of a few other irrigation systems that can be cited in infrastructure development phase. Apart from these, irrigation systems, which were developed under the Koshi and Gandak treaties with India, were also constructed during those three periodic plan periods.

iii. Intensive Development Phase

During 4th, 5th and 6th Periodic Plan periods, multilateral donor agencies like the World Bank and the ADB came forward in aid of Nepal in irrigation development. These agencies focused their assistance to convey irrigation water to farmers' fields with the canal network development from the infrastructure already created and to initiate coordination between irrigation and agricultural agencies, hence the name- intensive development phase. Development of Kankai and Mahakali-I Irrigation Projects, initiation of command area development in Narayani Zone Irrigation System, etc., were carried out with these agencies' assistance. During these periods, CARE Nepal had assisted to develop a number of small irrigation systems covering a total of 10,000 ha. BhairawaLumbini Groundwater, Marchawar Lift and Hill Irrigation Projects were also initiated in this intensive development phase.

iv. Integrated Development Phase

From the 7th Plan onward, i.e., since the mid-eighties, there has been a major paradigm shift in irrigation development. Construction oriented development has been given less importance and new dimensions- such as farmers' participation through organised associations, rehabilitation of farmers' canals, management transfer, etc., have been given more and more attention. Leaving Bagmati, Babai, Mahakali-II and Sikta Irrigation Projects aside, no other major projects were taken up. Rehabilitations of small farmers' canals were given high priority under sectoral approach. Irrigation Sector Projects were implemented and the ongoing Community Managed Irrigated Agriculture Support Project is being implemented in Central and Eastern regions under the assistance of ADB. The World Bank version of these projects implemented in the remaining three western regions are Irrigation Line of Credit Project, Nepal Irrigation Sector Project and the IWRMP.

IRRIGATION SYSTEMS MANAGEMENT PRACTICES IN NEPAL

The management of irrigation system comprises the physical, institutional, social and financial systems. The physical system comprises the infrastructures such as headwork,

conveyance network, distribution system, etc. The institutional aspect of irrigation system includes the Water User's Association (WUA) and skilled manpower from the Department of Irrigation (DOI). The social aspects include the well representation from the various groups in the society and maintaining the rules of law in the system governance. The financial aspect of irrigation system includes the repair and maintenance cost, water charges, etc. At the meantime, maintaining equity in water distribution is very essential. Nepal government's Irrigation Policy, 2013 has prescribed five categories for irrigation management: i) user operated system, ii) government operated system, iii) government and WUA jointly operated system, iv) local bodies and WUA jointly operated system, and v) systems operated at private level. The user operated system includes both traditional irrigation system as well as the systems transferred to the users by governmental or nongovernmental bodies. Irrigation systems were developed in Nepal and managed by farmers, well known these days as farmer managed irrigation systems (FMIS). (Pradhan, 2000) claims almost 70% irrigated area in Nepal, fall under farmer managed irrigation systems (FMIS). And, (IMP, 2019) has mentioned that FMIS accounts only 51% of the surface irrigation systems. The remaining contribution may be from groundwater systems. Therefore, jointly managed irrigation systems (JMIS) and FMIS are the two major approaches widely adopted in irrigation system management in Nepal. The irrigation policy has the provision of WUA from field channel to main canal. It has assured the one third participation of women in the management committee and appropriate representation of various social groups. It has envisaged the role of the WUA registered as per the law to be capable and accountable for sustainability of the irrigation systems. However, the irrigation service fee (ISF) collection from these systems in practice is very minimum. The table shows the ecological zone wise coverage of irrigation systems under these two management approach.

Table 1: Irrigation coverage under different management systems

Ecological zone	Jointly Managed (ha)	Farmer Managed (ha)
Terai	350,926	240,213
Hill	4,275	105,109
Mountain	1,852	26,072
Total	357,053	371,394

(Source: IMP, 2019)

Behind these two systems, government operated systems popularly known as agency managed irrigation systems (AMIS) covering about 303,000 ha of irrigated land are in some way under the process of management transfer to joint management.

Although the farmers' management systems are considered as a social capital, the changing population dynamics, migration, modernization of society, etc. have created negative pressure to the irrigation system management. At the meantime, the increased level of awareness in the farmers, political changes have enhanced the inclusive participation of the farmers in the system management. Similarly, the usual problems of agriculture sector such as lack of market facility, not getting fair price of the produce, unavailability of inputs on time, hindering provision for loans, inefficient subsidy mechanism, etc. also have negative impacts in the management of irrigation systems.

The government policy also has the provision for privately developing and operating the irrigation systems by obtaining the license. However, the provision still needs the clear mechanism for implementation.

CONCLUSION

The irrigation systems management in Nepal is dominated mainly by JMIS and FMIS. The AMIS are mostly under the process of management transfer. The involvement of the users in water management has led to the ownership of the farmers towards the irrigation systems. Therefore, people's participation can be increased in the maintenance of the system. However, in some cases the situation is more deteriorating.

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Design of an Integrated Livestock Farming System

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ABSTRACT

Integrated farming (mixed farming) is a system with simultaneous activities involving crops and animals. The main purpose of integrated farming is so that the farming components support one another; hence, reducing external inputs. For instance, the crop can provide animal feed/fodder for the livestock, and the livestock as fertilizer (manure) for the crop. Some livestock can also act as weed control by foraging in the weeds. Because of reformist contracting of ranch holding to acquire the greatest yield appropriation of the blended cultivating framework with domesticated animals and fish become mainstream in the country's wetland and watershed spaces. The result use of one sub-framework for example excreta of animals turns into a contribution to a second sub-framework for example in fish culture. The study involves the detailed design and layout of integrated farm components and the estimation. The result obtained from the study was found to be satisfactory in terms of economic and management analysis. Here, the Fish cum duck cum swine cum cattle cum poultry system is primarily focused. This project presents the study and design plan of the various components which can be integrated to achieve the best performance.

Keywords: Integrated Farming System; Fish Pond; Swine House; Poultry

INTRODUCTION

Integrated Livestock Farming System is an eco-friendly approach to Sustainable Agricultural Environment that is environmentally friendly and cost-effective. The farming system concept takes into account the components of soil, water, livestock, labor, capital, energy, and other resources, within the farm. The most beneficial theme of the Integrated Livestock Farming System is that the waste of one component of farm activity becomes the input for the other component.

For the project, we take into account the design of an integrated livestock farming system. An integrated livestock farming system refers to the good management of various types of livestock in such a way that they are interrelated to each other and occupy the least space possible. Integrated Farming is a judicious mix of agricultural enterprises like dairy, poultry, piggery, fishery, sericulture, etc. suited to the given agroclimatic conditions and socio-economic status of the farmers would bring prosperity in the farming. The integrated farming system approach introduces an adjustment of the cultivating methods for the greatest creation in the editing example and deals with the ideal usage of assets. Integration of livestock in fish culture is an old-age system of practice. Ducks, poultry, pig, cattle, buffalo, sheep, and goats are common in mixed farming.

Due to the progressive shrinking of farm holding to obtain maximum output adoption of a mixed farming system with livestock and fish become very popular in wetland and watershed areas of the country. The byproduct utilization of one sub-system e.g. excreta of livestock becomes an input to a second sub-system i.e. in fish culture.

Sustainable agriculture refers to the method of farming in such a way that the present food and textile need of the society is fulfilled completely without compromising the ability of the future generation to meet their needs. The problem with the present agricultural practice in Nepal is the mere practice of sustainable agriculture. There are also the problems like agricultural inputs and low yields. Small Farmers in nonindustrial nations are more unfortunate than the remainder of the populace, regularly not getting sufficient food to lead ordinary, solid what's more, dynamic lives. Managing neediness and craving in a large part of the world along these lines implies standing up to the issues that little ranchers and their families face in their day-by-day battle for endurance.

In IFS, a product of one component acts as input for the other farming system. As we can integrate various farming practices in a single unit so that it becomes productive, research should be done in IFS. Livestockfish production systems develop to satisfy needs if they fit into the resource base or environment, and if they are socially and economically viable. Macro-level factors may also have a significant influence and there are environmental implications, both on- and off-farm, for the development of a sustainable system.

The general objective is to design the layout and demonstrate a model of the Integrated Livestock Farming System.

The specific objectives of the study are as follows.

- To understand and interpret the interaction of livestock with each other in respect of physical, biological, and socioeconomic factors.
- To plan a proper waste management system.
- To design and estimate housings for farmsteads.

METHODOLOGY

There are certain activities to fulfill our mentioned activities. Various activities with their materials or software required are well illustrated in the table.

Table 1: Research Methodology

SN	ACTIVITIES	EQUIPMENT/SOFTWARE REQUIRED
1	Data collection	Research paper, Recorded data (Questionnaire)
2	Data analysis	Collected data
3	Site Selection	-
4	Surveying	Software (Google Earth)
5	Decision-Making and Calculations	-
6	Allocation of plots	Software (AutoCAD)
7	Model Design	Software (AutoCAD, Sketchup, Lumion)

RESULTS AND DISCUSSION

Table 2: Salient Features of the Project

SN	Name of the project	Integrated Livestock Farm
1	Total Area	7130sq. m
2	No. of Varieties of Livestock	5
3	Varieties of Livestock	Fish, Buffalo, Chicken, Duck, Pig
4	Infrastructures	Fencing, Gate, Office Room, Storage Room, Worker's Quarter
5	Roadways	Available
6	Irrigation Canal	Available
7	Distance from nearest Residence	500m
8	No. of manpower required to Operate	4
9	Skilled Manpower	1
10	Unskilled Manpower	3
11	No. of Fish Reared	3500
12	No. of Cattle (Buffalo)	10
13	No. of Chicken	120
14	No. of Duck	50
15	No. of Pig	5
16	Expected Fish Production	10500 kg per year
17	Expected Milk Production	26000 liters per year
18	Expected Chicken Egg Production	34560 per year
19	Expected Duck Egg Production	16425 per year
20	Expected Piglet Production	80 piglets per year

A. Infrastructure Components

Fencing and Compound

Dimension of Field:	115 × 62m
The total area of the field:	7130m ²
The perimeter of the field:	354m
Type of Fencing:	Wired Net
Fencing Length:	348m
Height of Fence:	1.5m
No. Of Gates:	2
Type of Gate 1:	Sliding Gate
Length of Gate 1:	4.5m
Height of Gate 1:	1.8m
Type of Gate 2:	Door Type
Length of Gate 2:	1.5m
Height of Gate 2:	1.8m

Pathways

All the possible spaces can be utilized as pathways. The possible pathways go all around the farm and are represented in the plan.

Office Building

1. Office Room

Dimension: 3m ×3m

Office Room is to carry out the required administrative function of the farm. It provides a space for the office personnel to carry out paper works and management functions.

2. Storage & Sales Room Dimension: 4m ×3m

The purpose of the storage and sales room is to provide a space for performing the sales activities. The products from the farm can be stored in the room and transported to the market or sold in retail. This room is equipped with product handling and packaging tools including refrigerator and weighing equipment.

Worker Quarter

Dimension: 6m ×2.4m

It includes two rooms each of 3m*2.4m and a washroom of 1m×2.4m

Feed Storage

Dimension: 5m×2.4m

The purpose of the building is to store the feed for the poultry chicken, fish, and buffalos.

Water Storage

Water Supply is one of the most important parts of farm planning and farm design. There must be enough storage of the water required for the day-to-day operation of the farm. A continuous source of water is to be determined. This might be water supplied from the well, canal, or municipal pipelines.

Table 3: Water Requirement Calculations

Member	Number	Water Required per liter per day per member	Total water consumed liter per day
Chicken	120	0.2	48
Buffalo	10	50	500
Pig	5	50	250
Workers (Quarter)	2	50	100
Workers (Regular) (Day Time)	2	10	20
Office	1	45	45
Irrigation		500	500
		Total	1463 liter/day

Determination of Size of the Tank

We all know the Volume of water formula as $1 \text{ m}^3 = 1000 \text{ liters}$ of water

To get the size of the water tank, you need to mention at least one dimension (Length, Width, or Depth of the water tank).

In this case, Let's determine the depth of the tank to be 1.5m.

The plan is to construct the underground water tank

$$1 \text{ liter} = 0.001 \text{ m}^3$$

$$1713 \text{ liter} = 1.713 \text{ m}^3 \quad \text{Depth} = 1.5\text{m} \quad \text{Length} = 2 \times \text{Width}$$

$$\text{Area} = 1.713 / 1.5 = 1.142 \text{ m}^2$$

$$\text{Therefore, Length} \times \text{Width} = 1.142$$

$$\text{Length} = 1.511 \text{ m}$$

$$\text{Width} = 0.755 \text{ m}$$

Finally, since we need to have some extra water in the storage for the time of shortage we add an extra factor of 100% to the length and width and 0.15m as freeboard.

Hence,

$$\text{Length of Tank} = 3 \text{ m}$$

$$\text{Width of Tank} = 1.5 \text{ m}$$

Height of tank= 1.65m

Dimension: 3m × 1.5m ×1.65m

Drainage and Water Supply

This part of the design is mainly associated with the pond for fish rearing. Mechanical Drainage and Emergency outlet provisions are to be done. A canal is provided to perform the task.

