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6th SONEUK Conference

Engineering Challenges and Opportunities: Post COVID-19

Society of Nepalese Engineers in UK

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Editorial

As viruses respect no borders, the disease known as COVID-19, which originated from Wuhan, China in late 2019 has spread to almost all countries and territories across the globe, claiming millions of lives. During this unprecedented situation, both public and private sectors and individuals have exercised tremendous efforts in fighting against this invisible enemy, which have yielded tangible results. Scientists, medical experts and engineers have played a vital role in the local and global COVID-19 response and are expected to be more significant still in the post-pandemic recovery.

The unprecedented spread of COVID-19 has touched every facet of our lives, from our health and wellbeing, to financial status, to our working environments. It has brought many challenges, but also opportunities for positive change. The engineering response to the Coronavirus crisis so far has been second to none. We have seen engineers from around the world acting quickly and decisively in the face of a sudden increase in demand for PPE, ventilators, oxygen concentrators and other high-tech solutions, as well as serving an integral role in building new hospitals or expanding the capacities of existing hospitals where necessary. Furthermore, the engineering sector is sure to play a very important role in the post COVID-19 era to help us recover from the crisis, minimise the possibility of similar events happening again in the future and prepare us to respond more efficiently to threats, should they occur.

With this context, and following the success of conferences over the years, Society of Nepalese Engineers in UK (SONEUK) is organising its 6th conference virtually on 10th July 2021 on "Engineering Challenges and Opportunities: Post COVID-19". This conference proceedings comprises of eight peer-reviewed papers, most of which are focused on impact of the Coronavirus pandemic in engineering, construction, sustainable development and the workplace. Together, they provide valuable insights into the challenges faced and opportunities available in engineering, sustainability and technology sectors post COVID-19.

It has been a very challenging year for all of us. From us, the editorial team, a deep sense of appreciation and gratitude goes out to all the authors for their valuable contributions, the peer-reviewers and advisers for their relentless support and invaluable guidance throughout and the sponsors for their financial support. Above all, our sincere thanks always go to all SONEUK members for their unconditional support and love. We feel very proud to be the part of this journey and have enjoyed compiling the papers together and presenting the proceedings to you. We hope you will enjoy reading them.

Ambassador's Message

नेपाली राजदूतावास
EMBASSY OF NEPAL,
LONDON, U.K.

AMBASSADOR

10 June 2021

Message

I am glad to learn that Society of Nepalese Engineers, UK (SONE,UK) is going to publish a proceeding of the annual conference entitled 'Engineering Challenges and Opportunities: Post COVID-19'.

I believe that the international conference organized by SONE, UK, a society of the Nepalese engineers in the UK would be a momentum where notable Nepalese professionals and engineers from different corners of the world would discuss relevant topics of interest with a view to benefit Nepal. I would like to congratulate SONE, UK for the publication of the proceeding and hope this publication will be successful in disseminating pertinent information to all the Nepali engineers and other interested people and organizations.

I appreciate the activities of the Society which has connected the Nepalese engineers in the UK and even worldwide in sharing ideas and transfer of knowledge. I also appreciate the valuable support from SONE,UK recently in fighting against Covid-19 in Nepal. The Embassy is pleased to work with the Society of Nepalese Engineers UK to support the development endeavours of the Government of Nepal in order to achieve the national resolve of "Prosperous Nepal, Happy Nepali" utilizing the knowledge and expertise of Nepalese engineers.

Taking this opportunity, I would like to extend my best wishes for the success of the conference. I wish Society of Nepalese Engineers UK all success.

Lokdarshan Regmi
Ambassador

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Chairperson's Message

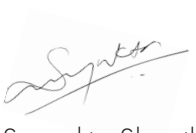
The future of Nepalese engineers in the United Kingdom relies on how organised we are and how receptive we are of new engineer friends arriving from Nepal. The possibility of our achievement transforming into something useful for Nepal, is what has driven us all the time. In the last fourteen years of our journey to bring Nepalese engineers together and garnering their expertise for the good of Nepal, we have identified a number of potential areas, discussed several of them to great depth, and frequently delivered many to Nepal as a documented output.

Engineering support for Nepal is not just our objective but also one of the necessities for Nepal, which defines the relevance of our overall existence. As I write this message, Nepal has been cited as the top target for cyber-attack in the world by a reputed international cyber threat map. On the other hand, natural calamities like the 2015 earthquake and the current global pandemic due to COVID-19 is something that the engineering community has a huge stake in converging to effective and sustainable solutions. Nepal deserves all the technical and financial support that we have continued to offer so far.

There are also many unanswered questions that I have chased for quite a while. How can we appropriately reinforce traditional building practices with the advanced building technologies and materials from the West? What is stopping us from introducing Nepal's indigenous knowledge, that has been historically modelled for earthquake resilience, to the contemporary building principles in the West? Today, artificially intelligent algorithms are designing new computer chips within hours, which would have taken months for a human brain. Can the introduction of machine learning models invite similar revolutionary results in infrastructure development? There is always some ground for imagineering.

It is often said that there is no appreciation for documentation in Nepal, but this has not always been the case. Nepal's tallest temple, the Nyatapola of Bhaktapur, which survived two of the biggest earthquakes in 1833 and 2015, was built in merely 7 months and there is a day-by-day record of its construction process even from the early 18th century. There is a lot that even Nepal can teach the world. If only we make an effort to preserve our own engineering heritage among many others in rapid decline.

SONEUK Vice-President Mr Narad Bhandari has left no stones unturned in giving us the 2021 annual SONEUK conference, and I have personally seen him go through sleepless nights to deliver what is finally being offered in the form of this proceeding. The entire team of SONEUK Conference Sub-committee truly deserves all our accolade.



Sanyukta Shrestha
Chairperson,
Society of Nepalese Engineers in UK

Lessons from the COVID-19 Pandemic and the future of workplace

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Abstract

The recent COVID-19 pandemic has shown just how quickly the way we live and the way we work can change. High-rise office buildings and state of the art headquarters emptied of employees overnight. Leaving many of the office's comforts behind, not just the ability to separate work from home but many of the security measures business had in places were no longer available. Security layers such as CCTV, secure internet connections, on-site security, and security doors just to name a few, all left behind to be replaced by a laptop and a kitchen table. With such a quick and large-scale move to remote working, it is easy to forget and miss weak points in our "new office" security and it is important to analyse and learn from them. At the end of 2020, we conducted a survey to find the answers to three questions related to remote working during the pandemic, the cybersecurity methods to mitigate any vulnerabilities, and areas that had been left exposed. This will be further discussed, analysed and new measures on cybersecurity will be presented in this paper.

Keywords: COVID-19 pandemic, Cybersecurity, Remote working, Virtual machines

1. Impact of COVID-19 Pandemic on Work

It is very important to study how often people work from home before and during the pandemic to understand whether the pandemic has changed how we work. The survey was conducted online in which 110 responses were received from small and medium business (SME) to big corporations within the United Kingdom. There was 90% response from full-time employed and 10% were self-employed. The profession we covered is very diverse including IT professionals, business analysts, finance managers, engineers etc. From the survey conducted during this research, it has been found that 64.5% of people worked from home at least one day a week before the pandemic as shown in Figure 1. This is supported by the International workplace group that found that internationally around 70% of professionals worked remotely at least one day a week in 2018 (IWG PLC, 2018). In the UK however, the total percentage of people who have worked at home drops down to 26% of the population (Office for National Statistics, 2019). This overall number is supported by a prediction made by a Labour Force Survey that was realised in 2014 which predicted that the proportion of workers who occasionally work from home will be around 25% in 2018 (CIPD, 2020). It is important to note, however, that when looking at the rates of home-working by industry jobs in the information and communication, professional work in science and technology, and education are closer to the original statistic of 64.5% with these areas of employment remote working 51%, 44% and 39%, respectively. From all this data we can see that remote working is a constantly growing form of working especially in industries that require higher qualifications and experience (Office for National Statistics, 2019).

Considering the previous statistics in mind, we can see that remote working was a growing trend within the work environment but only at a very slow pace before the COVID-19 pandemic. When the statistic during the pandemic is compared against the last year, we can see that there has been an exponential growth in remote working. Using the results from this survey, we can observe in Figure 2 that remote work is up 32.7% from before the pandemic, when we compare Office for National Statistics reports, remote working increased from 26% in 2019 (Office for National Statistics, 2019) to 46.6% in 2020 (Office for National Statistics, 2020). In professional occupations mentioned above, the rate of remote working has also increased from 40.3% to 69.6%.

In addition to more jobs being done in a remote working capacity, the number of days in which people are working remotely has increased. In Figure 3, we can see that the number of days spent remote working is somewhat split evenly with around 16% of people working less than one day a week to five days a week with the exception being lesser for the four days a week spent remote working.

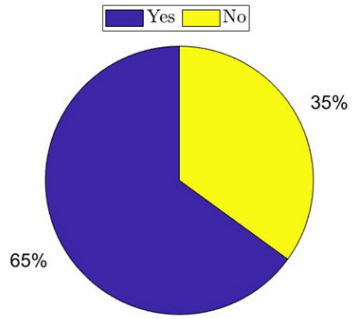

Figure 1. Did you regularly work from home before the pandemic?

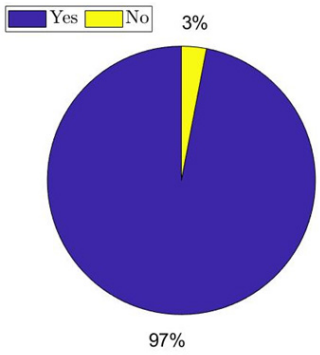

Figure 2. Did you regularly work from home during the pandemic?

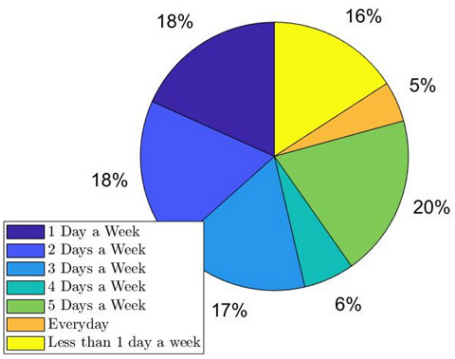

Figure 3. Working from home in days % before the pandemic

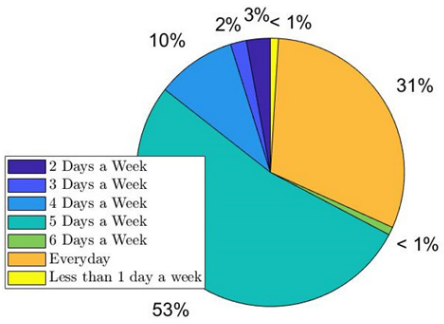

Figure 4. Working from home during the pandemic.

Comparatively, when asked how often participants spent remote working now the result was far more homogeneous with 53.3% saying they worked five days a week and 30.5% working three days a week, compared to 19.5% and 17.1% consecutively as shown in Figure 4. This clearly shows that the pandemic has significantly increased the adoption of remote working, especially in professional roles. Business across the spectrum have had an increase in their use of remote working and in a very short period, possibly leading to gaps in the implementation of a cybersecurity framework.

Since the pandemic continues to force us to stay at home and remote working will remain in practice, the question is how common it will be when life returns to some level of normality. During the survey, respondents were also asked what their company's plans were after COVID-19 and the end of lockdowns. In Figure 5, results show that 57.9% of respondents replied they would be returning to a mixture of remote and office working, 8% planned to move to full-time remote working and 10% replied they were already remote working full-time. When comparing to other sources, it was found that 5.1% of people responding to an ONS survey said they would continue to mostly work from home (Office for National Statistics, 2019). Furthermore looking at the professional breakdown of this same survey, we see in the Information and Communication Technology sector that 14.8% say they plan to mostly work from home and 53.1% plan on remote and office working on an even mix. This was followed closely by the Professional, Scientific and Technical sector at 46.3% saying they would have

a mixture of remote and office work and 12.8% saying they would move to a mostly remote working capacity. This comparison closely supports the survey data presented here. This statistic is also supported by the ONS report released on the 8th October 2020 which stated that 67% of business did not intend to move to a permanent remote working model. However, 19% replied that they would increase home working as a permanent business model and in our survey 8.5% responded they would be moving to remote working on a full-time basis. This shows that, on average, most people will be returning to a mixture of remote working and office working. However, the amount of time spent remote working is predicted to increase as well as many businesses permanently moving to a remote working business model.

What we can learn from this survey is that the pandemic forced many companies to ramp up their use of remote working as a business model, some by choice and others by government guidance. Many businesses have found it beneficial to operate on a more remote model and plan to continue to do so either as a mixture of office and remote working or on a more permanent basis.

2. Cyber Security Risks and Mitigations during the Pandemic

As the move to remote working has rapidly increased due to the pandemic, it is important to look at how businesses have responded and communicated with their employees about the changes and the importance of cybersecurity. During the survey, it was important to gain a better understanding of how businesses have reacted and whether employees are confident in the reaction of their place of work. To gain this understanding, three questions needed to be asked. The first question is how confident people are with their company's cybersecurity policy. From the results shown in Figure 6, we can see that 81.5% of respondents said that they rated their employer's cybersecurity response between confident (80%) and very confident (100%). This figure was also supported by the UK government's survey for Cyber Security Breaches 2020 (Department for Digital, Culture, Media and Sport, 2020) which showed that eight out of ten businesses surveyed said that cybersecurity was their top priority. This was up 4% from the survey done the previous year (Department for Digital, Culture, Media and Sport, 2019) which was also up another 4% from the year before that (Department for Digital, Culture, Media and Sport, 2018). This shows a growing trend in UK businesses around the importance and confidence of cybersecurity even during the pandemic.