Inlet Pipe:

An inlet pipe is provided for the pond. The water capacity of the pond is calculated to be 6088m³ when the water is filled up to 1.2m height. Assuming that the water in the pond has to be completely circulated/changed in a day, i.e. 24 hours. The length of the inlet pipe from the main canal to the pond is calculated as 15m and the head loss of 1m per 500m. The total discharge of water required to perform accordingly is calculated to be 70lpm. Each pipe is provided with valves to regulate the water flow.

Hence the diameter of the pipe for the inlet = 8inch

For safety factors and during the time of emergencies, it is good to have two pipes of the required dimensions i.e. 8-inch dia. each.

Outlet Pipe:

An outlet pipe is provided at the lower end of the pond. The diameter of the pipe is kept as the inlet pipe i.e. 8inch. The pipe is placed at the height of 1 meter from the bottom of the pond to drain out the water during the harvesting of fish. It is used during the recirculation of the pond. Two such pipes are planned for faster operation and emergencies. Each pipe is provided with valves for regulating water flow and a net at the end to prevent fish from going through it. **Overflow channel:**

An overflow channel is provided on the surface of the bank of the pond with a width of 0.6m and depth of 0.3m which lets the water out of the pond in case of heavy rainfall. Such channels can be customized according to the need and requirements of the area. Two such channels are provided such that their dimension can be changed in case of emergencies. A steel bar net is provided to prevent the escaping of fish during the overflow of water.

B. Farming Components

Fish Farming

Fish Pond:

Dimensions, Area, and Volume

Total allocated Plot Area: 5304 m² = 0.53 hectares

Dimensions of Pond: 102m×52m=5304m²

Depth of Pond: 2m

Height of water inside the pond: 1.2m to 1.5m

The volume of Water Pond: 6088m³

Stocking Density: 7000 fingerlings per hectare

No. of Fish in Pond:	3500
Dyke Slope:	100% (1:1)
Base Slope:	0.2% (500:1)

Fish Rearing:

Semi-Intensive fish culture is to be implemented. The pond is stocked after the pond water is properly detoxified. They will feed on the phytoplankton and zooplankton growing in the pond water. The surplus nutrition required is provided by the palates. The stocking rates vary from 6000 - 8500 fingerlings/ha and a species ratio of 40 % surface feeders, 20 % of column feeders, 30 % bottom feeders, and 10-20 % weedy feeders are preferred for high fish yields. The mixed culture of only Indian major carp can be taken up with a species ratio of 40 % surface, 30 % column, and 30 % bottom feeders. The species to be chosen will be Silver Carp, Common Carp, Bighead Carp, Grass Carp, and Indian Carp.

Poultry Farming

Chicken Coop:

No. of Chicken Coop:	1
Dimension of Chicken Coop:	3.75m×3.3m
Rearing System:	Three-tier steel cage system.
The capacity of Chicken Coop:	120 Layers of Chicken
Dimension of Cage:	2.15m × 2.1m ×1.5m
Space per Bird:	376 cm ²

Chicken Rearing:

The Layers chicken of 8 to 16 weeks old is caged in the cage system. They are provided with the required feed and water from the systems attached to the caging system. Deep Litter Farming can also be adopted instead. The advantage of cage farming over deep litter farming is the easy handling of eggs, feed and waste as well as the use of less space. Each chicken coop has the maximum ability to hold 120 layers' of chicken each.

Experiments have shown that the Layers chickens are the best option in this system of farming because of their susceptibility to various diseases. Apart from this, they need less care and maintenance than the broilers. Furthermore, they produce eggs daily for a long period of up to 2 years which can generate daily income. The mobility of the chicken is kept very less. The stocking density must be maintained to ensure the welfare of the birds.

Duck Farming

Duck Housing

No. of Duck Housing:	1
Dimension of Shed:	5m×1.4m
The capacity of the Shed:	50
Space per Bird:	1400cm ²

Duck Rearing:

The kind of duck to be raised must be chosen with care because not all domesticated races are productive. The important breeds of ducks are Sylhet Mete and Nageswari. 2 - 4 months old ducklings are kept on the pond after giving those important prophylactic prescriptions as a defense against diseases and epidemics.

Ducks in the open water can find natural food from the pond but that is not sufficient for their proper growth. A mixture of any standard balanced poultry feed and rice bran in the ratio of 1:2 by weight can be fed to the ducks as supplementary feed at the rate of 100 gm/ bird/day. The feed is given twice a day, first in the morning and second in the evening. The feed is given either on the pond embankment or in the duck house and the spilled feed is then drained into the pond. Water must be provided in the containers deep enough for the ducks to submerge their bills, along with the feed. The ducks are not able to eat without water. Ducks are quite susceptible to aflatoxin contamination; therefore, moldy feeds kept for a long time should be avoided.

The ducks start laying eggs after attaining the age of 24 weeks and continue to lay eggs for two years. The ducks lay eggs only at night. It is always better to keep some straw or hay in the corners of the duck house for egg laying. The eggs are collected every morning after the ducks are let out of the duck house.

Pig Farming

Swine Housing

No. of Swine Housing: 2

Dimension of Swine Housing 1: 13.9m ×4m

The capacity of Swine Housing: 5 Adults, 10 Piglets

Space per Pig: 2.2m ×3 m

Feed Storage;

Dimension: 3m×2.5m Swine Rearing:

Change is the breed mostly preferred in Nepal. It feeds about 2-4 kilograms of feed per day.

Buffalo/Cow Farming

Buffalo Shed

Dimension: 13.65m×2.5m

Capacity: 10 Buffalos/Cow

Space per buffalo: 1.35m×1.65m

Feed Storage

Dimension: 8m×2.5m

Working Space

Dimension: 2.75m×2.5

Compost Pit

Dimension: 6m×2.5m

Mixture Diameter: 0.9m

Buffalo Rearing

Any local or hybrid species of buffalo rearing can be practiced. The certain amount of grass required for the buffalo can grow in the field available within the boundary. Approximately 4 to 6 kilograms of concentrate feed, 20 kilograms of grass, 10 kilograms of dry fodder such as paddy straw, 50 grams of the mineral mixture, and 50 liters of water are required per day for a murrah buffalo. The storage facility is provided to store paddy straw and feeding materials.

Cow Rearing

Rearing of any local or hybrid species of cow is also equally possible in the shed designed. The advantage of cow rearing over buffalo is that it produces more milk than buffalo but requires more care.

The design includes barn equipment such as water bowls and stanchions.

INTEGRATION OF THE FARM COMPONENT AND THEIR OPERATION

The International Organization of Biological Control (IOBC) describes Integrated Farming according to the UNI 11233-2009 European standard as a farming system where **high-quality organic food**, feed, fiber, and **renewable energy** are produced by using resources such as soil, water, air, and nature as well as regulating factors to farm sustainably and with as little **polluting inputs** as possible. Particular emphasis is placed on an **integrated organic management** approach looking at the whole Bio farm as a cross-linked unit, on the fundamental role and function of **agro-ecosystems**, on **nutrient cycles** that are balanced and adapted to the demand of the crops, and on health and welfare of all livestock on the farm. Preserving and enhancing **soil fertility**, maintaining and improving a **diverse environment** and the adherence to ethical and social criteria are indispensable basic elements. **Crop protection** takes into account all biological, technical, and chemical methods which then are balanced carefully to protect the environment, maintain the profitability of the business and fulfill social requirements.

The designed system of agricultural practice is Integrated Livestock Farming, which integrates Fish, Duck, Pig, Buffalo, and Duck and is capable of producing Fish, Eggs, Meat, and Milk as the product. The production cost of the items will be decreased by the execution of the plan. The waste created by the animals is utilized inside the ranch as feed to each other.

This system is somewhere revolving around Fish farming. The main potential linkages between livestock and fish production concern the use of nutrients, particularly the reuse of livestock manures for fish. The term nutrients mainly refer to elements such as nitrogen (N) and phosphorous (P) which function as fertilizers to stimulate natural food webs rather than conventional livestock nutrition usage such as feed ingredients. Fish Pond is considered an essential component in the integration of various livestock. Studies show that the feeding cost

of fish can be decreased by 50-60% by the application of this technique. Furthermore, the operational cost and maintenance costs can also be decreased. The entire integrated system can be explained by understanding the relations between the various components and their working mechanisms.

Fishery

Fishes are the major component of the integration. Most of the waste produced by the other components of the farm act as the input to the fish. First of us let us understand the basic requirements of the fish ponds.

The pond ought to be water retentive and not to be arranged in the flood-inclined territory. There should be consistent water supply or throughout the year there should be water in the pond. Ponds that can hold 8 or more-month water additionally, can be considered for integrated fish farming. In any event, there should be 1.0 m of water and the ideal is 1.5 to 3.0 m.

Soil pH ought to be within the range of 6.5 to 7.5. On the off chance that the soil pH isn't up to the ideal level, the pH might be amended by utilization of lime and the amount of lime is 2000 kg/ha for 4.0 to 5.0 pH, 1200 kg for 5.1 to 6.0, 1000 kg for 6.1 to 6.5 (mildly acidic), 400 kg for 6.6 to 7.0 (more or less neutral) and 200 kg/ha for pH 7.1 to 7.5, which is somewhat alkali. Lime helps in looking after pH, and executes and breaks down parasites. The lime ought to be applied in 3 to 4 split doses. The basal portion of lime and cow fertilizer application per hectare of water bodies is 1200 kg and 5000 kg, separately. The pond should be routinely cleaned from aquatic plants which block sunlight and hampers oxygen circulation in water as well as provide shelter to the fish predators.

The wedding should be possible physically, precisely, naturally, artificially, or by expanding the water profundity in the lake. To murder ruthless fishes, Mahua (*Bassicala centifolia*) might be applied at the pace of 2500 kg/ha of water bodies. By continued netting, undesirable fishes may likewise be eliminated. The alkali, tea seed cake, and fading powder likewise can be applied to eliminate fish.

Stocking Density of fish matters a lot. Many studies carried out in different places of the world suggest from 6000 to 8500 fish per hectare of fishpond. For the design 7000 fishes per hectare is suggested i.e. 3500 fishes in each of the ponds. In general practice as well as in research it is found that the stocking ratio of various kinds of fish maintained as 40% surface feeder, 30% column feeder, and 30% bottom feeder provides the maximum yield. Hence, the number of fishes and their species is determined as:

Pond with 3500,

Table 4: Fish Species and Number

Type of Fish	Species	No. of Fish
Surface Feeder	Silver Carp, Grass Carp, Catla	1400
Column Feeder	Bighead Carp, Rohu	1050
Bottom Feeder	Common Carp, Naini	1050

Research done by the experts and the farmers has shown that due to the integration of fish with the livestock, the feeding requirements of the fish have been decreased by 40% to 60%. On average, we can clearly understand that approximately half reduce the feeding requirements. We can plan the nutrition value to half the standard requirement.

Poultry with Fishery

Layers of Chicken are reared for integration with the fish. The poultry coop is generally built just above the pond or alongside the pond. For the design, the coop is designed above the pond. Chickens are fed with the regular or standard grains available in the market. Poultry is not responsible for the production of meat and eggs only but it also produces manure, which has a high nutritional value. Integrated fish farming with poultry is generally cultured as the poultry manure is a very efficient fertilizer for fishponds. The poultry droppings comprise 2% nitrogen, 1.25% phosphoric acid, and 0.75% potash. The low feeding cost per individual fish makes poultry farming along with fish, a common investment for farmers. Production wastes include spilled feed as well, and they may be used as fresh inputs for the fish. Likewise, during the accidental death of the chicken, they can be chopped into pieces and fed to the fish as a source of protein. Studies show that a chicken produces approximately an average of 60 grams of dropping per day with the nutrition content. The mass of poultry dropping required for a one-hectare pond has been calculated as 50kg/day. The excess amount of feces can cause issues with the quality of water in the pond (Ojha & Michael, 2013).

In the design, the chicken coop has been designed to accommodate 120 chickens in each pond, which are capable of producing 7.2kg of manure per day. This data will be taken into account in the upcoming title and explained.

Duck Farming with Fishery

This combination of integration farming has been in practice for a very long time ago. There is a great interrelation between the fish and the duck. Considering the easy operation of day-to-day farm management and optimum production the livestock house is constructed above the water bodies, especially for duck or poultry, nearby the pond or bank of pond or partly in water and land. In the design, the duck housing is alongside the pond which gives the duck enough access to the water. Rearing Ducks require water bodies because of the duck's nature. The Fish Pond provides the water area required for the duck. The duck also feeds on unwanted plants and creatures.

On the other hand, Ducks provide manure to the fish pond which helps the zooplankton and phytoplankton to flourish which feeds the fish. Furthermore, the most important role that ducks play role in the fishery is that the movement of duck on the surface of the water helps in the aeration of the water and dissolves the oxygen required by the fish.

Further advantages came forward by the practice of this method of livestock farming. The water surface of the pond comes to full utilization by the rearing of the duck. The predators are fed upon by the ducks and enhance the growth of the fingerlings. It has been found that duck raising in ponds reduces the protein demand of the fish by 2-3%.

The important breeds of ducks are Sylhet Mete and Nageswari. Each duck voids between 125 – 150 gm of droppings per day. The stocking density of 200-300 ducks/ha gives 10,000 – 15,000 kg of droppings. It has been found that 200 – 300 ducks are sufficient to produce

manure adequate to fertilize a hectare of water area under fish culture. For the design rearing of a total of 50-75, ducks are sufficient for both ponds but the design can accommodate 50 ducks in each duck housing. This data will be explained in the upcoming title.

Ducks in the open water can find natural food from the pond but that is not sufficient for their proper growth. A mixture of any standard balanced poultry feed and rice bran in the ratio of 1:2 by weight can be fed to the ducks as supplementary feed at the rate of 100 gm/ bird/day.

Pig Farming with Fishery

Integrated fish-pig farming is a viable and feasible scientific approach to augment fish production at a low cost. The Pigs provide manure to the pond, which enhances the growth of the phytoplankton and zooplankton. The pig shed is so designed that the feces of the pigs are directly fed into pond water. The fishes directly consume a part of the feces as well. Production wastes of pigs include manure, urine, and spilled feed; and they may be used as fresh inputs for the growth of fish.

Maize, groundnut, wheat-bran, fishmeal, and mineral mixture provide the base for concentrated feed mixture for feeding the pigs. It is not only that the pigs only contribute to fish, the dead fish can act as feed for the pigs as well. In such cases, the dead fish can also be utilized properly. In the studies, it is found that the excreta produced by 35-40 pigs are found adequate to fertilize one hectare of the pond. For the plan designed, we rear 5 pigs for the pond.

The table shows the approximate amount of excreta produced by pigs of various stages of the pig.

Table 4: Pig Manure

Age (weeks)	Live weight (kg)	Nutrients available
12	14	Nitrogen (N), Phosphorous (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulfur (S), Manganese (Mn), Copper (Cu), Zinc (Zn), Chlorine (Cl), Boron (B), Iron (Fe), and Molybdenum (Mo).
20	45	
28	80	

Buffalo Farming with Fishery

Buffalo plays the same role as the pigs play in this system of integrated farming i.e. provides manure to fertilize the pond for the growth of feed for the fish. The excreta of the buffalo is directed towards the pond. Researchers have found that 50kg/ha/day of buffalo dung is necessarily used to fertilize the ponds to obtain maximum output. Generally, this amount of manure is produced by 2-3 buffalos. It means that the designed pond requires 25kg of buffalo dung per day. The dung from the buffalo is collected and slurry is made in the mixture. The slurry thus made, is fed into the fishpond. Furthermore, before filling the pond with water after construction or before putting fish higher amount of dung is spread throughout the pond (Ojha & Michael, 2013).

In the design, the plan accommodates 10 buffalos. It is designed so because of the various reason. There is sufficient region around the pond which is available for the vegetation.

Enough amount of grass can be planted along with various fruits and vegetables around the pond region. The excess manure thus produced is made into compost manure and can be utilized for growing feed for the buffalo itself or sold. Furthermore, rearing 2 buffalos is less productive than rearing 10 buffalos, as 10 buffalos can generate more income comparatively rearing 5 sets of 2 buffalos.

Vegetation around the Fish Pond

This is not the actual part of the study for the allocated project but we must understand these aspects as well. The land around the pond can be properly utilized for the growth of Grass, fruits, and vegetables. Extra income can be generated by selling those products as well as they act as feed, especially for buffalos and pigs. Grasses, Fruits like Banana and Guava, and Seasonal Vegetables can be grown around the pond. The crops require less irrigation and the pond water can be utilized for irrigation. Since the pond water is rich in fertilizer, it enhances the growth of the crops. The design provides an area of 867sq. meters of open area, which can be utilized to grow crops. Furthermore, the water from the pond discharged due to overflow or water circulation should be directed towards the crops, especially paddy. The nutrients from the water are likely to enhance the production.

DETERMINATION OF THE NUMBER OF LIVESTOCK

A tabulated summary of the planned number of livestock involved in the integration with the fishpond can be tabulated as:

Table 5: Determination of the Number of Livestock

Livestock	No.
Fishes	4000
Chicken	120
Duck	50
Pig	5
Buffalo	1

Since we have both the pond of equal size,

Let us carry out the calculations considering one pond.

For Fishes ,

According to the experts and research, No. of Fishes to be reared in one ha pond: 8000

Area of Pond = 0.5ha

Therefore, the appropriate number of fish to be reared= 4000

Since the other component is Chicken. Duck, Pig, and Buffalo are there to contribute manure to the fishpond, their numbers must be well calculated so that there are not too less nor too many nutrients in the pond. No. of chicken, ducks, pigs, and buffalo to be reared should be in equal proportion to the nutritional value of their excreta produced by them.

For Chicken,

For only fish and chicken integration, the amount of manure required: is 50kg per ha per day

Area of the Pond = 0.5ha

$$\text{Amt. of manure required} = 50 \times 0.5 = 25 \text{kg/day}$$

$$\text{Hence, for the total integration, Amt. of manure requires} = \frac{25}{4} = 6.25 \text{kg per day}$$

Manure Produced by one chicken: 60g per day = 0.06kg per day

$$\text{Therefore No. of chicken to be reared} = \frac{6.25}{0.06} = 104$$

For Duck,

From the research, it is shown that 200-300 ducks are enough to produce enough fertilizer for the fishpond of one hectare, let us go with 300 ducks.

Accordingly,

For fish and duck integration,

No. of Ducks required for 0.5ha fish pond = 150 ducks

$$\text{Hence, for total integration, No. of Ducks to be reared} = \frac{150}{4} = 38$$

For Pig,

For only fish and pig integration,

No. of pigs required to produce enough excreta: is 40 per ha Area of Pond=0.5ha

$$\text{No. of pigs required} = 40 \times 0.5 = 20$$

$$\text{Hence, for total integration, No. of pigs required} = \frac{20}{5} = 5$$

For Buffalo,

For only fish and buffalo integration,

Amount of manure required: is 50kg per ha per day Area of Pond: 0.5 ha

$$\text{Amt. of manure required} = 50 \times 0.5 = 25 \text{kg per day}$$

$$\text{For Total integration, Amt. of manure required} = \frac{25}{4} = 6.25 \text{kg per day}$$

Manure Produced by one buffalo: 15kg per day

$$\text{Hence, No. of buffalos required} = \frac{6.25}{15} = 0.41$$

Calculation and Estimation of Potential Yield:

• Expected Fish Production

In the system of fish farming, we can implement further two techniques of introducing the fingerlings to the pond. We get two different outcomes for both techniques. The

first technique is to introduce the fry into the pond and the second technique is to introduce advanced fingerlings into the pond. Nowadays introduction of advanced fingerlings into the pond is more popular because of their growing duration. In the case of the Introduction of advanced fingerlings, they become ready to harvest in about 4 months. In this way, we can produce 3 yields in a year. On average one fish can grow upto 2kilograms during this interval. Thus producing approximately 10500 kilograms per year.

- **Expected Milk Production**

On average one buffalo gives 10 liters of milk per day (can give upto 16litres per day). On average a buffalo can give milk 260 to 300 days in a year. Let us assume that the buffalo gives milk 260 days a year. Then we can calculate that rearing 10 buffalos can produce up to 26000 liters of milk per year. Furthermore, we can produce calves that can be sold with value.

- **Expected Egg Production**

Chicken Eggs

The layers are brought into the cage after 16 weeks of hatching. We have 120 layers of chicken in the cage system of chicken rearing. The egg production rate of chicken is considered to be 80%. i.e. if we rear 100 chickens then we can obtain 80 eggs daily. Considering this fact they can produce 34560 eggs per year.

Duck Eggs

Adult ducks start laying eggs at the age of 6-7 months and can last up to 3-5 years. We have 50 ducks. The egg production rate of duck is greater than that of chicken which is 90% i.e. if we rear 100 ducks can get 90 eggs daily. Considering this fact they can produce 16425 eggs per year.

- **Expected Piglet Production**

A good Sow can produce up to 10 piglets in each pregnancy and can have up to 2 litters each year. We have 5 sows. Let us assume only 8 piglets per litter then we can consider that 80 piglets are produced per year.

- **Meat Production**

Meat is the complementary product that comes with animal husbandry. The layers of chicken stop their production after 2 years and have to be replaced by the young ones. They can be utilized as meat products. Ducks also stop production after certain years and hence can be utilized as meat products. The pigs can also be used as meat products after they stop bearing piglets. The buffalos after aging can be traded to make meat products.

CONCLUSION AND RECOMMENDATION

Finally, the Integrated Livestock Farming System model was prepared after the data collection and analysis, which is to be applied in the field. A study of the Integrated Farming system was done through various analyses and data. It was concluded that the output of one enterprise becomes the input for another enterprise in such a farming model. Quantity Estimation of various components of the Integrated Farming System was done per the

Drawings. The research model portrays the scope of such a farming system in the days to come. We recommend that such type of system should be practiced in various parts of the country and extended research on biochemical and environmental analysis should be done.

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Detailed Feasibility Study and Agri-Economic Analysis of Bhabar Lift Irrigation Project, Dadheldhura

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ABSTRACT

Bhabar Lift Irrigation Project has been proposed based on the genuine demand of farmers who have agreed to comply with the Irrigation Policy/procedures throughout the sub-project development process and operation and maintenance after completion. The project has a gross command area of 30 Ha, with a net command area of 25 Ha. Water is pumped from the intake to the tank at the head of 80 m through a proposed 80 mm dia GI pipe to deliver water from the well to the reservoir. The project aims to benefit 122 households with a population of 800 people, by providing them with a consistent water supply. Currently, agriculture practices in the area are completely dependent on rainwater and the present cropping intensity is 130%, with maize and pulses being the major crops. However, after the completion of the project, the future cropping intensity is expected to reach 232%. The proposed development plan includes an intake, pipeline works, reservoir tank, and electrical pumping system installation with a total cost of Rs. 15,136,000.00. Farmers have been extensively consulted and involved in the development of the project plan, with their active participation being a vital aspect. Comprehensive economic analysis shows that the project is technically feasible, environmentally friendly, socially acceptable, and economically viable, with an EIRR of 19.91% and a B/C ratio of 1.91 and 1.66, respectively. Overall, the feasibility study concludes that the project should be implemented, and the farmers are enthusiastic about its potential success. Further training in areas such as O&M, water management, and leadership development will be essential to ensure that farmers can take full advantage of the project's benefits.

Keywords: Cropping Intensity, EIRR, Reservoir, Pump

INTRODUCTION

Lift irrigation is an important source of water for agriculture in Nepal, especially in areas with limited water availability. However, the feasibility of implementing lift irrigation systems and the economic benefits they can provide for farmers are often unclear. Therefore, conducting a feasibility study and agri-economic analysis of lift irrigation systems is necessary to assess their viability and potential impact on agriculture in Nepal. This analysis should consider factors such as the availability and quality of water sources, the terrain and topography of the area, the cost and maintenance of lift irrigation systems, and the potential impact on crop yields and farmer incomes. The results of such a study can provide valuable information for policymakers and investors to make informed decisions about the implementation of lift irrigation systems and their potential impact on rural communities in Nepal. Reviewing the literature, “The study Assessing the Operation Management: A Case of Narayani Lift Irrigation System, Nepal” used field visits, surveys, and interviews to collect data, which was analyzed using various methods. The system's past performance showed limited irrigation coverage, occasional supplements, and frequent disputes during water

distribution. The role of NLIWUA was effective in managing these disputes. The system has brought about changes in the socioeconomic and agricultural status of the users, including an increase in economic status and a shift from rice plantations to cash crops. The system needs proper rehabilitation as the allocated budget is only sufficient for temporary maintenance, and sediment management is a significant problem. The study “Enhancing Water Productivity in Agriculture at Fokshingkot Lift Irrigation System” briefs that a high-head lifting/pumping system was constructed that successfully delivers 1.94 liters per sec of water for drinking and irrigation. This has benefited 102 households, saved time for women and children, and increased household income through farming.

The Bhabar Lift Irrigation Project is located in the Alital-5 region of Sudur Paschim province in Nepal, with a proposed lifting point at a latitude of $29^{\circ} 7'54.29''N$ & longitude of $80^{\circ}29'46.68''E$.

Access to the project area is provided by nearby roads such as the Bhimdutta Panta Highway & Mahakali Highway, and the specific road for the site is Jogbuda-Alital or Budor to Alital. The water in Rangun Khola is sufficient for the pumping requirement.

The study of Bhabar Lift Irrigation includes feasibility analysis, the construction of necessary irrigation infrastructure to ensure reliable water supply, providing year-round irrigation to the area, and increasing cropping intensity and productivity. Additionally, the project aims to strengthen water user associations and institutions, promote advanced farming technologies, and increase farm income.

METHODOLOGY

To achieve the objectives, the project team conducted field visits, topographical surveys, and focus group discussions to identify the location of the lifting point, source, and reservoir. GPS surveys were conducted to determine the altitude and location of the source and command area. The results of the digital data were then imported into CAD and GIS software for further analysis.