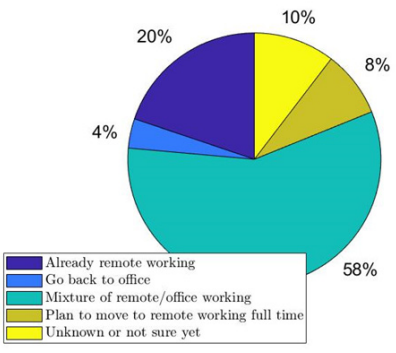

Figure 5. Companies plans regarding remote working post-pandemic.

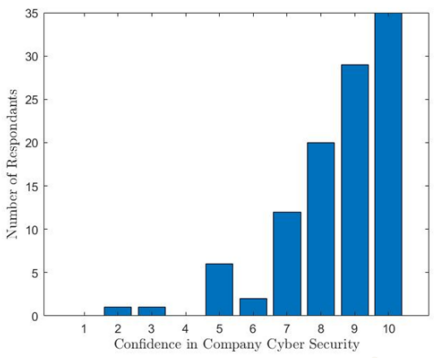

Figure 6. How Confident are you with your companies Cyber Security?

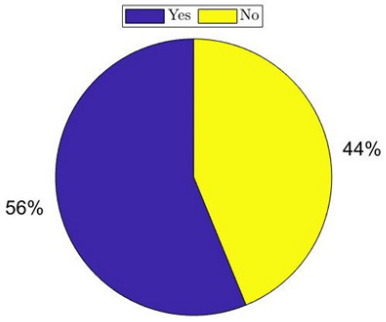

Figure 7. Respondents who have discussed remote working and cybersecurity with your employer during the pandemic.

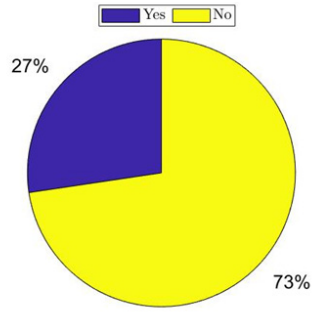

Figure 8. Respondents who have considered increasing cybersecurity in their home

The second question aimed to find out whether employers had actively kept their employees in the loop about changes to security and remote working. The survey results in Figure 7 shows that the majority, i.e., 57% participants, engaged in a conversation within their company. Among many different cybersecurity measures that the respondents said were discussed, was the use of Virtual Private Networks (VPNs), updated training programs and changes to the cyber policy. The reason they had not had a discussion varies from their employers already having a strong security policy that did not require any changes due to the pandemic to being a part of a smaller company that did not have the training and access to information on improvements they could or should make.

The final question was asked to respondents whether they had considered increasing their home/personal cybersecurity as a way of protecting themselves and their employer. The results in Figure 8 demonstrate that 72.9% of respondents had not considered improving IT security with a large majority of those respondents saying that they trusted their companies would have implemented the appropriate security measures. This result shows two possible outcomes - the first being that most businesses have reached a level of security that means employees do not need to consider improving their cybersecurity. The second outcome is that companies are not doing enough to actively engage with their employees about cybersecurity which would most likely be part of the 43% of respondents who had not had a discussion with their employer about cybersecurity and remote working.

These three questions show that many employees trust in their employers to secure the business and from the UK government statistics that cybersecurity businesses are becoming more proactive in increasing cybersecurity policy. However, more needs to be done to engage employees in cybersecurity, as the weakest link in cybersecurity is the human factor.

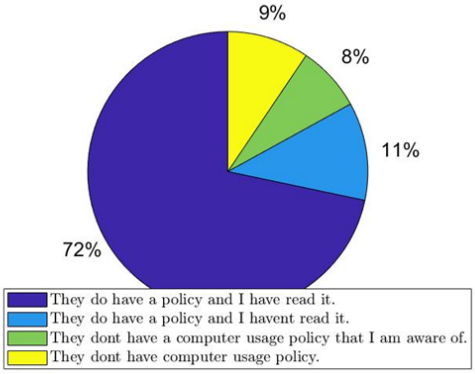

Figure 9. Do respondents know if their employer has a computer usage policy and have, read it?

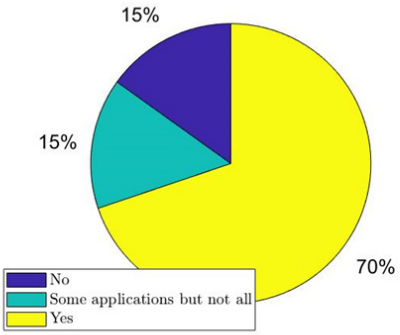

Figure 10. Respondents that use 2FA/MFA at work for some, all, or none of their work applications

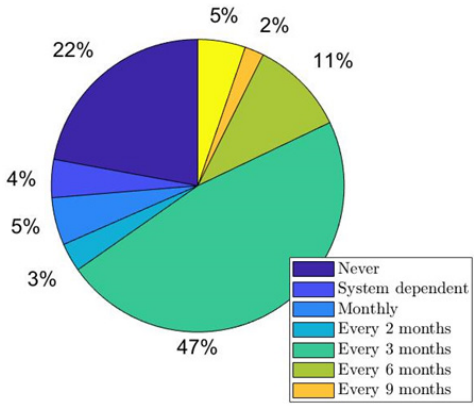

Figure 11. Does your company prompt password changes if so, how often?

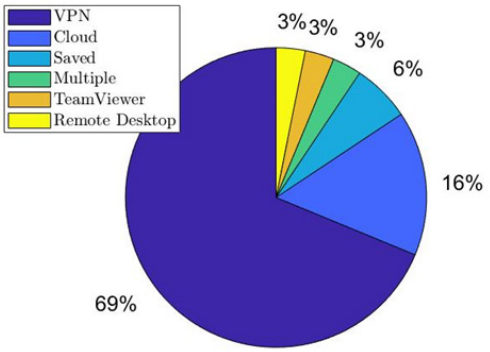

Figure 12. How do you access your work resources?

2.1 The Good, the Bad and the Ugly

The UK government reported around 46% of business and 26% of charities reported having a cybersecurity breach (Department for Digital, Culture, Media and Sport, 2020). This is up from 32% for business and up from 22% for charities the previous year (Department for Digital, Culture, Media and Sport, 2019). This shows a large increase in attacks. In addition to this, the amount companies are losing has also increased from £3,230 to £5,220 (Department for Digital, Culture, Media and Sport, 2020). During the survey, we investigated how different businesses have reacted to the pandemic and what sort of cybersecurity features have been implemented to protect themselves.

As a part of the survey, respondents were asked whether they knew if their company had a computer usage policy. We found in Figure 9 that 72% of respondents said their company did have a computer usage policy, however, 11.2% of those also said they had not read the policy. Furthermore, 7.5% said they were not aware whether the company had a computer usage policy followed by 9.3% saying they did not have a policy, this does encompass self-employed start-ups. Overall, this shows that most of the workforces are engaged in the cybersecurity of their workplace but more needs to be done as the human factor is the biggest

security weakness.

Two-factor or multifactor authentication has quickly become an industry standard for many companies as it provides an extra layer of security other than username and password to logins. When asking about 2FA/MFA in the workplace (Figure 10) 69.2% of respondents said they used this security layer in their company with another 15% saying that they used it on some applications but not all. What was also interesting was that some respondents did express concern about the rise of 2FA/MFA, stating that email and short messaging service (SMS) as a way of sending authentication codes were not as secure as using two-factor authentication.

The recommended policy for passwords has started to change. In the past, many organisations recommended that people changed their password every 90-180 days. However, now the new recommendation is that a strong password changed every year, using two-factor authentication that is not SMS based is the best option (Piazza, 2020). This recommendation comes from the Federal Communications Commission (FCC, 2016), it is supported by the Better Business Bureau (Better Business Bureau, 2020) and featured in the National Institute of Standards and Technology (NIST) yearly Digital Identity Guidelines in Appendix A – Strength of Memorized Secrets (NIST, 2020). From our survey results shown in Figure 11, we can see that most respondents are following the previous policy of password changes every 90-180 days with 43% of respondents saying that they are prompted every three months to change their password. This is followed up with 10% saying they change it every six months. It is important that companies are provided with clear instructions on the best security practices if they are to stay a step ahead of malicious actors.

As companies have closed their offices due to COVID-19 it was important to understand how people were accessing their work files. In Figure 12, 69% of respondents said they used a VPN to access company documents followed by 16% who replied that work documents were stored on the cloud applications. Only 6% said that work files were locally stored on any devices, which is a security risk if those devices are stolen leading to the possible loss or leak of personally identifiable information. VPNs are an important resource post-pandemic as it allows people to send encrypted data as well as businesses whitelisting IPs that connect to their network increasing the security while remote working.

According to the recent cybersecurity breaches, 2020 report 53% of companies have a bring your own device (BYOD) policy (Department for Digital, Culture, Media and Sport, 2020). During the survey we asked our respondents whether they used a work assigned computer or a personal computer. 83.2% said they use a work computer and 16.8% said they use a personal computer. Of the respondents who said they used work computers 60.2% of respondents said they could use their computers for personal reasons such as social media, shopping, and family use. Bring your own device policy seem more popular with micro-firms at 55% having a BYOD policy. This drops down to 44% for medium-sized companies and a further drop to 38% for larger companies. BYOD can provide many cybersecurity vulnerabilities especially if personal devices are not kept to the same security standards as other company

assets on the network. Personal devices may also be used by multiple users outside of the company meaning that unauthorised people may gain access to company data knowingly or unknowingly.

Looking at the data we can see that companies are doing what they can to provide the best protection, but many areas still need to be worked on. Companies need to plug these small holes in security such as BYOD and create a greater understanding of computer policy. Companies must endeavour to follow a more layered approach to security and ensuring that all parts of the company do what they can to maintain cybersecurity.

3. The Future of Cybersecurity in the Workplace

COVID-19 has forced us all to adapt to the way that we work. For many people, remote working has just increased in frequency and for others, it is a completely new way of working. Remote working provides more challenges, especially around cybersecurity. As the office moves so do the targets of malicious actors change. We must endeavour to keep up with the constant changes to the world of work and cybersecurity and find a fine balance between being secure and being able to efficiently operate remotely.

3.1 A New Way of Working

As remote working has become more widely used and with one-third of businesses saying they play to remote work more often if not entirely, it is time to create a new type of office. Imagine an office space that does not have walls, or wires, or windows. An office space that exists entirely online in the cloud. Using virtual machines, it would be possible to virtually build an office. Companies mainly micro and small enterprises that work entirely in the remote environment would be able to afford a virtual office. They would be able to have a customized desktop template for all new employees. When a new staff joins the company, a new computer is added to the virtual office network with everything pre-installed. The templates would be well secured, and it would reduce the risk to companies if an employee lost or had an asset stolen as the users VM could be locked or their computer blacklisted from access to the virtual machine. This would allow people to use personal laptops without them affecting the company. Protocols stopping the device from uploading anything to the virtual machine can be set up and how people connect to the virtual machine can be set up with end-to-end encryption.

These virtual offices would work the same as if they were in an office space. Each device would be able to connect to each other. If one device is infected, then it can be quickly restored to the original image or a backup. Virtual offices would get rid of the need to have office space as well as reducing the risk of keeping company assets in people's homes. Access to the virtual machines would be password protected with multi-factor authentication with administrators being able to monitor the locations people login from and IP block anyone who manages

to gain unauthorised access or just allow only certain IPs access to the virtual machines in the first place. Virtual offices would mostly benefit start-ups, micro, small companies who do not need a physical office space or do not have the funding to have one. Virtual offices would also benefit companies in third world countries as it would give them access to a fully secure and functioning office environment and only need a computer that can connect to the internet.

The security of the servers these machines would be run on would be controlled tightly by whoever operates the server farm. This would provide greater cybersecurity to companies that would use this service as it would reduce risk from hardware devices either being stolen or lost, the virtual machines would also allow for easier backing up of data and if a machine were compromised then the machine could be rolled back to a more secure version of itself if not completely reset. Companies would have greater control of the machines than they would of any device. It also means that people can use the device they access the virtual machine on without risk to the virtual machine as this will be accessible online. This is where we see office working moving to in the future, the only issue being the resources need to set up the servers that would run such an operation.

The pandemic has caused us all to improvise, adapt and overcome. The quick change to full-time remote working and the constant changes to cybersecurity policies have proven a struggle to some and show triumphs, among others. Although in time things will return to some level of normality with two-thirds of companies planning to return to the office, how we perceive remote working has changed forever. One thing is for certain whether offices are physical or virtual, the battle for cybersecurity will continue. Therefore, the government, enterprises, service providers, financial sectors, regulators, social scientists, among others, should be proactive to restructure and update the existing cybersecurity practice, frameworks and legislation for the post-pandemic proliferation of cyber technologies.

4. Conclusions

The trend of working remotely is almost similar in developed and developing countries. Even after the COVID-19 pandemic, many businesses would prefer some of their workers to operate remotely from home. There will be a paradigm shift in the work pattern post-pandemic that has never happened before. However, this could minimise the operating and travel cost for businesses, there is another challenge we will have to face in near future, i.e., cybersecurity. It is found that businesses are not investing sufficiently in protecting online user data and infrastructure, the number of cybercriminals is constantly increasing. Businesses in both developing and developed world need to implement the cybersecurity framework as recommended by international cybersecurity experts, government regulators and standard organizations.

5. References

Better Business Bureau. (2020). BBB Tip: How to create a strong password. Retrieved January 11, 2021, from https://www.bbb.org/article/tips/12795-bbb-tip-how-to-create-a-strong-password

CIPD. (2020). Working from home: Whats driving the rise in remote working. London: CIPD.

Department for Digital, Culture, Media and Sport. (2018, April 25). Cyber Security Breaches 2018. Retrieved from UK Government : https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/701840/CSBS_2018_Infographics_-_General_Findings.pdf

Department for Digital, Culture, Media and Sport. (2019). Cyber security breaches Survey 2019. Retrieved January 06, 2021, from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/875799/Cyber_Security_Breaches_Survey_2019_-_Main_Report_-_revised.pdf

Department for Digital, Culture, Media and Sport. (2020). Cyber security Breaches Survey 2020. Retrieved January 06, 2021, from https://www.gov.uk/government/publications/cyber-security-breaches-survey-2020/cyber-security-breaches-survey-2020

FCC. (2016). Time to rethink mandatory password changes. Retrieved January 11, 2020, from https://www.ftc.gov/news-events/blogs/techftc/2016/03/time-rethink-mandatory-password-changes

IWG PLC. (2018). The Workspace Revolution: Reaching the tipping point. ZUG: IWG PLC.

NIST. (2020). NIST Special Publication 800-63B Digital Identity Guidelines. Retrieved January 11, 2021, from https://pages.nist.gov/800-63-3/sp800-63b.html

Office for National Statistics. (2020, July 8). Coronavirus and homeworking in the UK: April 2020. Retrieved from Office for National Statistics : https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/coronavirusandhomeworkingintheuk/april2020

Office for National Statistics. (2019, March 24). Coronavirus and homeworking in the UK labour market: 2019. Retrieved from Office for National Statistics: Coronavirus and homeworking in the UK labour market: 2019

Piazza, D. (2020). NIST Password Guidelines 2020. Retrieved January 11, 2021, from https://stealthbits.com/blog/nist-password-guidelines/

UK Government. (2019). Cyber security breaches Survey 2019. Retrieved January 06, 2021, from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/875799/Cyber_Security_Breaches_Survey_2019_-_Main_Report_-_revised.pdf

UK Government. (2020). Cyber security Breaches Survey 2020. Retrieved January 06, 2021, from https://www.gov.uk/government/publications/cyber-security-breaches-survey-2020/cyber-security-breaches-survey-2020

Potential of natural fibres and their composites for South Asian countries: Moving towards sustainability

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Abstract

Increased environmental concerns and depletion of petroleum-based resources arising from the use of non-renewable resources have increased the demand of natural fibre reinforced composites (NFRCs). Composite materials reinforced with glass and carbon fibres have limited end-of-life (EoL) options, which is a major concern. To minimise this situation, lignocellulose plant fibres have been studied extensively in recent years, due to the increasing demand for sustainable, lightweight and environmentally friendly materials. Natural plant fibres are considered as a viable substitute to E-glass fibres owing to their many attractive benefits, such as biodegradable, recyclability, high specific strength and stiffness suitable as reinforcements for many semi-structural and structural composite applications. This new class of lightweight sustainable composites can offer environmental, social and economic benefits as substitute materials for various applications. Through an up-to-date review, this work presents an overview of natural plant fibres as reinforcements of composites for various applications, especially in the context of the South Asian countries.

Keywords: Natural fibre reinforced composites (NFRCs); Fibre morphology; Mechanical properties; Sustainability; Environmental impact; Applications, South Asian countries.

1. Introduction

Composite material can be broadly defined as the resultant of combining two or more materials on a microscopic scale, each of which has their own unique properties, to produce a new material that has properties far superior than either of the base materials. Main constituents of composite materials include matrix and reinforcement (fibres). The matrix acts as a binder. Both constituents enhance the properties of the resultant material (Hull and Clyne, 1996; Dhakal and Ismail, 2020).

Environmental legislation as well as consumers' pressure for adaptation of a "cradle-to-cradle" life cycle thinking for material use throughout the world has triggered a paradigm shift towards using sustainable composite materials, as a substitute to non-renewable man-made fibres such as glass and carbon (Bledzki and Gassan, 1999), among others. Over the last couple of decades, research in the potential use of renewable natural fibres as reinforcements in structural composites has increased significantly, due to their relative cheapness and with their high specific properties when compared with synthetic glass fibres (Dhakal and Ismail, 2020).

2. Natural plant fibres, their origins and potentials for South Asian countries

Dating back to the origin of mankind, natural fibres have been used to make cloths, building materials, such as bricks, ropes and to mention but a few products. Natural fibres have been used as reinforcement materials for over 3000 years (Bledzki and Gassan, 1999). The oldest example of composite material is addition of straw to clay for making bricks for buildings in ancient Egypt. From this application, straws or grass are the reinforcing fibres and clay is the matrix.

The natural fibre-based composites market is expected to grow to $531.3 million US in the year 2019 from $289.3 million in 2010 with 28% market shares by natural fibres. Similarly, this can be compared with the amount of money generated yearly in some South Asian countries, as briefly presented in Table 1.

Table 1: Illustrates key natural fibres, their producing countries, annual production and prices (Syduzzaman et al. 2020)

Fibre types	Main producing countries	Production quantity per year ($x10^3$ ton)	Price (US$/ton)
Hemp	China (80%), Chile, France, Germany, UK	214	1000–2100 (1550)
Jute	India (60%), Bangladesh, Myanmar, Nepal	3450	400–1500 (950)
Flax	Canada, France, Belgium, Netherland, Poland, Russian Federation, China	830	2100–4200 (3150)
Bamboo	Myanmar, Nigeria, Sri Lanka, Philippines, Pakistan	30,000	500
Banana	India (22%), China, Philippines, Ecuador and Brazil	134,000	890
Kenaf	India (45%), China, Malaysia, USA, Mexico, Thailand, Vietnam	970	300–500 (400)
Cotton	China, Brazil, India, Pakistan, USA, Uzbekistan, Turkey	25,000	1500–4200 (2850)
Sisal	Brazil (40%), Kenya, Tanzania, China, Cuba, Haiti, Madagascar, Mexico, Sri Lanka, India	378	600–700 (650)

3. Some key natural fibres available in the South Asian countries

Some key natural fibres that can be found in south Asian countries are presented in Figure 1.

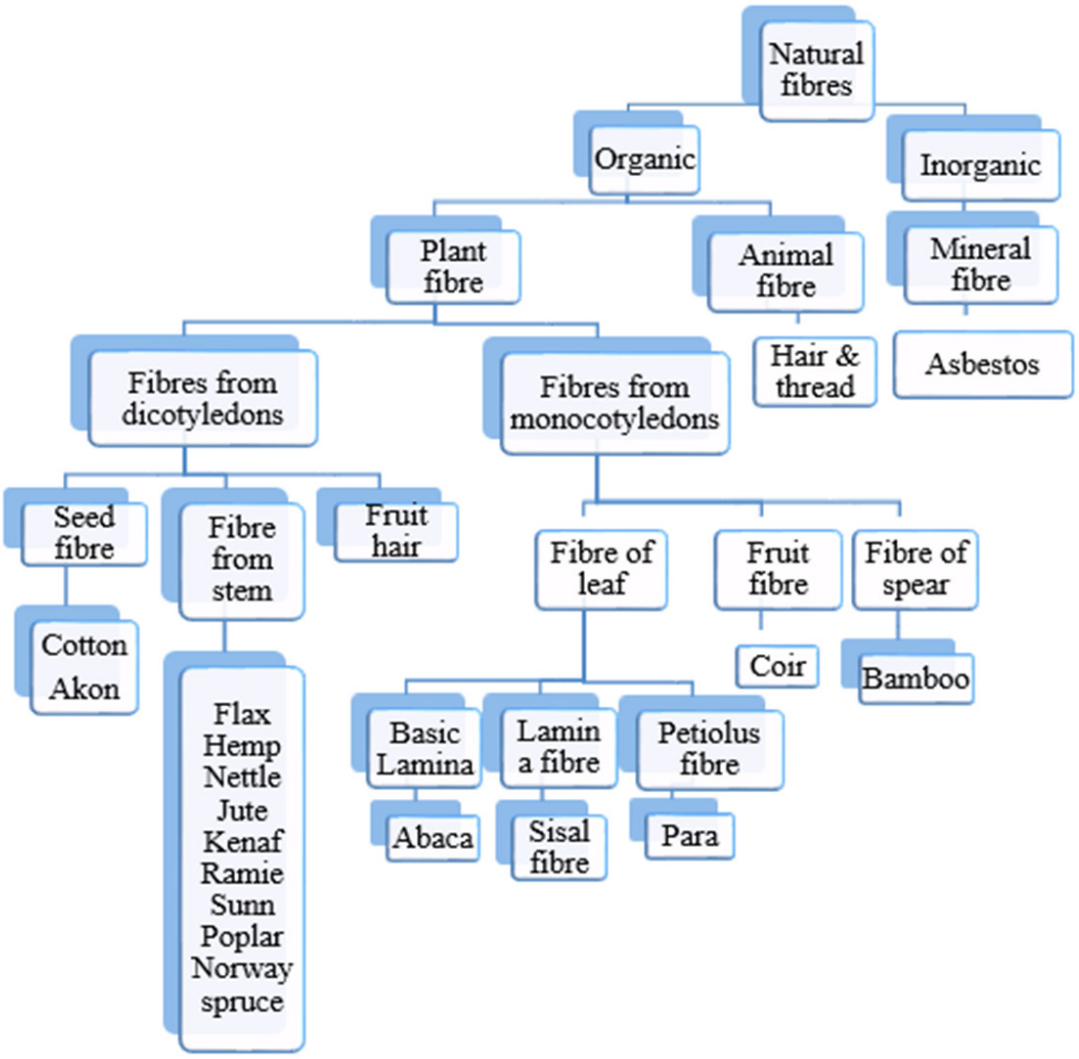

Figure 1. Some natural fibres available in south Asian countries (Müssig, 2010).

4. Natural plant fibres: Advantages and challenges

Despite many attractive attributes of natural fibres, they are not without some challenges, hinder their full structural applications. The main advantages and some drawbacks are summarily illustrated in Table 2.

Table 2. Advantages and some drawbacks of natural fibres as composite reinforcements (Faruk et al. 2012, Dhakal et al.; 2007, Dhakal and Ismail, 2020, Bourmaud et al. 2018).

Advantages	Some drawbacks
▪ High specific strength and stiffness ▪ Low hazardous manufacturing processes ▪ Low processing energy ▪ Renewable sources ▪ Lower cost of manufacturing (reduced tool wear) ▪ Low emission of toxic fumes when ▪ Non abrasive ▪ Lower risk to human health (no skin irritation)	▪ High moisture absorption (due to their polar characteristics) ▪ Lower durability compared to their synthetic fibres composites ▪ Low long-term durability ▪ Lower performance, in particular impact strength compared to synthetic fibres composites ▪ High variability in fibre property (due to their polar characteristics) ▪ Lack of standard, difficult for modelling ▪ Low thermal stability ▪ Lower flame retardance property (additional fire protection required)

5. Important properties of natural fibres

Basically, Table 3(a) shows a comparison of both mechanical and physical properties of some selected metallic, synthetic and natural fibres (bundles). It is evident that natural fibres (hemp and flax) have competitive properties with a few metallic and synthetic fibres, with greater specific strength and specific modulus than both steel and aluminium. This establishes the reason why they are competing with various application of these metals in manufacturing industries. In addition, Table 3(b) presents mechanical and physical properties of natural fibres, as compared among themselves.

Table 3(a): Differences in mechanical and physical properties of some selected metallic, synthetic and natural fibres (bundles) (Faruk et al., 2012; Gurunathan et al., 2015; Dhakal and Ismail, 2020).

Fibre types	Density (g/cm^3)	Tensile strength (MPa)	Young's modulus (GPa)	Specific strength (MPa)	Specific modulus (GPa) $\left(\frac{E}{\rho}\right)$
Steel	7.8	1300	200	167	26
Aluminium	2.81	350	73	124	26
Carbon	1.51	2500	151	1656	100
E-glass	2.10	1100	75	524	28
Aramid	1.32	1400	45	1656	100
Hemp	1.4	690	30-70	453	21-50
Flax	1.5	345-1830	27-80	230-1220	18-53

Table 3(b): Selected mechanical and physical properties of some natural plant fibres (Cheung et al., 2009; Pickering et al., 2016).

Fibre	Tensile strength (MPa)	Young's modulus (GPa)	Elongation (%)	Density (g/cm^3)	Diameter (micro meter)	Length (mm)
Date palm fibre	58-230	0.3-7.5	5-50	0.9-1.2	100-1000	20-250
Flax	345-1035	27.6	2.7-3.2	1.5	10-25	10-65
Hemp	690	70	1.6	1.4	25-35	5-55
Jute	393-773	26.5	1.5-1.8	1.3	25-200	0.8-6
Bamboo	140-230	11-17	-	0.6-1.1	14	2.7
Kenaf	930	53	1.6	-	1.14-11	12-36
Cotton	287-800	5.5-12.6	7-8	1.25	10-34	2.7
Sisal	511-635	9.4-22	2-2.5	1.15	7-47	0.8-8
Oil palm (empty fruit)	130-248	3.58	9.7-14	0.7-1.55	191-250	0.8-0.9

6. Natural fibre reinforced composites

Natural fibre reinforced composites (NFRCs) are composite materials produced using natural fibres as reinforcements as opposed to the carbon and glass fibre composites, which use non-renewable synthetic fibres such as glass and carbon fibres as reinforcements. There is a growing trend on use of carbon and glass fibre composites in many industrial sectors including aerospace, marine, automotive and construction. However, after the end of their product life, large quantities of these composites are sent to land field as waste materials. NFRCs are important for environmental sustainability as they are obtained from the renewable sources. These materials can also produce some favourable properties at a lower cost in comparison with synthetic fibre composites. Sustainable use of natural resources are key factors to achieve the sustainable development (SD) goal as described by the 1987 Bruntland Commission Report "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Due to the importance of protecting our environment, concepts and approaches such as sustainability, moving linear economy to circular economy, life cycle thinking, extended producer responsibility (EPR), corporate social responsibility (CSR) and 3R (reduce, reuse and recycle) principles (Dhakal and Ismail, 2020) have become visible in recent years.