The float method was used to measure discharge, and the cross-sectional areas at the start and endpoints of the reach were measured and plotted in the graph using a suitable scale. Discharge was computed by multiplying the average area and velocity. MIP (Medium Irrigation Project) was used to estimate mean monthly flows at ungauged sites. Nepal is divided into 7 hydrological regions, and the project location lies in Hydrological Region 1. Once the low-flow discharge measurement data is taken, long-term average monthly flows can be determined by multiplying the unit hydrograph with the measured catchment area according to the MIP Method. The criteria for the selection of design discharge were based on agro-technical considerations such as crop water requirement and command area.

In addition to the design discharge, high flood design discharge was also taken into consideration. The catchment area of the river source was computed to be 50 square kilometers, and the highflood discharge was computed using five different methods. The average of these values obtained is taken into consideration, and regional analysis is adopted for high-flow calculations.

This study aimed to design an irrigation project to provide water to the command area for crop cultivation. The study involved a joint walk-through survey and site investigation to identify river stability problems and high-risk zones for laying the pipe network. A focus group discussion was conducted to assess the agricultural situation of the command area.

Agro-economic data collection was carried out through household surveys and discussions with key informants. Crop water requirements and water balance were calculated using CROPWAT software and the mean monthly flow was determined using the MIP method.

Cropping intensity was calculated to evaluate the extent of multiple cropping on the farm. Engineering design involved the design of major components such as the intake well, pump house, electrical accessories and fittings, transformer and power connection, sump well, pipe networks, distribution system, and protective devices. The economic analysis was undertaken with two major assumptions: a) the project life is 25 years, and b) the maintenance cost is taken to be 1% of the total investment cost, occurring from the second year.

Sensitivity analysis was performed to assess the economic viability of the chosen irrigation project at several selected input scenarios. The analysis included examining the risks that occur when investment costs increased, incremental benefit shortfall, and when both investment costs increase and incremental benefit shortfall. The internal rate of return (IRR) and benefit-cost ratio (BCR) were applied in the economic analysis, and sensitivity analysis was carried out.

RESULTS AND DISCUSSIONS

The study showed that the project is feasible as the lift height is 80 meters. The water balance was calculated and found that the crop water requirement meets the design discharge.

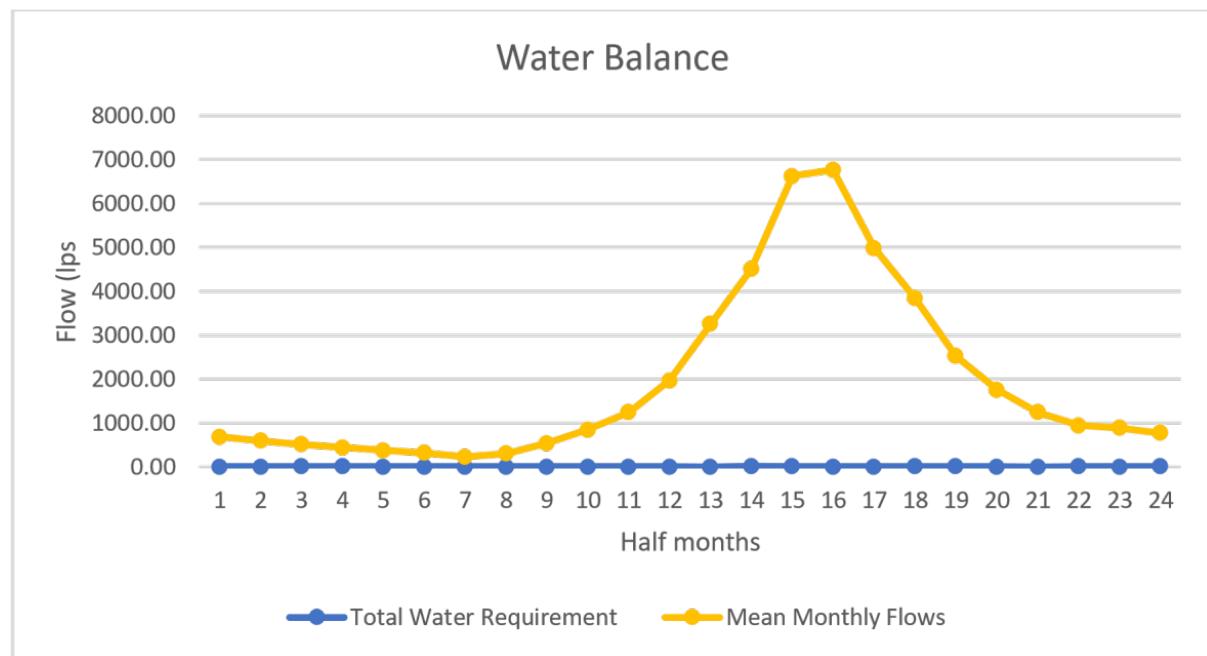


Figure 1: Water Balance

From the figure in the horizontal axis 1, represents the January First half and 2 represents the Second half and is similar in the case of other months respectively It was found that for every half month, the mean monthly flow is excess, indicating that water is enough for the command area.

The proposed project involves the construction of a lift irrigation system in Rangun Khola to provide year-round irrigation to the command area. Water is to be lifted from the river to an upper tank using an electrical pump and then distributed to the command area through a network of main pipes, sub-main pipes, and laterals. The pipes are made of GI and HDPE and

have been designed based on the necessary discharge to effectively irrigate the command area. The farmers in the project area currently follow traditional subsistence practices of agriculture, with terraced agricultural lands and a moderate gradient. The existing cropping intensity is 130%, and the proposed Cropping intensity is 232% the irrigation facility will have an impact on increasing the intensity of crops and modernizing the cropping pattern with more valuable crops, which will further enhance the potential to achieve the expected benefits.

The project has conducted a detailed item-wise rate analysis based on prevailing government approved norms and district rates. The analysis has also considered transportation costs to the rate of market materials at Dadeldhura or nearest, wherever it is available. The rate of labor and market materials are adopted from the district rate of Dadeldhura FY 2078/79.

In terms of technical specifications, the capacity of the tank is 73.13m³ and the main riser is made of GI pipe (Medium class) of 80mm dia with a length of 900m. The total length of the main pipe is 750m, the sub-main 1100m, and the laterals 3800m.

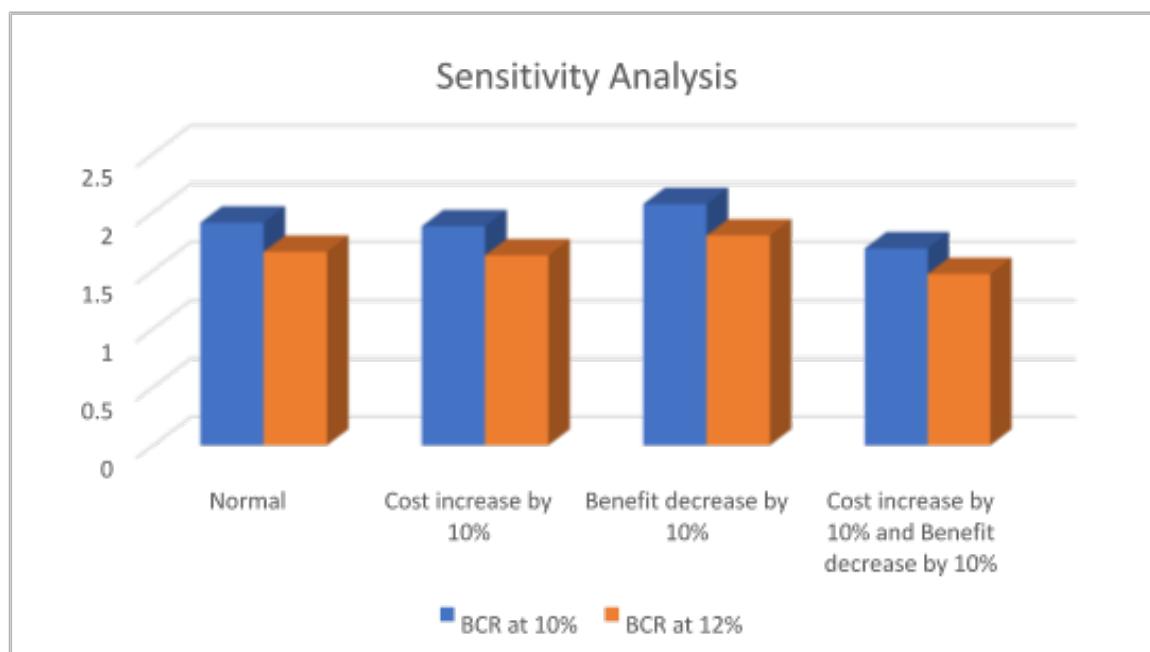


Figure 2: Sensitivity Analysis of the Study

The lift irrigation project proposed for the command area near Rangun Khola is expected to cost NPR 15,136,000.00. The economic viability of the project has been evaluated using several parameters. The Benefit Cost Ratio (BCR) of the project at 10% and 12% discount rates are computed to be 1.91 and 1.66, respectively, indicating that the project is economically feasible. The Economic Internal Rate of Return (EIRR) of the project is computed to be 19.91%, which is considered good. The cost analysis also considered different scenarios, such as a cost increase of 10%, a benefit decrease of 10%, and a combination of both, and the BCR values were still greater than one in all cases, indicating that the project is viable. Overall, the lift irrigation project is expected to have good economic returns and would benefit the farmers in the command area.

CONCLUSION

The Bhabar Lift Irrigation Project aims to provide reliable lift and distribution systems to the area as it lacks any irrigation facility, leading to low productivity. To guarantee the successful implementation of the project, special attention needs to be paid to the following risk factors: extended or prolonged implementation, decreased or delayed benefits, lack of coordination between beneficiaries and government organizations, inadequate agricultural support programs, and inadequate operation and maintenance. Therefore, the institutional development aspects should be implemented from the beginning of the project, including beneficiary participation, setting up of Water Users' Organizations, female participation in the WUAs, and setting up of a Steering Committee to coordinate the different aspects of irrigated agriculture.

Overall, the Bhabar Lift Irrigation Project is technically feasible, economically viable, socially acceptable, and environmentally friendly. Thus, the project is recommended for implementation. It has the potential to not only increase productivity and benefit the farmers but also promote institutional and social development in the region.

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Implementation of Greenhouses on High Hills of Nepal: A Case Study of Jiri, Dolakha

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ABSTRACT

This research paper focuses on implementing greenhouses in the high hills of Jiri, Dolakha, Nepal, to address agricultural production challenges and promote sustainable practices for enhanced food security. The study explores the feasibility of greenhouse technology in adverse climatic conditions, considering the characteristics of steep slopes and limited arable land in hill and mountain ecosystems. Jiri, located at an altitude of 1905 meters, experiences temperatures ranging from 3°C to 25°C and receives significant rainfall, with July recording 779.72mm. The research aims to identify suitable greenhouse types, evaluate existing ones, optimize resource utilization, and propose specific requirements for greenhouse implementation in Jiri. Through a systematic methodology involving greenhouse analysis, soil sampling, and thorough assessment of hydrological and meteorological conditions, the research addresses challenges such as low temperatures, winter dysfunction, snowfall damage, and excessive surface runoff. A High Tech Polycarbonate greenhouse is recommended for its durability, offering 200 times the strength of traditional structures, individual panel replacement, and optimal light diffusion. The proposed design includes essential features for greenhouse implementation, contributing to sustainable agriculture in high hills, overcoming challenges, and providing valuable insights for similar geographical contexts.

Keywords: Adverse Climatic Condition, Winter Dysfunction, Snowfall, Polycarbonate Greenhouse, Durability

BACKGROUND

Hill and mountain ecosystem spread over the world and nearly one fifth of land surface belongs to this ecosystem. Steeps slopes and higher relief are the major characteristics of this ecosystem that limits the arable land for agricultural production and productivity (KUMAR, KUMAR, & K., 2019). Protected cultivation using greenhouse technology tempts one's mind, as it permits enormous modification in microclimate enabling the cultivation of crops in adverse climatic, caring least for the outside environment. Vrikshayurveda, an epic of 11th century AD by Surapala, states that any plant/tree could be grown anywhere provided king, treasury and destiny are favorable. This is an indication that agricultural experts of that era were aware of the protected cultivation methods (Sharma, 2013).

Project Location

The maximum humidity recorded so far is 95% while the average humidity of Jiri is close to the location for the case study is selected in Jiri, also called Switzerland of Nepal, in the Dolakha district. It is the main gateway for the Everest region. The altitude of Jiri is 1905 m from the mean sea level. The location was chosen due to the very less temperature here which ranges from 14°C to 25° during the daytime. Meanwhile, the temperature during nighttime

ranges from 3°C to 16°C. The project area has a maximum of 25 rainy days in July and August, with maximum precipitation of 779.72mm in the month of July.

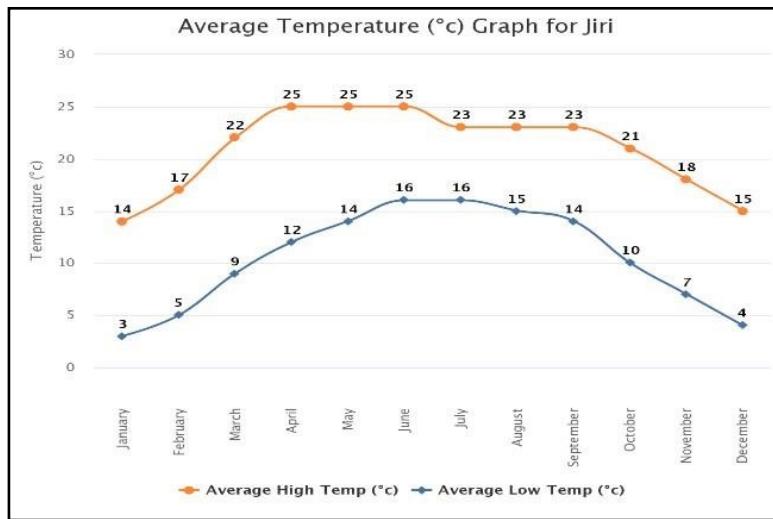


Figure 1: Average Temperature Graph for Jiri.

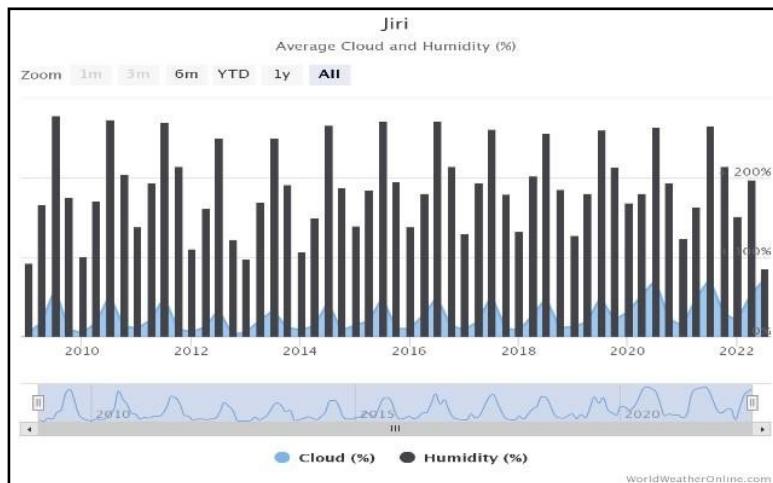


Figure 3: Average Cloud and Humidity (%)

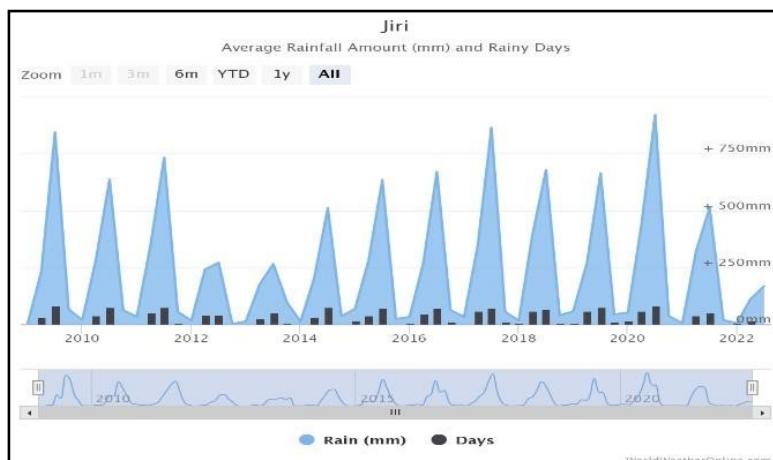


Figure 2: Average Rainfall Amount (mm) and Rainy Days

OBJECTIVES

General Objective

- To implement greenhouses on high hills of Nepal in order to promote sustainable agriculture and enhance food security.

Specific Objectives

- To study the types of greenhouses that are suitable for this location.
- To study the working status of greenhouses that are present on the project site.
- To provide suitable way to extend growing seasons in challenging geographical conditions by providing protection against harsh weather.
- To optimize resource utilization by minimizing water loss, reducing nutrient leaching, and effectively managing pests and diseases.
- To promote crop diversification by creating suitable conditions for growing a wide range of crops in greenhouses.
- To propose the greenhouse with its detailed project report suitable for the environment of Jiri.

METHODOLOGY

The study of existing greenhouses was done in the periphery of Jiri Technical School, which had constructed different types of greenhouses. The functioning of each greenhouse is studied and data were recorded. The random method based on the variability of the land was used to collect soil samples. The soil samples collected were 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. All the hydrological and meteorological status of the project area was properly studied. A suitable plan for the greenhouse is prepared based on the sample collected.

CHALLENGES:

The major challenge of the project is the very low temperature the surrounding experiences. The temperature goes down up to 3°C. Other existing greenhouses seem to dis-function during the winter season. Another major problem perceived there is snowfall. A very low climate precipitates snow on the roof of the greenhouse and the structures, and plastic covers over the roof are damaged. Besides, high rainfall during the monsoon makes excessive surface runoff due to which the base of the greenhouse is damaged. The moisture present in the air makes it difficult for plant growth and early decaying of fruit and vegetable products. The existing greenhouses are rated below average for their functioning status despite the good quality content of the soil, in high hills.

RECOMMENDATIONS:

The High Tech Polycarbonate greenhouse is suggested for these kinds of climatic conditions. Polycarbonate greenhouses are more durable and 200 times stronger than plastic/glass. When polycarbonate needs to be replaced, it's easy to remove the panels individually to make repairs. Polycarbonate greenhouses help diffuse light more evenly than plastic greenhouses,

which helps plants thrive and even grow faster (Glass or Polycarbonate Greenhouse, 2019). Polycarbonate cold frames can protect alpine plants from rain and prevent them from rotting and shield young annual plants. The size of 29*14 square meters of the greenhouse is recommended on the site. A flat brick soling is done to fortify the foundation of the structure. A 0.45m wall is proposed in the base, to give strength against surface runoff. The covering work includes the installation of 8mm cellulose polycarbonate all around the greenhouse. Two fans are suggested on MS Grouted Frame capable of exhausting air volume in one minute, together with a cooling pad of 16 square meters. The irrigation system is drip, which is controlled using an automation system. This automation system also regulates the hot air blower, proposed inside the greenhouse, if the temperature goes below the critical. The gutter is supplied through both sides with a 2% slope for draining roof water.

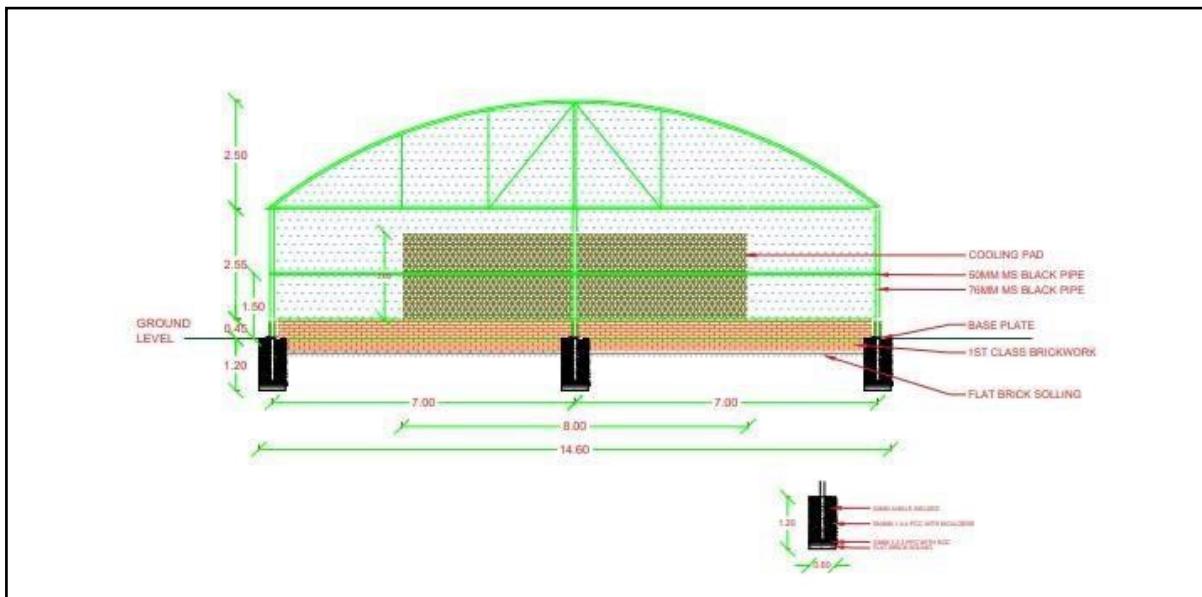


Figure 4: Section of Proposed High Tech Green House.

Table 1: Comparison of polycarbonate greenhouse over plastic/glass greenhouse on high hills

Description	High Tech Polycarbonate Greenhouse	Other Greenhouse
Climatic Impacts	The surrounding inside the greenhouse is independent of the temperature, relative humidity and other any climatic aspects outside the greenhouse. These factors are controlled automatically as per requirement inside the greenhouse. The less, or nearly zero damage is made by snowfall in its roof.	The cold temperature is penetrated somehow through their covering materials along with the moisture, mostly during winter. There is greater impact of snowfall in the roof covering.
Cost	The initial investment cost is relatively higher than the others. Nevertheless, the maintenance cost is less comparatively.	The initial investment cost is relatively less than the high tech greenhouse. Nevertheless, the maintenance cost is much more than that of it.

Resource Use Efficiency	Less labor-intensive with high utilization of production inputs like fertilizer and irrigation through automation system.	More labor-intensive as every function inside is done manually. Also, labor is required over and over for maintenance.
Productivity	Yields higher productivity under controlled environment.	Yields less productivity due to variation in temperature.
Disease and Pest	Less chance of spreading of insects and diseases.	High chance of spreading of insects and diseases.
Quality	Higher food quality.	Generally, lower food quality.
Risk	High initial investment so payback period is high.	Payback period is comparatively lower.

CONCLUSION:

Farmers can cultivate different suited horticultural commodities provided that the greenhouse is properly designed and equipped to control the climatic parameters. It is necessary to find out the research gaps and given clear recommendations for the overall handling of these gaps in the area of protected cultivation through government and non-governmental institutional (Rayemajhy, Kafle, Amgai, & Joshi, 2020). However, the initial and long standing costs of the facility, non-availability of various structural components, and non-standardization of region based greenhouse and other structures design and lack of awareness are major limiting factors in the adaptation of this technology (Dalai, Tripathy, Mohanta, Sahu, & Palai, 2020).

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Socio-Economic Impact Study of Shesnarayan Dakshinkali Irrigation SubProject, Dakshinkali, Kathmandu

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ABSTRACT

This article presents an impact study that assesses the effects of the Shesnarayan Dakshinkali Irrigation Sub-Project on the local community and environment. The study aims to analyze changes in crop yields, crop diversity, and income levels for farmers, as well as changes in water availability and water quality. Additionally, the sustainability of the project is evaluated, focusing on its ability to provide long-term benefits to the community beyond the project's funding period.

The study incorporates an assessment of the maintenance and management of the irrigation infrastructure, as well as the extent of community participation in the project's planning and implementation. Furthermore, the research explores indirect effects, including their potential impact on the local economy, such as the creation of new jobs or business opportunities.

To gather comprehensive data, a combination of surveys, interviews, and field observations was conducted, ensuring the inclusion of both quantitative and qualitative information. The study's findings are expected to make significant contributions to the sustainable development of the irrigation sector in Nepal.

Keywords: Crop Yields, Crop Diversity, Water Quality, Sustainable Development

INTRODUCTION

Nepal, known for its predominantly agrarian society, heavily relies on agriculture as the primary source of livelihood for a majority of its population. However, the country's irrigation infrastructure has been a persistent challenge, leading to limited access to reliable water sources for crop cultivation. With only 30% of arable land currently benefiting from irrigation, farmers face significant constraints in achieving optimal crop yields and sustainable income levels.

Recognizing the urgent need to address these issues, there has been a growing interest in recent years to improve irrigation infrastructure in Nepal. The government, in collaboration with international organizations, has undertaken various irrigation projects, such as the Irrigation System Project (ISP) and the Medium Irrigation Project (MIP), to enhance the irrigation network and increase agricultural productivity.

One noteworthy initiative among these projects is the Shesnarayan Dakshinkali Irrigation SubProject. Its primary objective is to improve irrigation infrastructure in the Shesnarayan Dakshinkali area, situated within the picturesque Kathmandu Valley. This sub-project aims to provide efficient irrigation facilities to approximately 32 hectares of agricultural land, with the ultimate goal of improving the livelihoods of farmers in the region.

Despite the promising nature of such endeavours, the impacts of these irrigation projects on the local community and environment are not yet well understood. It is crucial to conduct a comprehensive impact study to assess the effects of the Shesnarayan Dakshinkali Irrigation SubProject, encompassing various dimensions and aspects.

This impact study seeks to evaluate the multifaceted consequences of the project, encompassing changes in crop yields, crop diversity, and income levels for farmers. By examining these indicators, researchers can gauge the direct benefits of the sub-project in terms of enhanced agricultural productivity and improved economic well-being for the local farming community.

METHODOLOGY

Research Design

This research evaluates the impact of the Sheshnarayan Dakshinkali Irrigation Sub Project on the local community and environment, focusing on changes in crop yields, income levels, water availability and quality, sustainability, maintenance, and community participation. It provides valuable insights and recommendations for future irrigation projects in Nepal, using a mixedmethods approach of surveys, interviews, and focus groups to gain a comprehensive understanding of the project's outcomes.