Besides, recycling of natural fibres (such as flax, hemp and jute) are far more environmentally beneficial in comparison with other synthetic (glass and carbon) fibres (Figure 2). Ten environmental impact categories were considered by (Pil et al., 2016) to compare between flax and glass fibres (Figure 2). Apart from the land use, flax outperformed glass fibres in all other categories including abiotic depletion, acidification, eutrophication, global warming potential, ozone depletion, among others. When considering the energy required to produce 1 kg of fibres, the reported work by (Pil et al., 2016) further reiterated that scotched flax requires only about 10 MJ/kg whereas for glass fibres, it requires about 50 MJ/kg and for

carbon fibres, it requires about 290 MJ/kg. The reported work clearly suggests that when overall environmental performances of natural fibre composites are considered, there are clear advantages against conventional glass fibres.

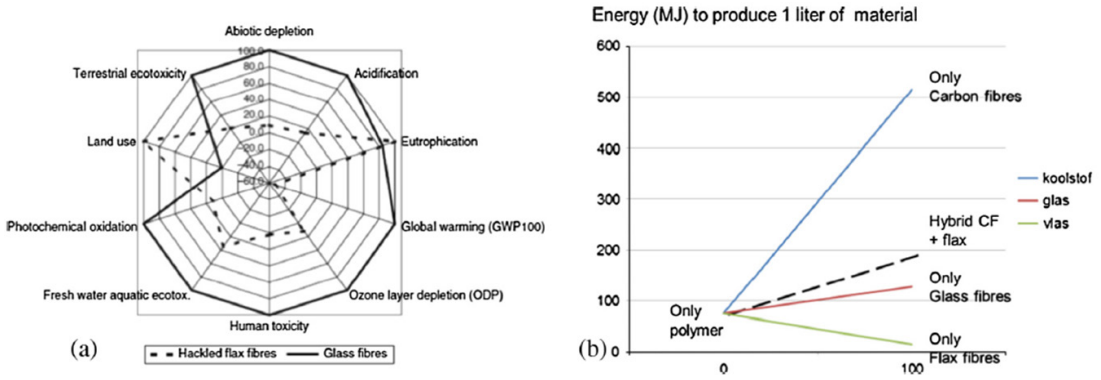

Figure 2: Environmental impact performance, depicting: (a) life cycle analysis/assessment of flax fibres against glass fibres and (b) energy content of flax against glass and carbon fibre reinforced composites (Pil et al., 2016).

Reported work by Sáez-Pérez et al. (2021) also highlights that hemp fibre has an ideal carbon sink, which reduces the CO2 emitted into the atmosphere, due to the absorption effect. For instance, hemp has an outstanding reabsorption capacity equivalent to 1800 kg of CO2 for each tonne cultivated.

7. Potential applications of NFRCs

Natural fibres have long history and their use in Asian countries. For example, jute fibres have been used in India, Bangladesh and Nepal for many years. Asia has one of the fastest growing market in the world. Jute fibres are not only available abundantly in these countries, other natural fibres such as banana, coir, sisal, bagasse, reeds, cotton and silk are also available. This puts the region as a strong powerhouse in terms of exploitation of these natural fibres for industrial applications. Therefore, many multinational companies are outsourcing and offshoring their business in this region. NFRCs are extensively used in automotive sector in Europe and North America (Figure 3).

However, many OEMs have moved their production facilities to Asian countries, specifically to India and China. Major applications of NFRCs include, but are not limited to, building and construction, aerospace and automobile, power and energy, oil and gas, telecommunication and electrical/electronics, games and sports/recreation, biomedical and health, security and military industries (Table 4). Some of the aforementioned sectors are briefly and subsequently elucidated.

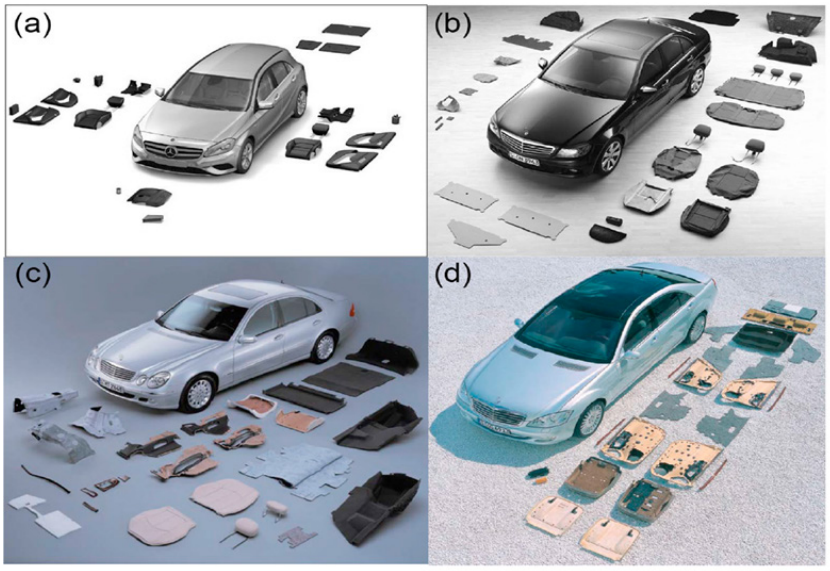

Figure 3: Applications of different natural fibres (flax, hemp, sisal, wool and others) in Mercedes-Benz model (a) A-class, (b) C-class, (c) E-class, and (d) S-class (Li et al., 2020).

Table 4: Industrial applications of key natural fibres (Syduzzaman et al. 2020).

Fibre types	Various industrial applications
Hemp	Textiles, geotextiles, paper and packaging, electrical, furniture, cordage, construction concrete items, 3D printing filaments, manufacturing pipes, auto parts and oil absorbent materials.
Jute	Building panels, door frames, chipboards, geotextiles, door shutters, packaging, transport and roofing sheets.
Flax	Tennis racket, bicycle frames, snowboarding, panels, doors, laptop cases, printed circuit boards and furniture.
Bamboo	Building and construction items, baskets.
Banana	Furniture, building and construction items.
Kenaf	Mobile cases, insulation materials, animal bedding and packaging materials
Cotton	Textiles, cordage, furniture upholstery and goods.
Sisal	Panels, doors, paper and pulp.

Many materials used in building and construction sector currently are not so environmentally friendly. For example, cement has been used for many years as structural material, but cement is one of the high energy consumption materials when considered its lifecycle performance. During the production process, it consumes high amount of energy. One of the solutions put forward to improve this sector is the use of sustainable materials to replace high energy consuming materials. There are several reported works that suggested the benefits of using natural fibre compounds, such as hemp and other natural fibres in building materials. There are many examples where biocomposites are successfully used in building and construction materials. The lower production costs with an improved environmental performance makes these materials sustainable and cost effective, as reported (Sáez-Pérez et al., 2021). They studied on influence of the state of preservation on different formulations of geopolymer

hempcrete and hydraulic lime hempcrete (Figure 5). Industrial hemp fibres have been extensively sought to be used in building and construction industry.

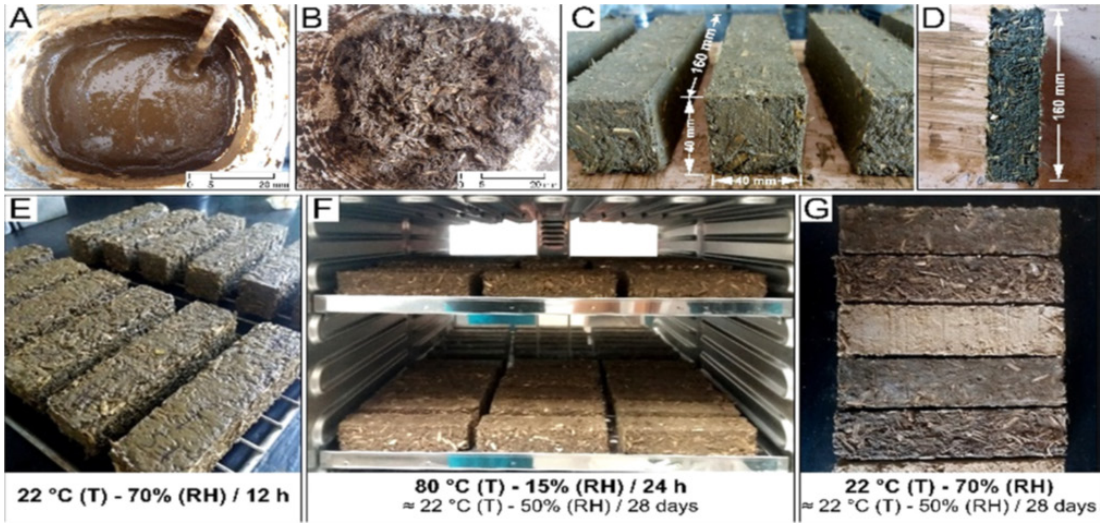

Figure 5: Process used for the preparation of geopolymer hempcrete samples and hydraulic lime hempcrete (Sáez-Pérez et al., 2021).

Moreover, NFRCs have been widely used in automobile companies to manufacture several components. Comprehensive applications of NFCs in automobile (such as Toyota, Fiat, Audi, Peugeot, Volvo, Ford, Mitsubishi, and others) and other sectors have been extensively reported (Mohammed et al., 2015; Dhakal and Ismail, 2020).

8. Conclusions and future perspective

Natural fibres offer several sustainable, low-cost, recycling, abundant resource, and environmental benefits as reinforcements in NFRCs, when compared with their synthetic counterparts such as glass and carbon fibres. Natural plant fibres are eco-friendly and sustainable and the global demand for these plant fibres is predicted to grow faster. Similarly, key research and development work in this field is expected to grow significantly in the coming years. NFRCs provide several advantages, including but not limited to, biodegradability, non-abrasive processing, high specific strength and stiffness. The findings of this review present that for the sustainable materials, these lightweight composites provide a strong alternative. Although, NFRCs provide multiple benefits, some inherent drawbacks (inherent hydrophilic polar and their limited long-term stability) of these fibres place some challenges that can limit their full potential for semi-structural and structural lightweight applications. However, the benefits of NFRCs outweigh their associated challenges. Therefore, it is evident that South Asian countries have inexhaustible natural resources of plant fibres to increase their opportunities and become global leading suppliers of natural fibres and their composites to multi-national manufacturing companies, hence increasing/improving their economy substantially.

9. References

Bledzki A.K., Gassan, J. (1999). Composites reinforced with celluose based fibres, Progress in Polymer Science, 24 (2), 221-274.

Bourmaud A., Beaugrand J., Shah D., Placet V., Baley C. (2018). Towards the design of high-performance plant fibre composites, Progress in Materials Science, 97, 347-408.

Cheung H.Y, Ho M.P, Lau K.T, Cardona F, Hui D (2009). Natural fibre-reinforced Composites for bioengineering & environmental applications, Composites Part B: Engineering, 40, 655-663.

Dhakal H.N., Ismail S.O. (2020). Sustainable Composite for Lightweight Applications, (1st Ed., pp. 1-310). Cambridge, UK: Elsevier Woodhead Publisher.

Dhakal H.N., Zhang Z.Y., Richardson M.O.W. (2007). Effect of water absorption on the mechanical properties of hemp fibre reinforced unsaturated polyester composites, Composites Science and Technology, 67, 1674-1683.

Faruk O., Bledzki A.K., Fink H.P., Sain M. (2012). Biocomposites reinforced with natural fibres: 2000–2010, Progress in Polymer Science, 37, 1552-1596.

Faruk O., Bledzki A.K., Fink H.P., Sain M. (2012). Biocomposites reinforced with natural fibres: 2000–2010, Progress in Polymer Science, 37 (11), 1552-1596.

Gurunathan T., Mohanty S., Nayak S.K. (2015). A review of the recent developments in biocomposites based on natural fibres and their application perspectives, Composites Part A: Applied Science and Manufacturing, 77, 1-25.

Hull D., Clyne T.W. (1996). An Introduction to Composite Materials, Cambridge Solid State Science Series, pp. i-vi). Cambridge: Cambridge University Press.

Li M., Pu Y., Thomas V.M., Yoo C.G., Ozcan S., Deng Y., Nelson K., Bagauskas A.J. (2020). Recent advancements of plant-based natural fibre–reinforced composites and their applications, Composites Part B: Engineering, 200, 108254.

Mohammed L., Ansari M.N.M., Pua G., Jawaid M., Islam M.S. (2015). A review on natural fibre reinforced polymer composite and its applications, International Journal of Polymer Science, 2015, 1-15.

Müssig J. (Ed.). (2010). Industrial applications of natural fibres: Structure, properties and technical applications. Chichester, UK: Wiley.

Pickering K.L., Efendy M.A., Le T.M. (2016). A review of recent developments in natural fibre composites and their mechanical performance, Composites Part A: Applied Science and Manufacturing, 83, 98-112.

Pil L., Bensadoun F., Pariset J., Verpoest I. (2016). Why are designers fascinated by flax and hemp fibre composites? Composites Part A: Applied Science and Manufacturing 83, 193-205.