Study Area

The Sheshnarayan Dakshinkali Irrigation Sub Project is located at Dakshinkali Municipality-5 which is around 14.5 km away from Balkhu. The project location is at an altitude of around 1500 m. The latitude and Longitude of the project area are 27°36'59.18" and 85°15'50.57"E.

Methods of Data Collection

- 1. Primary Data Collection:** It involves a household survey with structured questionnaires administered to project beneficiaries. The survey covered irrigation, agriculture, water management, and other relevant aspects. Focus Group Discussions (FGDs) were conducted to gather in-depth insights on the research topic. Key Informant Interviews (KIIIs) were conducted with relevant personnel to supplement FGD findings. Secondary data were collected from reports and documents.
- 2. Secondary Data Collection:** It includes reports, documents, and articles, to complement the primary data. This secondary data encompassed feasibility and baseline survey reports, design reports, environment study reports, monitoring reports, budget and expenditure documents, and information from the Agriculture Knowledge Centre and Water Resource and Irrigation Development Division. The integration of secondary data enriched the research methodology and analysis.

Data Processing & Analysis

Data analysis was conducted using MS Excel, employing both qualitative and quantitative techniques. After data collection, calculations relevant to the analysis were performed to derive meaningful insights from the data.

RESULTS AND DISCUSSION

1. General Overview of Irrigation System:

The Sheshnarayan Dakshinkali Irrigation Sub Project is one such initiative that aims to improve the irrigation infrastructure in Nepal. The farmers in the sub-project area used to convey water from intake near the Sheshnarayan temple through earthen channels in the past during the monsoon season before the implementation of the project. The water was not adequate to irrigate all farmer's fields, especially during the winter season. After the implementation of the project, the farmers in the project area formed a WUA for the operation and maintenance of canals. The proposed work is the rehabilitation of the existing irrigation system.

2. Land Holding Pattern:

Most of the farmers in the project area are owners of land. However, some farmers have taken land on lease and currently running farms. Even though, the land holding pattern is not uniform farmers hold around 4-5 ropani of land including leased land.

3. Major Occupation

The majority around 51% of the respondents belong to the agriculture sector followed by service, business and others.

4. Income and Expenditure:

In the project area, agriculture is the primary occupation for the respondents. However, most of them stated that they have not been able to generate significant income from agriculture, as the crop yield is primarily sufficient for family consumption. Only a few farmers with larger farms can generate some savings from agriculture. The main sources of income from agriculture include vegetables, wheat, and paddy. A small number of respondents send their crops to the market, earning approximately NRS 25,000 per month. Other sources of income for the respondents include labour, electrician work, services, and business, contributing to a monthly income of around NRS 30,000. Surprisingly, only a few farmers in the project area are involved in livestock farming, resulting in minimal income generation from this sector.

5. Change in Cropping Intensity:

The project intervention aimed to increase the productivity of crops and crop intensity in the command area by rehabilitating existing irrigation facilities. So after the intervention cropping intensities increased to 231%. From the figure we can conclude that cropping intensities have increased to 231% from 169%. The table below shows a comparison of crop intensities during the different seasons before and after the project interventions in the respondent's land.

6. Change in Cropping Pattern:

After the implementation of the project, the cropping pattern of farmers in the project area changes hugely as compared to the old pattern. Most of the farmers used to grow paddy during the monsoon season and maize during the winter season. But after the implementation project, most of the respondents told during the field survey that they have started growing

high-yielding vegetables during winter and summer. Now farmers grow paddy and vegetables during summer while wheat, potato and vegetables during the winter.

7. Agricultural Productivity

Overall, the productivity of agricultural products increased after the implementation of SDISP which is due to sufficient irrigation.

Summer & Monsoon Crops		
Crops	Before Project (t/ha)	After Project (t/ha)
Paddy	5.4	6.03
Maize	1.56	2.7
Vegetables	5	15

Winter Crops

Crops	Before Project (t/ha)	After Project (t/ha)
Potato	6	14
Vegetables	8	19
Mustard	1.54	1.83
Wheat	1.39	2
Barley	1.2	1.8

8. Project Impact:

Several factors, including poverty reduction, food sufficiency, higher income and spending, decreased workload for women, gender equality, and migration, were used to assess the irrigation system's impact in the command area.

1. Economic Sustainability:

The project's implementation has had a significant impact on raising the standard of living for the underprivileged. One of the biggest effects following the project's implementation in the command area is a decrease in poverty.

2. Employment:

Farmers have begun selling their goods on the market as a result of the growth in agricultural productivity on irrigated land. Farmers who previously relied on seasonal and off-seasonal veggies for their living now have revenue. As a result, one of the key industries in this command area is the production of out-of-season vegetables. There is a visible increase in employment opportunities for farmers due to the provision of irrigation.

3. Food Sufficiency

Overall, most of the respondents told that the cultivated food items are just sufficient to fulfil their household demands. About 10% of respondents responded that the food

is not sufficient for a whole year and they need to buy food products from the market.

4. Women's Drudgery:

Since women perform most agricultural labour, it goes without saying that the lack of water in agricultural fields adds to the burdens they already bear. This irrigation project's greatest benefit to women has been the reduction of their fieldwork workload and hardship.

5. Time-Saving Utilization

To transfer water from the source into their irrigation canal, farmers used to devote important time. They also need to spend more time distributing water to their farms. The farmers had to wait for their turn because the water flow was limited. Farmers who steal water are dishonest, therefore disagreements are frequent. Peasants greatly increased their time for animal husbandry after the project participated in the project region. Similar to this, the civilization built an alluring social harmony that decreased water conflicts.

CONCLUSION AND RECOMMENDATIONS

A) Conclusions

In conclusion, the study on the impact of the SDISP irrigation canal has provided significant insight into the positive effects that the efficient operation of an irrigation canal can have on a community. The successful operation of the canal has improved agricultural productivity, increased crop yield, and promoted economic growth in the surrounding areas. The efficient water distribution system has ensured that the farmers have access to water when they need it, allowing them to increase their crop production and maximize their profits.

B) Recommendations

To ensure the successful implementation and long-term sustainability of the canal system, a series of important recommendations can be put forth. Firstly, addressing accessibility issues is of paramount importance to guarantee the equitable distribution of benefits to all farmers in the region. This may necessitate improvements in transportation infrastructure or the provision of alternative means of access for remote areas. Concurrently, measures must be implemented to minimize environmental impacts associated with the canal, such as soil salinization and the loss of wildlife habitat. Achieving this objective entails adopting and promoting sustainable farming practices while preserving and protecting natural ecosystems.

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Digital Twin Concept and It's Applicability in Agriculture

INTRODUCTION

Dr. Michael Grieves from the University of Michigan first used the phrase "digital twin" in 2002. He described it as a virtual representation or simulation of a real-world thing, activity, or system. The idea of establishing a virtual version of an actual object or system that allows for study, prediction, and optimization served as inspiration for the concept. A digital twin is essentially a virtual equivalent or digital copy of a real-world system or thing. Data from numerous sources, including sensors, Internet of Thing (IoT) devices, and other data collection techniques, is used to build it. The creation of precise insights and predictions is made possible by the continual feeding of the digital twin with real-time data from the physical system.

The digital twin acts as a representation of the real object, recording all of its traits, actions, and interactions with its surroundings. It allows for concurrent physical counterpart monitoring, analysis, and simulation. Digital twins can offer insightful information, speed up decision-making, and enhance the functionality of the physical system by combining data analytics, modeling, and simulation techniques. Digital twins can be used in any company or field. They can be used for a variety of things and systems, such as construction projects, production lines, transportation networks, and, naturally, agricultural practices. Digital twins can be used in agriculture to mimic and simulate a variety of agricultural ecosystem components, including soil quality, crop growth, equipment performance, and supply chain processes.

The way that digital twin technology functions is by simulating an actual process, system, or object in a virtual environment. It entails gathering and integrating instantaneous data from sensors to produce an extensive representation. Based on the combined data, a mathematical or computational model is constructed and used to produce the digital twin. The digital twin receives continuous, real-time data feeds from the physical system, enabling analysis, visualization, and controlling. To improve the functionality of the physical system, insights, forecasts, and recommendations are provided by the digital twin. The physical system can be influenced by the digital twin through feedback and control mechanisms, and continual development makes sure the digital twin is updated with fresh information. Overall, digital twins facilitate immediate monitoring, analysis, and optimization of complex systems by creating a virtual counterpart that mirrors the physical system.

DIGITAL TWIN APPLICATION IN DIFFERENT AREAS OF AGRICULTURE:

Soil quality

The measurement of soil quality using digital twin technology has changed agricultural methods. Digital twins build a virtual representation of the soil environment using information from weather stations, soil sensors, and historical records. This makes it possible to regulate and analyze soil characteristics, moisture levels, nutrient levels, and pH balance in real time. Farmers may choose crops wisely and implement effective irrigation measures and nutrient management strategies using this knowledge. With the help of digital twins, irrigation timing and volume can be improved, resulting in less water stress on plants and more effective water utilization. By spotting nutrient shortages or surpluses, they also support

precision agriculture by enabling farmers to alter fertilizer application procedures for optimum plant development and minimal environmental effect. Farmers may control soil pH with the help of digital twins, ensuring that nutrients are available to plants. Digital twins aid in preventing soil deterioration, erosion, and nutrient depletion by simulating situations and foreseeing the effects of administration decisions.

Soil quality evaluation in agriculture has been revolutionized by digital twin technology. Digital twins enable farmers to optimize irrigation, fertilizer regulation, and crop choice by offering realtime insights about soil conditions. This results in enhanced soil health, increased output, and environmentally friendly farming methods. Precision farming is made possible by digital twins, which also enable proactive decision-making to keep soil quality and nutrient balance intact. Farmers are able to improve soil quality and promote more effective, ecologically friendly agricultural methods by using the power of digital twins.

Food Production

Digital twin technology is transfiguring food production by providing concurrent inspecting, analysis, and decision support throughout the production process. Digital twins create virtual replicas that simulate and optimize crop growth, livestock management, and processing operations. By integrating data from various sources such as sensors, weather stations, and historical records, digital twins offer valuable insights for informed decision-making. Farmers can optimize irrigation, fertilization, and pest regulation based on the simulated crop growth parameters, leading to increased yields and reduced resource waste. Livestock management benefits from simultaneous monitoring of animal health and behavior, enabling optimal feed formulation and disease prevention. Decision support tools based on real-time data and predictive analytics empower stakeholders to make informed decisions for improved efficiency and profitability. Digital twin technology is driving more efficient, transparent, and sustainable food production systems.

Harvesting

Digital twin technology offers significant benefits in the context of harvesting within the agricultural industry. By integrating data from sensors, machinery, and environmental conditions, digital twins provide synchronic insights and opportunities for optimization. These digital replicas enable farmers to closely observe crop maturity, moisture levels, and other relevant parameters, empowering them to make informed decisions for efficient harvesting operations. With the help of real-time data, digital twins can offer recommendations for adjusting harvesting techniques, machinery settings, and logistics planning. This ensures minimal losses, improved crop quality, and reduced resource waste. Furthermore, digital twins enable predictive maintenance of harvesting equipment by continuously monitoring machine performance and detecting potential issues in advance. By facilitating proactive maintenance interventions, digital twins minimize downtime and enhance the overall efficiency of harvesting processes. In summary, digital twin technology plays a crucial role in optimizing the harvesting process by enabling precise governing, informed decision-making, and predictive maintenance, leading to increased productivity and resource efficiency in agriculture.

POST HARVEST OPERATION:

Digital twin technology plays a crucial role in post-harvest operations, encompassing various aspects such as food processing, storage, supply chain management, and customer consumption.

Let's explore each of these areas:

Food Processing:

Digital twins optimize food processing operations by simulating production lines, monitoring realtime data from sensors, and identifying inefficiencies. They enable process optimization, predictive maintenance, and synchronic adjustments to ensure consistent product quality, reduce waste, and improve overall production efficiency. Additionally, digital twins help optimize food processing by identifying bottlenecks, improving quality control, and enhancing traceability. Resource handling is optimized through data analysis, reducing environmental impact and operational costs. By analyzing data on equipment performance, ingredient ratios, and processing parameters, digital twins help streamline food processing operations and enhance productivity.

Storage:

Digital twins revolutionize the way agricultural products are stored and preserved. By continuously monitoring storage conditions such as temperature, humidity, and air quality, digital twins ensure optimal environments for maintaining product freshness and standard. They provide real-time alerts and recommendations, allowing for proactive interventions to prevent spoilage and extend shelf life. Digital twins facilitate precise inventory administration, reducing losses, and enabling efficient product rotation and allocation.

Supply Chain Management:

Digital twins optimize supply chain management by integrating data from various stakeholders, including farmers, distributors, and retailers. They provide real-time visibility into inventory levels, demand forecasts, transportation routes, and logistics operations. Digital twins enable efficient product tracking, traceability, and compliance with food safety standards. By analyzing data on demand patterns, delivery schedules, and market trends, digital twins enhance supply chain responsiveness, reduce waste, and ensure timely delivery of agricultural products.