Sáez-Pérez M.P., Brümmer M., Durán-Suárez J.A. (2021). Effect of the state of conservation of the hemp used in geopolymer and hydraulic lime concretes, Construction and Building Materials, 285, 122853.

Syduzzaman M., Faruque M.A.A., Bilisik K., Naebe M. (2020). Plant-based natural fibre reinforced composites: A review on fabrication, properties and applications, Coatings, 10, 1-34.

Sustainable Management of Construction Materials in Post COVID-19: Sand and Gravel Mining from local Rivers in Nepal

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Abstract

Sand and gravel extracted from local rivers are the commonly used natural materials for the buildings and infrastructure projects globally. The demand of such materials is increasing intensely due to the boom in the construction industry and to reactivate the national economy post COVID-19. Local rivers are the main source of construction materials in developing and developed countries including Nepal. Inconsistent and unregulated mining of rivers' sand and gravel have caused adverse impact on environment, economy and society. The unsustainable practices remain largely unaddressed by local stakeholders and the existing sand mining policy in Nepal. Hence, the paper focuses on examining the impacts caused by rivers' sand mining on environment and local community and recommending the potential mitigation measures. The research is based on the exploratory approach followed by comprehensive literature review, and quantitative data collection via field survey around Chure Hills where majoring of rivers used for sand mining in Nepal. The observations at sand mining sites and views from local stakeholders were collected using a questionnaire survey, and Excel was used to analyse the research data and summarise the survey findings. The survey found that the existing sand mining policy in Nepal has a negative impact and a need of a new policy to reduce the impact on environment and local community livelihoods including loss of farmlands and woodlands, land erosion, flooding, health hazard with dust and noise pollution, and local economy. The paper concludes that local stakeholders including local government must be made accountable for sustainable use of the rivers' extracted materials and protect the local environment and communities by designing a new sand mining policy.

Keywords: Construction, Material, Sand, Gravel, Mining, Sustainable, Policy, Nepal

1. Introduction

Fine aggregate (sand) and coarse aggregate (gravel) amongst the world's largest amount of construction materials extracted globally (Gallagher and Peduzzi, 2019). The construction industry is the leading sector that consumes aggregate the most for producing buildings and infrastructure projects. This is because aggregate is a major component of asphalt and concrete mixes and it is required in every part of the construction industry sector like streets, highways, railroads, bridges, buildings, sidewalks, sewers, power plants, and dams, etc. According to Environment Impact Assessment (EIA) guideline, three type of monitoring need to establish environmental monitoring that refers to systematic sampling of air, water, soil, and biota in order to observe and study the environment impact, as well as to derive knowledge from this process (IUCN, 1994). This paper focuses on sand mining practices of the fine aggregate (sand) and course aggregate (gravel) from local rivers in Nepal that have adverse impact on society, economy and environment. Garba et al. (2019) said that sand is the third largest exploited natural resource globally, with an estimation that the world consumed between 25.9 to 29.6 billion tons of aggregate in 2012 alone. As well as, with the rapid development in the national economy and construction industry, the demand for sand in the construction market is increasing. Simultaneously, the current sand mining policies need to meet the demand of 10 billion people in the world with effective policy, planning, regulation, and management. However, construction materials particularly sand, have been experiencing depletion in recent times, which has impacted negatively on the environment through the destruction of beaches and endangering the ecosystem they protect and escalated the cost of construction. Gallagher and Peduzzi, (2019) indicated that we are approaching a future where access to this resource is a critical barrier to sustainability, and the full costs of uncontrolled sand extraction come due.

The quantity of sand being extracted has direct impact on rivers, deltas and coastal and marine ecosystems, sand mining results in loss of land through river or coastal erosion, lowering of the water table and decreases in the amount of sediment supply. So, using it sustainably denotes extracting in sustainable manner, with minimal impact or no impact to environment, get it economically cheaper and meeting our own needs without compromising the ability of future generations to meet their own needs. Rivers are the main source of sand in Nepal along with many countries across the world. As resources of sand on land are depleted the demand for rivers' sand has increased rapidly and is expected to continue. However, rivers' sand is limited in quantity and sand mining brings environmental externalities such as environmental degradation, habitat destruction and coastal erosion. By means of using digging and loading heavy equipment excessive sand mining can alter the riverbed, force the river to change course, destruct the farmland, erode banks and lead to flooding. Figure 1 shows some observations of the river sand and gravel mining practices in Nepal. It also destroys the habitat of aquatic animals and micro-organisms besides affecting groundwater recharge. Therefore, the mining plans of rivers' sand must be formulated in order to strengthen the management of rivers' sand mining, scientifically and rationally exploit the sand in the river,

ensuring flood safety, river ecological safety and infrastructure safety, and avoid excessive exploitation of river sand resources.

Figure 1: Shows current practices of River sand mining sites for construction materials in Nepal

Moreover, the workers need to be kept in healthy squatter (place) having enough ventilation with provision of clean and drinkable water, electricity, and toilet facility for male and female separately. The worksite or extraction site must be maintained safely so that the wild animal and ants could not enter to the mining site and attack on the workers. In the site amicable safety equipment including personal protective equipment need to be provided to them. Similarly, enough mask gloves need to be provided so that they could take clean oxygen and could not suffer from dust and noise. As well as, human interventions like the construction of dams, sand mining, channelization, land-use changes, etc., have been responsible for the observed changes in riverbed morphology. Extraction of bed material in excess of replenishment by transport from upstream causes the bed to degrade upstream and downstream of the site of removal. Bed degradation can undermine bridge supports, pipe lines or other infrastructures, may change the morphology of the river bed, which constitutes one aspect of the aquatic habitat It can deplete the entire depth of gravelly bed material, exposing other substrates that may underlie the gravel, which could in turn affect the quality of aquatic habitat, during a flooding aquifer drains to the stream. Groundwater levels can be lowered because of bed degradation. Rapid bed degradation may induce bank collapse and erosion by increasing the heights of banks which disturb the sustainability. Consequently, the key issue is to determine how to provide the maximum benefit of river sand resources under the premise of ensuring river stability and environmental and economic security. Zhai et al. (2020) and Gunaratne (2010) found many problems associated with the existing strategies of rivers' sand mining. At present, there are a few studies that analyse the impact of river sand and gravel mining on the surrounding ecological environment.

Additionally, unregulated and unmonitored sand mining has taken place without a clear regulatory framework and this has aggravated environmental problems. Proper policy needs to formulate if the private or public land, houses, including any infrastructures damaged, that could pay or settle down. With the continuous development of engineering construction, the shortage of sand for construction has not been improved, and the scarcity of sand and gravel resources is more obvious. In IT- technological innovation, including through automation,

digitization, and electrification, are having a fundamental impact on the mining sector. Some of the technologies include autonomous vehicles, automated drilling and tunnel boring systems, drones and smart sensors. However, these technologies have not been used in Nepal for extracting sand and gravel from riverbed. Sand prices have increased several times based on the traditional sources of supply and current increasing demand of sand and gravel in the construction industry.

The main problem may come from non-holistic approach; it becomes a reason that the research needs a holistic approach in assessing sustainability index performance of mining management" (Aryanti et al, 2013). "Police nabbed proprietor of a crusher industry on the charge of murdering local youth and engineering students, who protest for illegal sand mining and save his village from flooding and erosions, Mr Dilip Mahato, 24, on the banks of the Aurahikhola of Shreepur in Mithila Municipality-5, Dhanusha. He, a critic of illegal sand mining, was run over by a tipper and killed while trying to stop unauthorised excavation of sand yesterday morning. (The Himalayan Times, 2020). Hence, this paper focuses on analysing the impact of rivers' sand mining on the environment and the local communities in Nepal in order to help with saving the farmland and the livelihood of the local communities around rivers in the country. In other words, the purpose of this study is to evaluate the negative impacts of sand extraction from rivers to reduce the degradation of farmland and saving livelihood of the communities around rivers in Nepal.

2. Literature Review

In Nepal's river, unmanaged and unplanned construction material mining is inviting lot of problems. River mining can create both positive and negative impacts concerning social, economic, and environmental aspects. Since negative impacts appear due to unmanaged mining that later on will affect its sustainability. It is important to ensure sustainable management of mineral resources exploitation and minimise the impact on local community. "Two youths have lost their lives after drowning in Daringal River in Gajuri Rural Municipality-6 of Dhading district Saturday morning. Enraged locals burned down excavators used to extract sand from the river citing the excavation as the cause of their death. Bhim Tamang (19) and Suman Tamang (21) of Gajuri Rural Municipality-7 drowned in the river today afternoon. Both worked as labourers to extract sand." (The Himalayan Times, 2019).

Rivers are the main source of sand that is used in construction industry around the world such as India (Mohammad et al., 2020), China (Zhai et al., 2020), Korea (Kim et al., 2020), Malaysia (Isahak et al., 2018), Singapore, Sri Lanka (Gunaratne, 2016), Nepal, Nigeria (Garba et al., 2019), Vietnamese and southeast Asia (Park et al., 2020) and many countries across the world. The production of rivers' sand involves extraction and processing of the raw material into a usable product, transport of that commodity to the point of use, and the reclamations of the extraction sites. Meanwhile, the existing rivers' sand mining policies are

in need to meet the challenges of high demand in the construction industry worldwide in a way that reduces the impact of aggregate mining on the local people and the environment. This could be achieved by developing sustainable mining policy, planning, regulation and effective management in local levels. However, such actions remain largely unaddressed by the decision-makers in public or private sectors in many countries worldwide (Gallagher and Peduzzi, 2019). Moreover, it is important to analyse the impact of the current action of rivers' sand mining in order to develop a sustainable mining policy.

Langer (2016) analysed the management of the aggregate resources throughout the lifecycle of the sand mining projects. He found that the following challenges associated with rivers' sand mining including, (i) environmental impact such as changes to the landscape, noise, dust, vibrations from blasting, and degradation of groundwater and surface water, (ii) economic challenges such as maintaining a viable business environment; the added cost of fixing the damages that result from rivers' sand mining actions such as roads, houses and infrastructures damages; and encouraging value-added production and employment, (iii) corporate social responsibilities including the environmental and financial performance of rivers' sand mining; following the rules and standards; and providing aggregates to meet the material requirements of society. Gunaratne (2010) tried to identify policy options for sustainable rivers' sand mining in Sri Lanka. Private and social costs were compared, then the trade-offs between environmental conservation and sand extraction as perceived by miners were analysed under a choice modelling framework. The evaluation criteria of this study were based on local studies and experts' judgement of local stakeholders. Therefore, the recommendations from the study is that it wasn't effectively used to analyse river sand mining policies in other geographical regions. The study was limited by not using the spatial data related to the issue. This should be combined with the economic analysis to generate meaningful results.

Zhai et al. (2020) developed a model for optimising the utilisation of rivers' sand resources during the planning period. The objective function of the model is the economic benefit of the utilisation of rivers' sand resources for many years. In order to guarantee the healthy and safe operation of the river ecosystem overall, several constraint conditions are given, including the maximum and minimum mining quantity. They presented an optimisation model of sand mining which are constructed only with the economic benefit of rivers' sand resources utilisation as the objective function but missed to consider the social and ecological benefits of the utilisation of rivers' sand and gravel resources in the objective function. In other hand, Weng (2005) have analysed the perceptions of all the stakeholders in Malaysia regarding a sustainable management and policy of rivers' sand mining.

In this study, the author has analysed the perceptions of government organisations, Non-Governmental Organisations (NGOs), industrialists, farmers, and other stakeholders who play a greater role, and more efforts and funding need to be injected to sustain the river clean-up programme. The data were collected from one river only. Therefore, the study needs

to be extended to all other rivers in the country to make the results and the findings of the paper more applicable to the entire country.

It was suggested that the government should also explore the option of working together with NGOs and the people in the cleaning and restoration of rivers. Furthermore, all of the above mentioned studies by Langer (2016), Gunaratne (2010), Zhai et al (2020) and Weng (2005) did not take the water resource management supply (e.g. water demand and water supply) in consideration while analysing the river sand mining policies in their studies. With regards to analysing the impact of rivers' sand mining practice on people and environment, this study has analysed literature from the past studies and found several negative impacts associated with rivers' sand mining practices in different countries across the world. The findings from literature are summarised in Table 1.

Table 1: The summary of the criteria of analysing the impact of rivers' sand practices on the local people and environment

Impact		Authors
Environmental impact	Noise	Langer, (2016)
	Dust	
	Vibrations from blasting	
	Water and river pollution	Garba et al, (2019)
	Soil contamination and erosion	
	Loss of biodiversity	
	Degradation of groundwater and surface water	(Gallagher and Peduzzi, 2019)
	Flood and marine currents	Rumbaur et al., (2015)
	Effects on climate through transport emission	Garba et al, (2019)
	Displacement of fauna	Almeida et al., (2020)
	Effect on the farmlands	(Gallagher and Peduzzi, 2019)
	Acids (e.g. cadmium, copper, lead, zinc, arsenic).	Almeida et al., (2020)
Economic impact	Cost of operation, including costs of prevention or remediation of environmental damage.	Langer, (2016)
	Effect on the landscape	(Gallagher and Peduzzi, 2019)
	Economic losses through tourist abandonment	Garba et al, (2019)
	Depletion of sand	Zhai et al., (2020)
	Increasing the cost of construction	Garba et al, (2019)
	Impacts on houses, coastal infrastructure and embankments	Rumbaur et al., (2015)
	Damage to the channels' beds	
Social Impact	Loss of livelihood for coastal fishermen	
	Effect of the historical places like churches, graveyards and archaeological sites	
	loss or damage to houses	(Gallagher and Peduzzi, 2019)
	Safety and livelihoods of the people living by the rivers and the mining projects.	
	The increasing volume of aggregates extracted is often illegally in many countries.	

According to Gallagher and Peduzzi (2019), the impacts from river sand mining can be reduced by avoiding the use of cement and concrete where possible so that demand for natural sand is reduced to reasonable levels. Construction industry can make more efficient use of sourced aggregates through land use planning, pursuing alternative infrastructure and building design and construction methods. Need to strengthen standards and best practices to curb irresponsible extraction, invest in sand production and consumption measurement, monitoring and planning, and establish a dialogue based on transparency and accountability. The findings from literatures are the impacts of rivers' mining policies and activities, which will be used later on in this research as the criteria to analyse the impact of the existing rivers' sand mining activities on the local people and environment in Nepal.

3. Research Methodology

The factors/criteria of analysing the impacts resulting from rivers' sand mining were taken from various studies that analysed the impact of such action in different countries across the world (see Table 1). These factors/criteria were analysed with regards to their degree of impact on the local environment and people living around the mining projects in Nepal using a questionnaire survey. The study used a semi-structured questionnaire survey to explore the impact and potential mitigation measures about the rivers' sand mining practices. The survey asked the participants to answer several questions, which are relevant to evaluate the environmental, economic and social impacts that result from rivers' sand mining sites in Chure Hill areas particularly in Mahottari and Dhanusha districts in Nepal. The study used interviews via online and face-to-face to collect the research data through questionnaire survey. This research is based on quantitative approach (Creswell, 2009) for testing objective theories by examining the relationship among variables. It even included the qualitative data in this perspective it can address to this research as a descriptive research.

3.1 Questionnaire Survey and Data Collection

The survey was designed in five sections. The first section involved collecting demographic information of the participants like gender, age and relevant status related to rivers' sand mining projects. The second part of the survey asked the participants about their opinion about the impact of the current action of rivers' sand mining and their satisfaction level with the government's rules and policy for rivers' sand mining. The third part focused on the participants' view on the most influential problems that are associated with the activities of rivers' sand mining. The fourth part of the survey asked the participants about their awareness and information level about the impact of rivers' sand mining practice in their areas. Finally, the fifth part of the survey was about collecting the participants' opinions about the level of impact of rivers' sand mining activities in their areas. The data collected from the survey were analysed using descriptive statistical analysis method. The results of the survey are presented with its implications discussed in the next section.

3.2 Survey Results

In the questionnaire survey, a total of 55 responses from the local stakeholders, which have answered successfully, are included in the statistical analysis of the survey date. The MS Excel was used to analysis the research data and present the survey results. The demography of responses in terms of gender and age group are presented first, followed by participants' categories. The survey results revealed that 74.5% of the participants were males and 25.5% were females. Regarding the participants' age groups, 5.5% of the participants were between 21 to 25 years old, 10.9% were between 26 to 30, 16.4% were between 31 to 35, 27.3% were between 36 to 40, 18.2% were between 41 to 45, 9.1% were between 46 to 50, 5.5% were between 51 to 55 years old, and 7.3% were are over 56 years of age group. In respect of the participants' categories, who actively involved in the survey about rivers' sand mining are as follows: 61.8% of the participants were ordinary villagers, 18.2% were contractors and suppliers and 10.9% were VDS members. Similarly, participants either engineers or technician were (5.5%), drivers (1.8%) and other category of the participants were (1.8%) having different status related to rivers' sand mining projects. As regards answering the question about the impact of rivers' sand mining practice on the environment in Nepal, 13.9 % of the participants said it has no effect on the environment, 15.7% said it has a minor affect, 25.2% said it has a neutral effect, 27% said it has a moderate affect and 18.3% said it has a major effect on the environment, see figure 2 below.

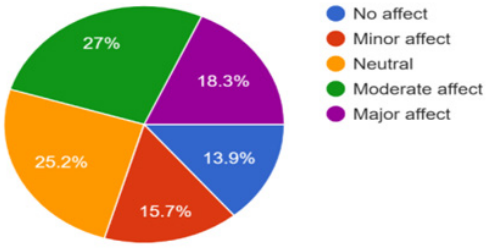

Figure 2: The of impact river's sand mining on the environments

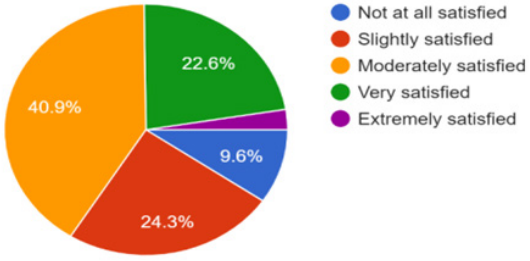

Figure 3: The satisfaction level with the rules of rivers' sand mining

Meanwhile, 24.3% of the participants are not satisfied with the rules and policy for rivers' sand mining in Nepal, 2.6% are slightly satisfied, 40.9% are moderately satisfied, 22.6% are very satisfied and only 2.6% are extremely satisfied with the existing rules and policy for rivers' sand mining in Nepal as shown in figure 3 above. This reflects the need of a sustainable mining policy.

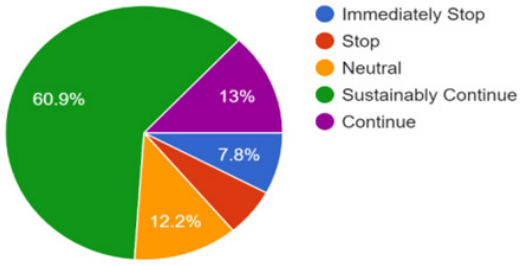

Figure 4: The responses about the continuation of rivers' sand mining sand.

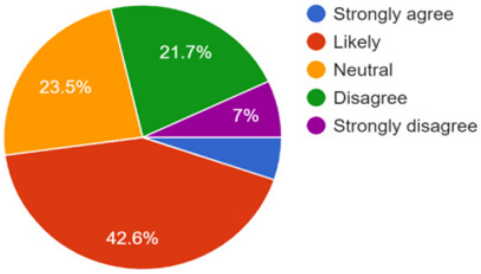

Figure 5: The responses about if they agree with the policy of rivers' sand mining.

Similarly, 13% of the participants said rivers' and sand mining should continue as it is on the current situation but 60.9% said rivers' sand mining should be continued in a sustainable manner whereas 12.2% were neutral but 6.1% said it should be stopped and 7.8% said it should be stopped immediately (see figure 4). Moreover, 7% of the participants strongly disagreed with the rules, policy and actions for rivers' sand mining in Nepal, 21.7% disagreed, 23.5% were neutral, 42.6% agreed and 7% strongly agreed with these rules, see figure 5. Based on the participants' point of view, it was found that loss of local farming and income is the major problem that results from river's sand mining as 52.63% of the participants said, followed by erosion of riverbank and farmland with 26% and air pollution with 22.67% as shown in figure 6.

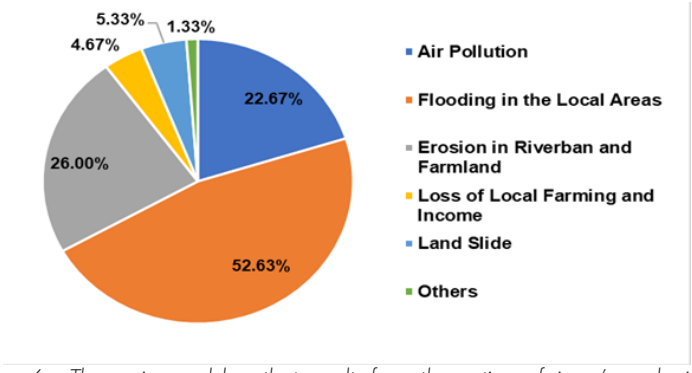

Figure 6: The major problem that results from the action of rivers' sand mining.

The results of the survey presented a correlation between the environmental impacts and participants' opinions about the continuity and the rules for rivers' sand mining in their areas. For example, 45.3% of the participants said that the current actions of rivers' sand mining have either a moderate impact (27% of the participants) or major impact (18.3% of the participants) on the environment and on their safety (results presented in figure 2). However, 60.9% of the participants said rivers' sand mining should be continued in a sustainable manner because this business provides jobs and work opportunities for the local people, as well as following a sustainable manner of rivers' sand mining will help in reducing the negative impact of this business (results presented in figure 3). Therefore, 63.5% of the participants are either moderately satisfied (40.9%) or are very satisfied (22.6%) with the government's' rules and policy for rivers' sand mining in Nepal (results presented in figure 4).

Moreover, 49.6% of responses either agreed (42.6%) or strongly agreed (7%) with these rules, policy, and actions of rivers' sand mining in Nepal (results presented in figure 5). This is because regardless of the environmental impacts that result for rivers' sand mining, it is a main source of income for them. The participants also think that loss of local farming and income, erosion of riverbank and farmland, and air pollution are the major problems associated with river's sand mining. In other words, the participants in the survey have chosen the economical problems rather than environmental problems when they were asked in the survey about the major impacts that result from rivers' sand mining in their areas. This means stopping rivers' sand mining effects their jobs and business as framers (results presented in figure 6). After analysing the awareness level about the problems associated with rivers' sand mining actions in their areas, it was found that the employment opportunities, the private benefit for local people, and loss of vegetation and trees are the major problems that the local people have low awareness level in. Ranking of awareness level is shown in Table 2.

Table 2: The responses about the awareness level about some of the problems associated with rivers' sand mining.

Problem	**Score ***
Environmental	3.5351
Local rules and regulations	3.5965
Riverbank, flow and sedimentation	2.8947
Loss of visitation and trees	2.8947 (the 3rd lowest value in the table)
Water pollution	3.4649
Damage to the local structures	3.5702
Employment opportunities	2.7105 (the 2nd lowest value in the table)
Private benefit for local people	2.6754 (the lowest value in the table)
*The average of five-point Likert scale [not at all, a little concerned, acceptable concerned, highly concerned and very highly concerned].	

As well as, after analysing the participants' answers about the ninth question of the survey, which was asking about "what is the impact of the current situation of river sand mining on the following (see the first column in Table 3)". It was found that air and dust pollution, riverbank erosion, and change in the riverbed are the main impacts that result from the rivers' sand mining actions in the local areas. The ranking of impact from river is presented in Table 3.

Table 3: The responses about the impact of rivers' sand mining.

Problem	Score *
Riverbank Erosion	2.9737 (the 2nd highest value in the table)
Change in riverbed	2.9649 (the 3rd highest value in the table)
Decline in groundwater	2.1579
Damage to local roads	2.9561
Loss of biodiversity	2.8070
Loss of local residences schools and housings	1.9035
Air and dust pollution	3.4123 (the highest value in the table)
*The average of five-point Likert scale [not at all; a small damage; moderate damage; highly damage and very high damage].	

3.3 Recommendations from results and possible mitigation measures

After analysing the survey findings, the study suggests four recommendations as a possible mitigation measures for the sustainable management practices at river mining sites particularly the river extracted construction materials such as sand and aggregate. This measure includes careful site selection; noise and dust protection; reduction of the impact on the water resources; and reduction of the impact of transportation of the river extracted materials like sand and gravel. The details of the discussion of four mitigation measures are presented below.

(i) Site selection: The site selection helps to minimise the amount of surface area that must be disturbed by resource extraction. Preproduction site inventories can identify rare or endangered species so that habitat can be set aside, selected species can be relocated, or extraction operations can be suspended during critical breeding or migrating seasons.

(ii) Noise and dust protection: : This includes use of low-noise equipment and dust suppression or collection systems that can significantly reduce impacts. Equipment that is noisy or generates dust can be located so that naturally vegetated areas, landscaping, earthen berms, quarry walls, and topographic barriers shield or absorb noise, block the wind that transports dust and they can be located in sound-deadening and vacuum-equipped enclosures. Alongside, proper location and surface treatment of haul roads and careful routing of trucks can help reduce noise and dust.

(iii) Reduce the impact on water resources: This includes the practices of regular inspections and maintenance that will ensure the continued erosion control. Turbidity can be controlled by filtering or by containing runoff or wash water at sediment traps. Impacts on the water table as a result of de-watering can be monitored by use of observation wells, and recharging aquifers or augmenting flows to streams with water that has drained into the pit or quarry can maintain water levels. In highly permeable deposits, slurry walls or grouting may be necessary to isolate the operation from the water table.

(iv) Reduce the impact from the transportation: This includes the reduction on environmental impacts and hazards of transportation trucks that can be minimised when they are well maintained and operated. Trucks can be equipped with mud flaps and load covers to prevent loose material from being thrown from wheels and loads. Limiting the number of quarries entrances and exits and constructing acceleration and deceleration lanes at pit or quarry entrances. Delivery routes can be designed to minimise interference with neighbourhood traffic by (a) Accurate information on deliveries, (b) Improved vehicle utilisation and performance by reducing the occurrence of empty return journeys and turnaround time of trucks, (c) Improved communication between sites and the vehicle, providing advance warning of the arrival of a vehicle to pick up the product, (d) Improved ability to monitor vehicle speed and driver performance, providing improved enforcement of local agreements and legal requirements in routing deliveries.

4. Conclusions and Future Study

The study concludes that most of the participants approved that the current rivers' sand mining policy in Nepal has a strong negative impact on their farmland or local community livelihood. The participants are not satisfied with existing sand mining policy, but they want it to be continued to generate local employment and business activities. Most of the participants demand with local government to modernise the existing mining policy and guidelines for sustainable mining of river sand and gravel. Some of the participants expressed that rivers' sand mining is causing flooding and erosion of farmland along the river and have direct impact on their livelihoods. However, most of them have a low awareness level about the problems like environmental impact, local rules and regulations, and damage to the local structures that result from the current river sand policy. Moreover, most participants agreed that losing of farmland and income are the main problems that have the highest influence on the local areas due to river sand mining.