Customer Consumption:

Digital twins also impact customer consumption by providing insights into consumer preferences, trends, and behavior. By analyzing data from customer interactions, purchase histories, and feedback, digital twins enable personalized recommendations and targeted marketing strategies. They help improve customer satisfaction and loyalty by ensuring the availability of desired products, maintaining consistent standard, and facilitating seamless ordering and delivery experiences.

CONCLUSION:

In conclusion, the advent of digital twin technology has brought about a paradigm shift in agriculture, offering unprecedented opportunities for monitoring, analyzing, and optimizing various aspects of the industry. From soil quality evaluation to food production, harvesting operations, and post-harvest processes, digital twins have demonstrated their immense value

in improving efficiency, sustainability, and decision-making. By leveraging real-time data and creating virtual replicas of agricultural systems, farmers can make informed choices regarding crop selection, irrigation strategies, nutrient management, and equipment maintenance. The integration of digital twins in agriculture has the potential to revolutionize the industry, paving the way for enhanced productivity, reduced resource waste, and more environmentally conscious practices. As the technology continues to advance, the agricultural sector stands to benefit greatly from the transformative power of digital twins, ushering in a new era of precision, optimization, and sustainable farming practices.

Machine Learning Based Wild Animal Intrusion Detection System

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ABSTRACT

Animal like Monkey, wild Boar and other wild animals had affected the farm land of hilly regions and some regions of Terai. They eat and destroy the large amount of crops. People didn't know the time of intrusion. They came in the random time. Wild Boar used to come in the night. So Farmers are unknown about their intrusion. So to solve these problems Animal Intrusion Detection System was designed to continuously monitor the farm land to prevent entry of wild animal and alert the farmer about their intrusion and repel the animal by playing irritating sound. This is done by detecting the intrusion with the help of camera and feed the frame of video which is fed to machine learning model. If the model identifies that object as wild animal then it plays irritating sound using speaker then it does phone calls to the farmer using GSM module. So that farmer will be able to receive the phone call with pre-recorded voice message.

Keywords: Animal detection, Image Processing, Speaker, GSM module

INTRODUCTION

Nepal is an agricultural country. Agriculture has always been Nepal's most important economic sectors. Though most of the Nepal's population depends on agriculture, there are still a lot of many problems faced by farmers. Animal intrusion in the farm land is a major problem faced by farmers where enormous amount of crops is eaten and destroyed by wild animals. So the farm is to be monitored continuously to prevent entry of this kind of animals or any other unwanted intrusion. Animal Intrusion Detection System continuously monitor the farm and captures the image and send to machine learning model and if the model identify that object as a wild animal then it play the irritating sound using speaker and call the farmer using GSM module and when farmer receives call he/she listen recorded voice message.

OBJECTIVE

The objective of this project is to continuously monitor the farm land and capture the image and sends to machine learning model and if the model identify that object as a wild animal then it play the irritating sound using speaker and phone call the farmer using GSM module.

METHODOLOGY

Implementation

In this system the machine learning model is prepared by training model on dataset of 1500 images of wild animals like monkey, wild boar etc. with batch size 16 and epochs 500 using YOLO Version 5 model. YOLOv5 is a model which stands for You Only Look Once (YOLO) is a family of computer vision models. YOLOv5 is commonly used for identifying objects. YOLOv5 is already trained to identify 20 objects but it does not include wild animal which

we had trained. We prepare the dataset using Roboflow[7] website by annotating the images of 1500 wild animal images, we put bounding box to the body of wild animal and put class label that is the name of the animal. The Ground truth of annotation is shown in the figure 2. After annotation is done we train the model on dataset in Google Colab backend GPU. The training took 6 hour to complete. The training snapshot is also shown in the figure. After the machine learning model is prepared and the machine learning model is uploaded on microcontroller of Raspberry Pi. Now the microcontroller takes input image and machine learning model present in the microcontroller perform image processing and identify the pattern and if the model identify that object as a wild animal then it plays irritating sound through speaker and call the farmer using GSM module and when farmer receives call, he/she listen pre-recorded voice message.

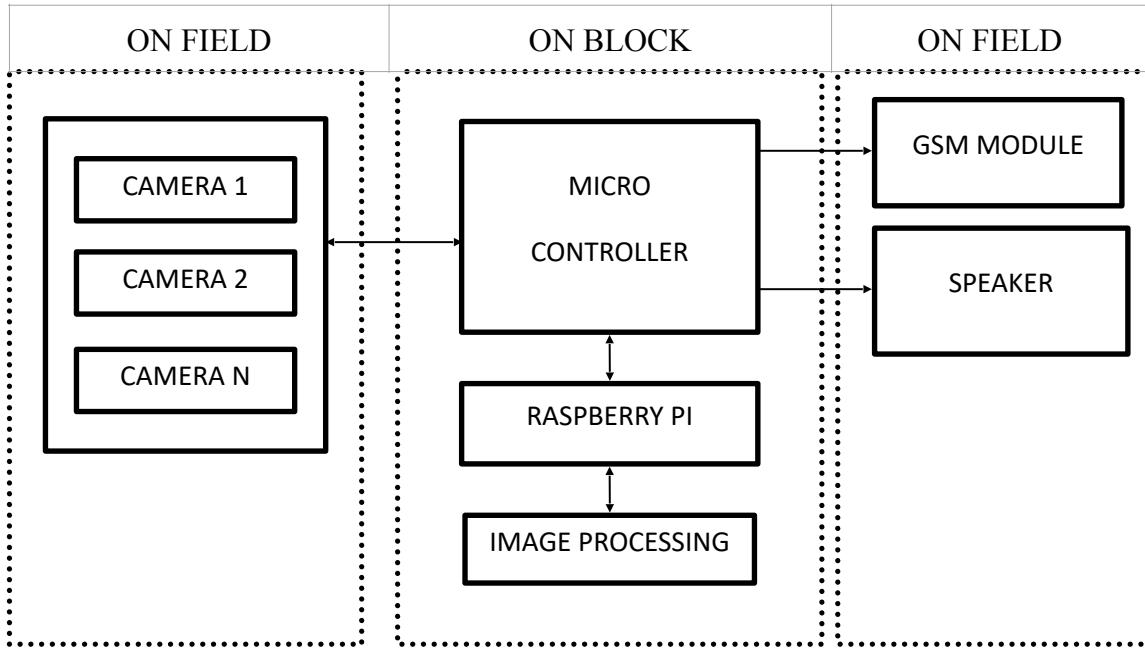


Figure 1. Block Diagram for Animal intrusion Detection System

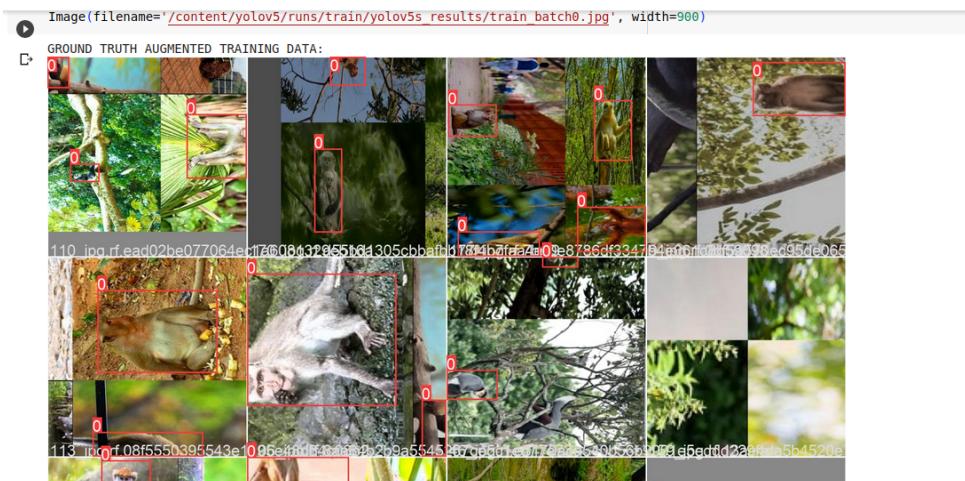


Figure 2: Annotating the object and labelling with class name

```

%%time
%cd /content/yolov5/
!python train.py --img 1500 --batch 16 --epochs 500 --data {dataset.location}/data.yaml --cfg ./models/custom yolov5s.yaml

```

Epoch	gpu mem	box	obj	cls	labels	img_size
127/499	14.2G	0.03816	0.01573	0	146	416: 100% 4/4 [00:03<00:00, 1.25it/s]
	Class all	Images 22	Labels 26	P	R	mAP@.5 mAP@.5:.95: 100% 1/1 [00:00<00:00, 2.80it/s]
0.588				0.577	0.576	0.247
128/499	14.2G	0.03763	0.01605	0	156	416: 100% 4/4 [00:03<00:00, 1.25it/s]
	Class all	Images 22	Labels 26	P	R	mAP@.5 mAP@.5:.95: 100% 1/1 [00:00<00:00, 3.44it/s]
0.548				0.577	0.46	0.173
129/499	14.2G	0.03588	0.0161	0	164	416: 100% 4/4 [00:03<00:00, 1.24it/s]
	Class all	Images 22	Labels 26	P	R	mAP@.5 mAP@.5:.95: 100% 1/1 [00:00<00:00, 3.00it/s]
0.583				0.423	0.488	0.171
130/499	14.2G	0.03786	0.01571	0	156	416: 100% 4/4 [00:03<00:00, 1.26it/s]
	Class all	Images 22	Labels 26	P	R	mAP@.5 mAP@.5:.95: 100% 1/1 [00:00<00:00, 2.38it/s]
0.436				0.594	0.479	0.182
131/499	14.2G	0.03732	0.01582	0	145	416: 100% 4/4 [00:03<00:00, 1.26it/s]
	Class all	Images 22	Labels 26	P	R	mAP@.5 mAP@.5:.95: 100% 1/1 [00:00<00:00, 3.00it/s]
0.841				0.654	0.775	0.311

Figure 3: Training Snapshot

The different graphs showing training box loss, object loss, class loss, metrics or precision, metrics or recall respectively and validation box loss, object loss, class loss, metrics or precision respectively is shown in the figure 4.

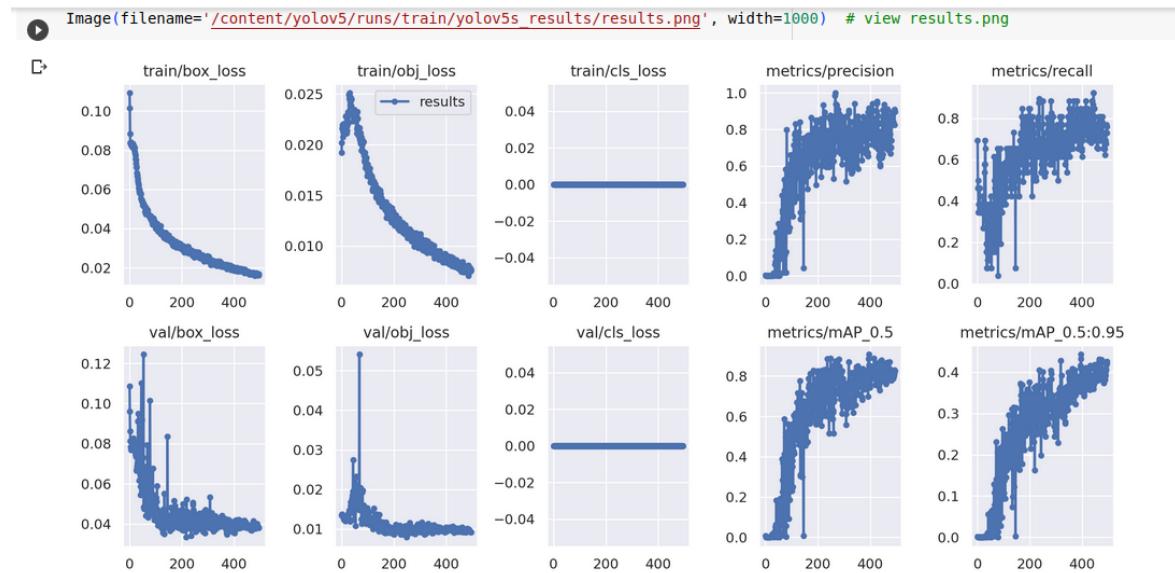


Figure 4: Performance measuring graphs

The Animal intrusion Detection has been explained with the help of flow chart also. The flowchart is shown below:

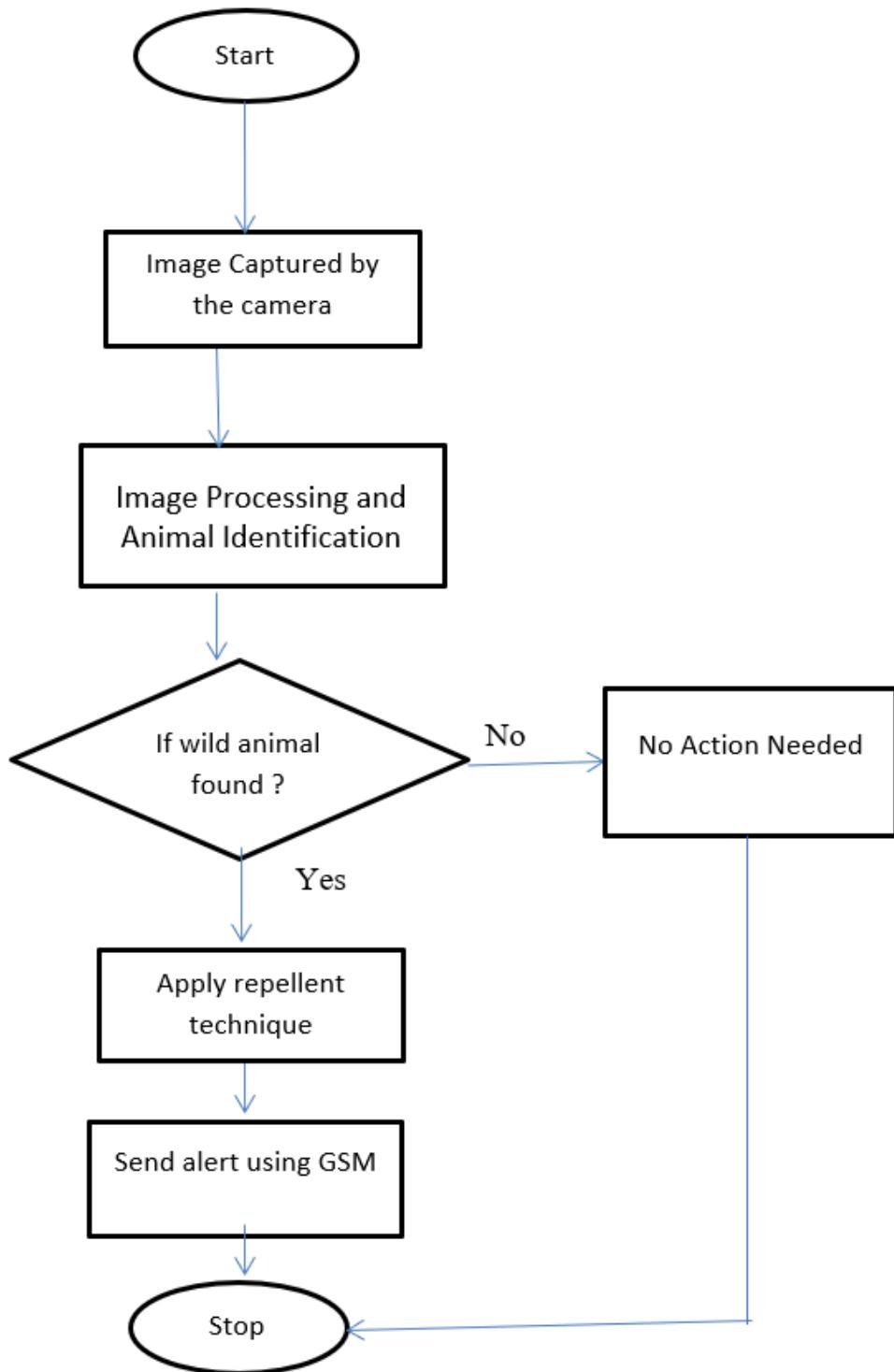


Figure 5: Flow chart of Animal intrusion Detection System

COMPONENTS

The following components has been used while developing the project.

1. SIM 900 GSM Module

A GSM module or a GPRS module is a chip or circuit that will be used to establish communication between a mobile device or a computing machine and a GSM or GPRS system. The modem (modulator-demodulator) is a critical part here.

These modules consist of a GSM module or GPRS modem powered by a power supply circuits and communication interfaces (like RS-232, USB 2.0, and others) for computers.

A GSM modem can be a dedicated modem device with a serial, USB, or Bluetooth connection, or it can be a mobile phone that provides GSM modem capabilities.



Figure 6: SIM 900 GSM Module

2. CCTV Camera

The CCTV camera is used to take frame of video which is fed to machine learning model for the image processing.



Figure 7: CCTV Camera

3. Raspberry Pi

Raspberry Pi is the name of a series of single-board computers made by the Raspberry Pi Foundation, a UK charity that aims to educate people in computing and create easier access to computing education. In the Raspberry Pi we run our Machine learning code which is written in python. The CCTV camera, GSM module and the Speaker are connected with Raspberry Pi. It receives frame of video from the Camera and feeds frame to the machine learning model. The machine learning model then performs pattern recognition and if pattern matches with wild animal then it predicts the object as a wild animal.



Figure 8: Raspberry Pi

RESULTS AND DISCUSSION

By developing the projects we got the following results. The window having title 0 represents a live streaming through camera, where we showed monkey in the android mobile and the machine learning model identified object as monkey and played the irritating sound and call the farmer using GSM module. Application starts by giving commands python detect.py --weights best.pt --source 0. Where Source 0 represents camera, best.pt is a saved weights.

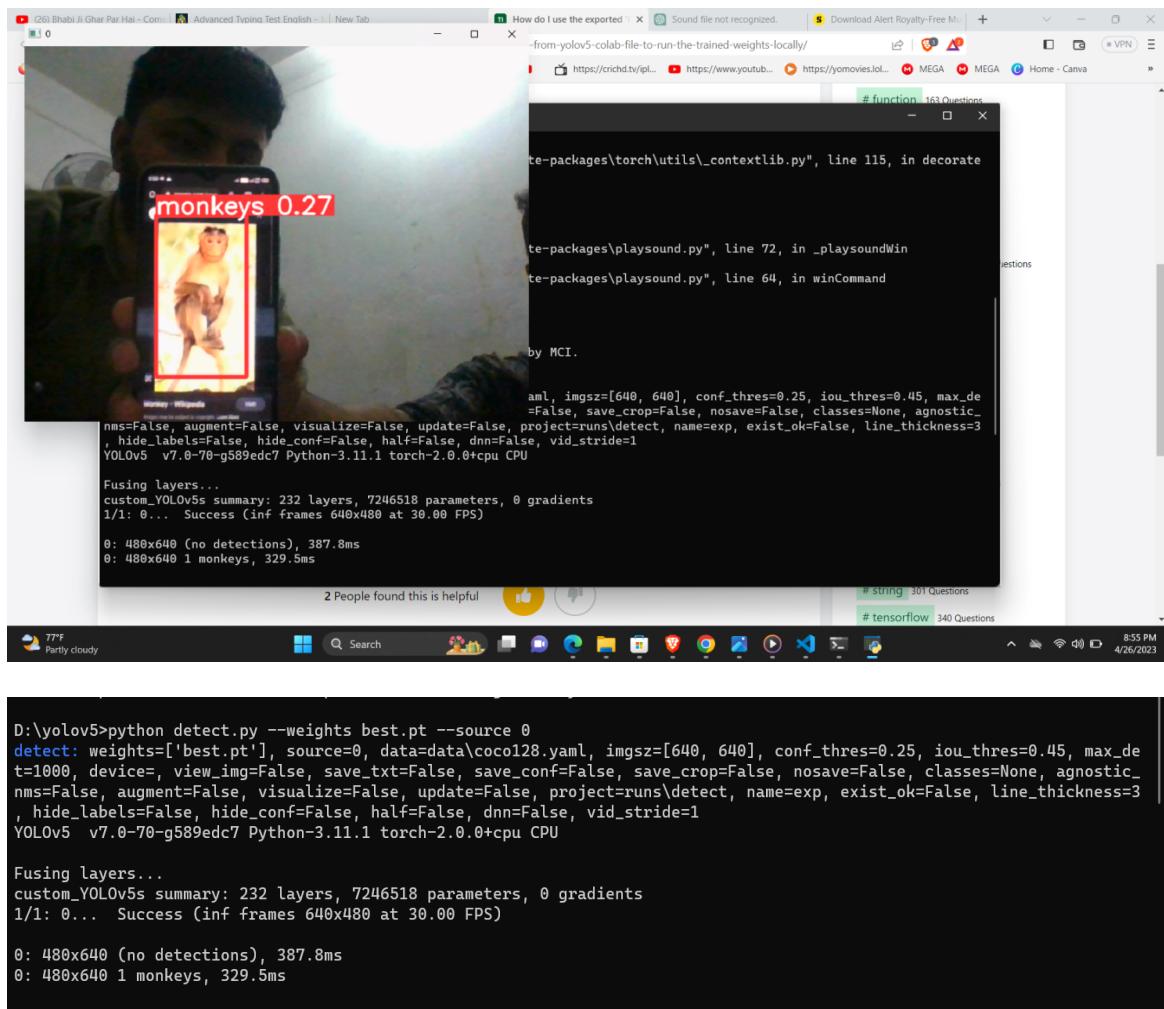


Figure 9: Passing Commands

CONCLUSION

The project successfully identified wild animals and alerted the farmer about the intrusion of wild animals by calling the farmer and repelled the wild animals by playing irritating sounds.

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नि:शुल्क औद्योगिक प्रशिक्षार्थी (अप्रेन्टीसीप) तालिम कार्यक्रम सम्बन्धी सूचना

नेपाल सरकार र स्वीजरल्याण्ड सरकारबीच भएको द्विपक्षीय सम्झौता अनुसार प्राविधिक तथा व्यावसायिक शिक्षा र तालिम (TVET) का क्षेत्रमा सञ्चालित दीगो तथा सम्मानित रोजगारीका लागि सीप परियोजना दोश्री (ENSSURE-II) अन्तर्गत यस मन्त्रालयको बजेटबाट कोशी प्रदेशका शिक्षालयहरु/ विद्यालयहरु मार्फत तल उल्लेखित ७ वटा विषयमा २४ महिने अप्रेन्टीसीप कार्यक्रम (औद्योगिक प्रशिक्षार्थी तालिम) कोशी प्रदेशका विभिन्न आंगिक शिक्षालय, साइंडेवर शिक्षालय र सामुदायिक विद्यालयमा प्राविधिक शिक्षा कार्यक्रम (TECS) सञ्चालित विद्यालयहरु मार्फत सञ्चालन हुने भएकाले आफुलाई पायक पर्ने शिक्षालयमा आवेदन गरी निशुल्क अध्ययनको अवसर प्राप्त गर्न सम्भव्यित सरोकारवालामा हार्दिक अनुरोध छ ।

तपसिल

१.प्राविधिक शिक्षा तथा व्यावसायिक तालिम परिषद (CTEVT) बाट स्वीकृत औद्योगिक प्रशिक्षार्थी (अप्रेन्टीसीप) तालिम सञ्चालन कार्यविधी बमोजिम विद्यार्थी छनौट, भर्ना र कार्यक्रम सञ्चालन हुनेछ । यो कार्यक्रम एस.इ.इ परीक्षाको नतिजा प्रकाशन पछि सञ्चालन हुनेछ ।

२.शिक्षालय र उद्योग, व्यवसाय दुवै स्थानमा रहेर कार्यस्थलमा आधारित सिकाइ विधि अन्तर्गत सञ्चालन हुने अप्रेन्टीसीप कार्यक्रम २४ महिना अवधिको हुनेछ ।

५.अप्रेन्टीसीप तालिम कार्यक्रममा छनौट भई अध्ययन गर्ने प्रशिक्षार्थीहरुले नि:शुल्क अध्ययनको अवसर प्राप्त गर्नेछन् ।

६.प्राविधिक शिक्षा तथा व्यावसायिक तालिम परिषदबाट अप्रेन्टीसीप कार्यक्रमका लागि स्वीकृत भएका सातवटा विषयहरु Electrical Engineering Mechanical Engineering Automobile Engineering Hotel Management Information Technology Civil Engineering (Building Construction) Early Childhood Development Facilitation(ECDF) रहेका छन् ।

९.विद्यार्थी भर्ना सम्बन्धी सूचना, परीक्षा सञ्चालन र उत्तीर्ण परीक्षार्थीलाई प्राविधिक शिक्षा तथा व्यावसायिक तालिम परिषदले प्रिंडिलोमा तहको प्रमाणपत्र प्रदान गर्नेछ ।

BAG 075



AARATI RAJ SHAH



AASHIKA ADHIKARI



ANUSTHAN THAPA



ASWIN NIRAULA



BABITA PAUDYAL



BANDANA YADAV



BHUWAN PRASAD POUDEL



BIKASH KHANAL



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JAYANT KR. DAS



KAPIL REGMI



KUSHAL DAHAL



MADHAV BASHYAL



NABIN SHRESTHA



PRABHAT KIRAN RAI



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PRAVESH YADAV



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AASHISH SIGDEL



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तथा किंडीबहिनीहरूम सु-स्वास्थ एवं उच्चोरचर
प्रगतिको कामना लाहित हात्क मंगलमय
रामुकामना व्यक्त गर्न्छो।

प्रदेश सरकार

मुख्यमन्त्री तथा मन्त्रिपरिषदिरिषद्को कार्यालय

कोशी प्रदेश, विराटनगर





PURWANCHAL CAMPUS

Dharan, Sunsari



Under the umbrella of Institute of Engineering

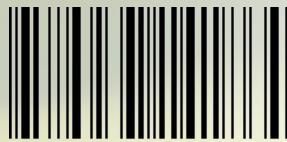
Courses Offered: Bachelor Level(4 years) in

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|-----------------------------|----------------------------|
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| 2. Civil Engineering | 6. Computer Engineering |
| 3. Mechanical Engineering | 7. Architecture(5 years) |
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