Taking into account the initial views from the survey and river mining site observations, the study recommends that the responsible stakeholders including local village administration must be made accountable for the sustainable use of the rivers' extracted construction materials such as sand and gravel in the construction industry. The future study will focus on design and development of a smart framework for the sustainable management of river's sand mining policy in Nepal by adding more rivers mining sites survey and more stakeholders' views, which would be useful to analyse and reduce the environmental, economic and social impact from rivers' sand mining practices more effectively. This would encourage the local policy makers to take necessary actions and increase social awareness for the sustainable mining practices. Finally, the investigation and results presented in the study is essential in the pursuit of enhancing the knowledge about sustainable management of construction materials extracted from rivers and in well-being of the local public.

5. Acknowledgement

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6. References

Almeida, J., Ribeiro, A.B., Silva, A.S. and Faria, P., (2020) Overview of mining residues incorporation in construction materials and barriers for full-scale application. Journal of Building Engineering. Available: https://linkinghub.elsevier.com/retrieve/pii/S2352710219320972.

The Himalayan Times, January 12, 2020 Nepal's daily English newspaper. [online] www.thehimalayantimes.com

The Himalayan Times, August 10, 2019 Nepal's daily English newspaper, [online] www.thehimalayantimes.com

Gallagher, L. and Peduzzi, P., (2019) Sand and Sustainability: Finding new solutions for environmental governance of global sand resources. [online] Geneva, Switzerland. Available: https://archive-ouverte.unige.ch/unige:117767.

Garba, A., Mairami, M.B. and Sanni, M.O., (2019) Assessment of Sustainable Sand Provision for Construction Projects in Nigeria. JOURNAL OF ENGINEERING AND ARCHITECTURE, [online] 71. Available: https://jea-net.com/vol-7-no-1-june-2019-abstract-5-jea.

Aryanti V. A., Suriamihardja D. A., Pallu M. S, Irfan U. R. (2013). Sustainability Analysis of Mining Management on Construction Material in Jeneberang River, South Sulawesi, International Journal of Engineering Research & Technology (IJERT), Vol. 2 Issue 12.

Gunaratne, L.H.P., (2010) Policy Optlons for Sustainable River Sand Mining in Sri Lanka. [online]: https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/46164/132654.pdf.

Creswell. J. W. (2009) Research Design: Qualitative, Quantitative and Mixed Method Approaches, SAGE Publication India Pvt. Ltd, B1/I-1 Mohan Cooperative Industrial Area, Mathura Road, New Delhi 110m044, India,

Gunaratne, L.H.P., (2016) Can River Sand Mining be Sustainable? Policy Options from Sri Lanka. Economy and Environment Program for Southeast Asia (EEPSEA).

Isahak, A., Reza, M.I.H., Siwar, C., Ismail, S.M., Sulaiman, N., Hanafi, Z., Zainuddin, M.S. and Taha, M.R., (2018) Delineating risk zones and evaluation of shelter centres for flood disaster management along the Pahang River Basin, Malaysia. Jàmbá: Journal of Disaster Risk Studies, 101, pp.1–7.

Kim, S., Yang, D.S. and Kim, Y.S., (2020) Distribution of metal contamination and grain size in the sediments of Nakdong River, Korea. Environmental Monitoring and Assessment, p.502.

Langer, W., (2016) Sustainability of aggregates in construction. In: Sustainability of Construction Materials. Elsevier, pp.181–207.

Mohammad, A., Bhanu Murthy, P., Dhanamjaya Rao, E.N. and Prasad, H., (2020) A study on textural characteristics, heavy mineral distribution and grain-microtextures of recent sediment in the coastal area between the Sarada and Gosthani rivers, east coast of India. International Journal of Sediment Research, [online] 355, pp.484–503.

Park, E., Ho, H. L., Tran, D.D., Yang, X., Alcantara, E., Merino, E. and Son, V.H., (2020) Dramatic decrease of flood frequency in the Mekong Delta due to river-bed mining and dyke construction. Science of The Total Environment, [online] 723, p.138066.

Rumbaur, C., Thevs, N., Disse, M., Ahlheim, M., Brieden, A., Cyffka, B., Duethmann, D., Feike, T., Frör, O. and Gärtner, P., (2015) Sustainable management of river oases along the Tarim River (SuMaRiO) in Northwest China under conditions of climate change. Earth System Dynamics, 6, pp.83–107.

Weng, C.N., (2005) Sustainable management of rivers in Malaysia: Involving all stakeholders. International Journal of River Basin Management, 33, pp.147–162.

Zhai, W., Ding, J., An, X. and Wang, Z., (2020) An optimization model of sand and gravel mining quantity considering healthy ecosystem in Yangtze River, China. Journal of Cleaner Production, [online]. Available: https://linkinghub.elsevier.com/retrieve/pii/S095965261933255X.

IUCN (1994), National Conservation Strategy Implementation Project, 1994. Environmental Impact Assessment Guidelines 1993 Kathmandu. [online] Available: https://portals.iucn.org/library/sites/library/files/documents/1994-009.pdf.

Himalayan Glacial Lake Volume and Potential Glacial Lake Outburst Flood (GLOF) Discharge Calculation

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Abstract

This research investigates historical glacial lake outburst flood (GLOF) events at the Hindu Kush Himalaya region (Nepal) and analyse the empirical relationship between lake volume and outburst peak discharge calculation. Several formulae already exist that relate lake area and volume from different parts of the world, which warrants further analysis to implement this research scenario at Himalayan glacial lakes. Due to the variation of geographical terrain and other various factors, ice and moraine-dammed glacial lakes often have different geometries and, therefore, different volumes. There are few investigations conducted at different parts of the world (Patagonia, Chile, Swiss Alps) based on the measured volume (by a field investigation and other means) of the lakes. This research aims to improve the volume estimation formula based on empirical evidence in different research scenario (Himalayan glacial lakes). This research has analysed the historic outburst details from Himalaya region, Nepal, and derived the empirical formula to calculate lake volume and potential discharge of GLOF of the glacial lake in the Hindu Kush Himalaya Region, Nepal.

Keywords: Glacial Lake Outburst Flood (GLOF), empirical parameters, potential discharge calculation.

1. Introduction

Snow melting and glacier retreating is the most visible indicator of climate change. Thinning and retreating of these glaciers over the past century has led to the creation and progression of glacial lakes at the margins of glaciers and moraines in all high mountain regions of the world (IPCC, 2014), particularly at Hindu Kush Himalaya (HKH) region. The continuous expansion of these glacial lakes poses the high risk of GLOFs, which can release millions of cubic meters of water in a short period and produce floods (debris flow, flash flooding) with high peak discharges and extraordinary erosive and transport capacity (Breien et al., 2008). Therefore, it is essential to study the present status of glaciers, glacial lakes and surroundings to understand the temporal and spatial changes of such glaciers, glacial lakes and forecast future worst-case scenarios. However, it is very challenging to obtain an accurate spatial extent of the glacial lakes and surroundings due to the extreme geomorphic condition of the Himalaya. Hence, remote sensing is considered the best way to investigate glacial lakes and the impact of GLOFs in the remote mountainous region (Bolch et al., 2008).

Data about failed glacial lakes have not been systematically analyzed in the Himalaya region yet; especially failure mechanism and its contributing factors remain primarily unknown. More than 30 GLOFs events were recorded in the Hindu Kush Himalaya region (Figure 1) since 1930; among them, 14 GLOF events affected Nepal (ICIMOD, 2011). This research analyses the data collected by extensive literature review and satellite data (Landsat 8) to establish the empirical relations between the glacial lake area, volume, and possible maximum discharge. Remote sensing techniques are particularly suitable for this task allowing rapid analysis of the large glaciated region economically (Huggel et al., 2002).

Figure 1: Hindu Kush Himalaya (HKH) region and Nepal Himalaya (Arcgis, 2020)

2. Data and Methodology

Measuring and modelling the natural hazard is a dynamic process. The use of remote sensing data and satellite imagery has a considerable advantage when it comes to glacial lake related hazard mitigation, mainly GLOF in the Himalaya region. Nevertheless, they are of limited use for modelling related processes. In this context, empirical relations are crucial to complete the modelling process, particularly when glacial lake volume and maximum discharge are considered. And it is essential to investigate the lake volume in order to calculate possible maximum GLOF discharge in the events and extent of the damage it may cause on its floodplain.

This research has generated digital elevation modelling of the glacial lake and surrounding from the past GLOF events. This will help to obtain spatial information of the lake and surrounding. The Landsat image downloaded from the United States Geological Survey (USGS) was processed in the TCX (Training Centre XML) converter to obtain the elevation information of the area of interest. Then contour map was created with the help of Google Earth Pro mapping application and finally processed into the QGIS to create the Digital Elevation Modelling (DEM).

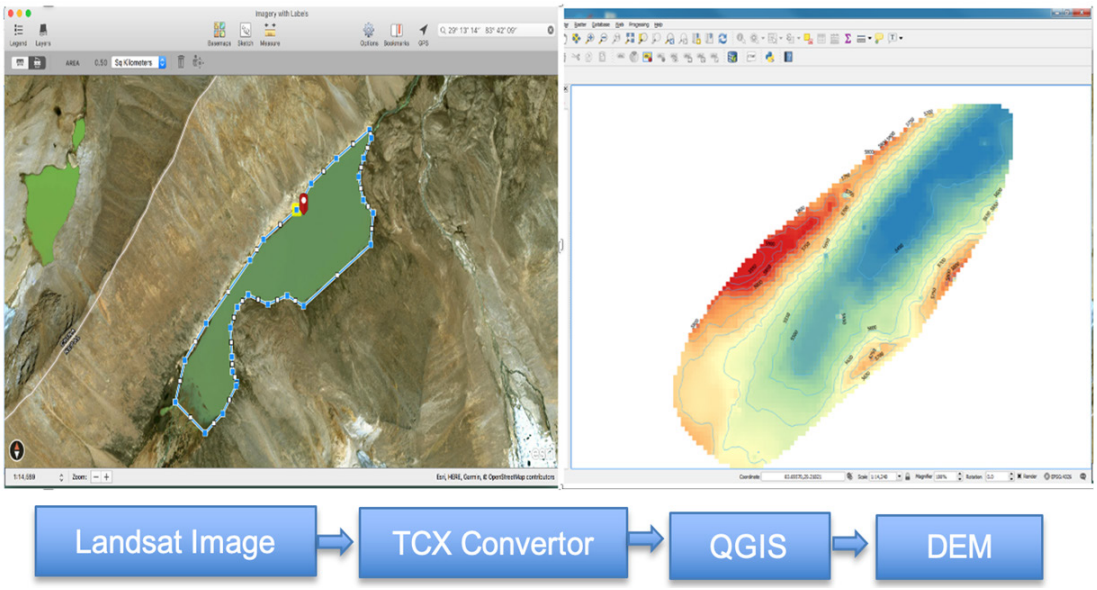

Figure 2: Workflow to create DEM

Furthermore, the lake area is extracted using path-distance tools in QGIS with satellite imagery from the historic GLOF sites. To mitigate the GLOF hazard, the volume of the lake is necessary. There are various optical remote sensing platforms that perform water surface profile mapping and depth measurement from satellite imagery. However, there is no reliable way to get this parameter directly from satellite imagery. The bathymetric survey may not be possible in all glaciated region, a poorly known high mountain area, since it relies on the relationship between water depth and reflects energy (Baban, 1993). Hence, an empirical method is

chosen instead. The volume of the lake is highly dependent on its area. Generally, volume of the lake can be calculated by the area and depth measurements. A similar approach as Huggel et al. (2002) was taken to derive the lake's volume based on empirical relations (Table 2).

The magnitude of the flood during the GLOF is also vital to analyse how destructive it would be. Once the area and volume of the glacial lake established, maximum discharge is calculated using empirical relations. Several formulae exist to estimate the maximum discharge of the moraine-dammed glacial lake (Table 1). This research analysed the maximum discharge based on past events and their empirical evidence.

Table 1: Relations between Glacial lake volume and discharge calculation

Lake	Relations	References
Glacier lake, moraine dam	$Q_{max} = 0.72V^{0.53}$	Evans, 1986
Glacier lake, moraine dam	$Q_{max} = 0.0048V^{0.896}$	Popov, 1991
Glacier, tunnel events	$Q_{max} = 46\left(V/_{10^6}\right)^{0.66}$	Walder and Costa, 1996
Glacier lake, moraine dam	$Q_{max} = 0.054V^{0.66}$	Walder and O'Connor, 1997

3. Results

Extreme climate events are more frequent than before due to global warming. Particularly in the remote Himalaya region, continuous monitoring of the glacier, glacial lake and adjacent area is necessary as they are receding in alarming rate. The proposed method will help to access the extent of the damage that may cause by the GLOF events. It will enable to calculate maximum possible GLOF discharge. This research has analysed eleven past GLOF sites using satellite imagery (Landsat) and QGIS, and concluded the following results. Some of the glacial lakes were completely drained and do not exist anymore. In those scenarios, geomorphological evidences and expert judgements were used to reconstruct the lake and calculate the area. Among these investigated eleven past events, two different set of the lake area are identical.

Table 2: Historic GLOF, lake area and flood volume

Date	Glacial lake outburst flood events	Area (m^2 x10^6)	Lake Volume (m^3 x10^6)
450 years ago,	Machhapuchhare, Seti Khola basin	0.770	0.855
03/09/1977	Nare lake, Dudh Koshi basin	0.250	0.284
23/06/1080	Nagma Pokhari, Tamor basin	0.680	0.757
04/08/1985	Dig Tsho, Dudh Koshi basin	0.410	0.461
12/07/1991	Chubung Tsho, Tama Koshi basin	0.300	0.339
03/09/1998	Tam Pokhari Tsho, Dudh Koshi Basin	0.250	0.284
Unknown	Barun Khola, Arun river basin	0.460	0.516
Unknown	Barun Khola_1, Arun river basin	0.120	0.138
Unknown	Chokarma Cho Dudh Koshi Basin	0.600	0.669
Unknown	Unnamed, Kali Gandaki basin (Mustang)	0.500	0.560
Unknown	Unnamed lake, Kali Gandaki basin_01	0.300	0.340

Source: Bajracharya et al. 2008, ICIMOD (2010)

The dependency of the lake volume on the area reflected in the regression analysis between area (A) and mean depth (D) of the glacial lake that shows high coefficients of determination (r^2) with the following equations.

$$D = 0.204\, A^{0.94} \qquad r^2 = 0.99 \qquad (1)$$

Then the glacial lake volume (V) is calculated as follows:

$$V = 1.104\, A^{0.98} \qquad r^2 = 0.98 \qquad (2)$$

This expression gives an estimated lake volume of the moraine-dammed glacial lake in the Himalaya region based on past events' empirical relations. However, further field investigation is needed for more precise volume calculation due to the high inconsistency of lake geometry in these glacial lakes.

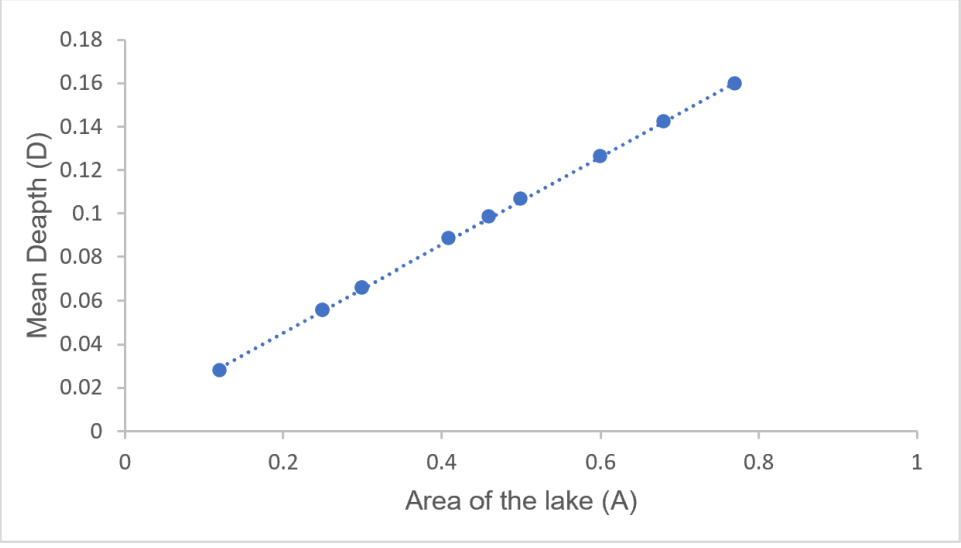

Figure 3: Relation between area of glacial lake and mean depth

For the detail hazard analysis, the magnitude of the flood is necessary. This research analyzed the existing formulae for maximum discharge during the GLOF events (Table 1) and reduced the uncertainty in the context of the Himalayan glacial lake. Often detailed hydrological and complex hydraulic parameters of the glacial lake are missing or challenging to extract, so often, these values have to be derived using indirect methods that may be less relevant (Clague and Evans, 1994). Moreover, often high-resolution satellite image of these parts of the world is not available. Hence, empirical relations are vital to establishing these relations. The following is obtained based on the published literature and analysis of the eleven past GLOF events in Nepal.

$$Q_{max} = 0.0077\, V^{0.60} \qquad r^2 = 0.992 \qquad (3)$$

4. Discussion

In the absence of complete understanding and the required parameters to estimate the volume and peak discharge of these glacial lakes, these can be used as an initial estimator of the magnitude of the potential flood and devastation it may cause. It is also vital to identify the possible mode of failure. It has been found that the moraine-dammed glacial lake produces more sediment and outburst flood than the ice or glacier-dammed lake with the same amount of the stored potential energy unless a mechanical failure of an ice dam is triggered (Walder and Costa, 1996).

The corresponding regression analysis for volume and peak discharge at different scenarios have produced different empirical relations. The conclusion drawn from the artificial earth-fill dam by Evans (1986) overestimates the lake's peak discharge with a smaller volume in the context of the Himalayan region. However, the general principle is relevant. Popov (1991) analyzed the data from northern Tien Shan, Kazakhstan, but it cannot be used from the Himalayan glacial lake as it produces higher peak discharge for a given volume. Hence, it warrants further investigation in different geomorphological conditions.

5. Conclusion

This research analysed 11 historic GLOF events recorded within the Nepal Himalaya to establish empirical relations between lake area, volume and possible maximum discharge. Based on the proposed method, it is concluded that empirical relations allow estimating volume and maximum discharge in case of the GLOF events. Proposed equations can determine potential discharge and volume in the GLOF events in similar geomorphic settings. This will be very useful to mitigate the GLOF hazard in the region. It will also help to prioritise the lake with higher risk potential, a more rigorous field investigation. Hence, the systematic application of such remote sensing-based methods can be beneficial in high mountain areas from GLOF hazard mitigation and to establish empirical relations.

9. References

Arcgis.com. (2020). World Imagery. [online] Available at: https://www.arcgis.com/home/webmap/viewer.html?useExisting=1&layers=10df2279f9684e4a9f6a7f08febac2a9 [Accessed 2020].

Bajracharya, S.R., Mool, K. and Shrestha, B. (2008). Global Climate Change and Melting of Himalayan Glaciers. [online]. Available at: http://www.hpccc.gov.in/PDF/Glaciers/Global%20Climate%20Change%20and%20Melting%20of%20Himalayan%20Glaciers.pdf [Accessed 4 Jun. 2021].

Baban, S.M.J. (1993). The evaluation of different algorithms for bathymetric charting of lakes using Landsat imagery. International Journal of Remote Sensing, 14(12), pp.2263–2273.

Bolch, T., Peters, J., Yegorov, A., Pradhan, B., Buchroithner, M. and Blagoveshchensky, V. (2011). Identification of potentially dangerous glacial lakes in the northern Tien Shan. Natural Hazards, 59(3), pp.1691-1714.

Breien, H., De Blasio, F., Elverhøi, A. and Høeg, K. (2008). Erosion and morphology of a debris flow caused by a glacial lake outburst flood, Western Norway. Landslides, 5(3), pp.271-280.

Evans, S.G. (1986). The maximum discharge of outburst floods caused by the breaching of man-made and natural dams. Canadian Geotechnical Journal, 23(3), pp.385–387.

Huggel, C., Kääb, A., Haeberli, W., Teysseire, P. and Paul, F. (2002). Remote sensing-based assessment of hazards from glacier lake outbursts: a case study in the Swiss Alps. Canadian Geotechnical Journal, 39(2), pp.316-330.

ICIMOD (2011). Glacial Lakes and Glacial Lake Outburst Floods in Nepal. [online] Nepal: International Centre for Integrated Mountain Development. Available at: http://documents1.worldbank.org/curated/en/150061467986261271/pdf/98829-WP-Box393178B-PUBLIC-Glacial-lakes-and-glacial-late-outburst-floods-in-Nepal.pdf [Accessed 28 Dec. 2020].

IPCC (2014) IPCC Fifth Assessment Report, Available at: http://www.ipcc.ch/(Accessed: 2 Nov 2016).

Iribarren Anacona, P., Norton, K.P. and Mackintosh, A. (2014). Moraine-dammed lake failures in Patagonia and assessment of outburst susceptibility in the Baker Basin. Natural Hazards and Earth System Sciences, 14(12), pp.3243–3259.

Ives, J.D., Shrestha, R.B. and Mool, P.K. (2010). Formation of Glacial Lakes in the Hindu Kush-Himalayas and GLOF Risk Assessment. [online] Kathmandu: International Centre for Integrated Mountain Development. Available at: https://www.unisdr.org/files/14048_ICIMODGLOF.pdf.

Popov, N. 1991. Assessment of glacial debris flow hazard in the north Tien-Shan. In Proceedings of the Soviet-China-Japan Symposium and field workshop on natural disasters, 2–17 Sept. 1991, pp. 384–391.

Sedai, S., Jayaratne, R., Grant, D. and Nepal, J. (2018). Glacial Lake Outburst Flood (GLOF) Triggering Factors at Hindu Kush-Himalaya, Mt. Everest Region, Nepal. The AGU 2018 Fall Meeting. [Online] London: American Geophysical Union. Available at: https://fallmeeting.agu.org/2018/abstract-submissions/

Walder, J.S. and Costa, J.E. (1996). • Outburst floods from glacier- dammed lakes: the effect of mode of lake drainage on flood magnitude. Earth Surface Processes and Landforms, 21(8), pp.701–723.

Walder, J.S. and O'Connor, J.E. (1997). Methods for predicting peak discharge of floods caused by failure of natural and constructed earthen dams. Water Resources Research, 33(10), pp.2337–2348.

Air Return Strategies and Airborne SARS-CoV-2

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Abstract

Ducted air return for heating, ventilating and air-conditioning (HVAC) systems is sometimes claimed to be a superior technique over plenum return strategies from the viewpoint of exposure to airborne pathogens. While both the return strategies have advantages, there is limited evidence in the literature as to which strategy is superior with respect to a building's vulnerability to airborne pathogens. This paper describes multizonal airborne contaminant dispersion modelling using CONTAM software Version 3.2 to simulate the overall building vulnerability to airborne SARS-CoV-2 aerosols when released in an office building and evaluates the two air return strategies. Results showed that for ducted returns, maintaining negative pressure in the release zone coupled with 100% outdoor air supply can greatly reduce overall building vulnerability. However, for a building maintained under a slight positive pressure and a recirculated air percentage as low as 31%, ducted return does not necessarily outperform plenum return in terms of overall vulnerability to airborne pathogens. Building-specific details and factors that are not easily represented with multizone modelling are important, making general preferential statements for either strategy difficult to make. Insights from this study can guide new construction and retrofits of buildings both during and after the COVID-19 pandemic with the aim of safe re-occupancy of buildings while keeping the buildings resilient against potential future events.

Keywords: CONTAM, COVID-19, SARS-CoV-2, HVAC, ventilation

1. Introduction

The heating, ventilating, and air conditioning (HVAC) systems of buildings require both supply and return air systems to maintain a required rate of airflow through the conditioned zones. Air return strategies used in the building HVAC system for commercial office buildings are commonly of two major types: overhead plenum return and overhead ducted return. In the plenum return strategy, air from a zone first passes to the plenum space above the suspended ceiling with lay-in acoustical tiles (suspended the roof or floor deck above), and kept at a negative pressure relative to the zone underneath. Air is then returned from this plenum space back to the air handling unit (AHU) of the HVAC system through a single return vent located in the plenum. Commonly, multiple zones of a single floor will have a single plenum zone above the floor. Ducted returns, on the other hand, have at least one dedicated return grille directly returning air from the zone through a duct back to the AHU of the HVAC system. Based on energy and indoor air quality considerations, there are varying schools of thought as to which technique is superior. It can be generally agreed upon that different return system types may have a significant effect on infiltration rates and air flow patterns in a building, thereby affecting energy consumption and indoor air quality.

A report from Bahnfleth et al. (2008) summarized a comprehensive literature review on the topic of plenum versus ducted return in which over 50 references were reviewed. The literature review noted that duct leakage in unconditioned spaces wastes substantial energy and may entrain contaminants into a building. According to one study, the HVAC systems with plenum returns consume comparatively less energy than the ducted returns due to lower static pressure drops (Hydeman et al., 2003). Studies suggest using ducted returns rather than plenum returns, as fan suction causes a greater negative pressure across the drop ceiling and building envelope with a plenum return (Harriman et al. 2001; Lstiburek 2002). The argument made here is that negative pressure of the plenum spaces can lead to infiltration and potential moisture build-up if the plenums are negatively pressurized with respect to the ambient environment, and that ducted return systems offer better control over the pressure boundary in order to contain any indoor release of airborne contaminants. Plenum spaces are also viewed as places for airborne contaminants to intermix with clean air before being redistributed by the HVAC system. Plenum spaces may also act as reservoirs of airborne contaminants where contaminants may gather. However, there is a lack of field measurement data and analytical models investigating these issues.

This paper describes a modelling study to investigate the differences in contaminant dispersion patterns under both the ducted and plenum return scenarios in a hypothetical office building. Airborne SARS-CoV-2 viruses were simulated as the airborne contaminant with the hope that any valuable insights gained from this study could provide important guidelines for both new constructions as well as retrofits and re-opening of existing office buildings to keep the occupants safe against the exposure to present and future airborne pathogens.

2. Materials and Methods

Simplified steady-state multizonal airflow and contaminant dispersion modelling was undertaken using CONTAM software Version 3.2 (Dols et al., 2015), of a detailed medium office prototype (DMOP) building. The DMOP building is one of the hypothetical prototype building designs developed by the Pacific Northwest National Laboratory under the U.S. Department of Energy's support of ANSI/ASHRAE/IES Standard 90.1 and IECC commercial building energy codes (DOE, U.S., 2020). The DMOP building is a three-story building with a floor area of 1660 m2 per level, two unpressurized stairwells, and three air handling units (one per level). Each floor contains one restroom with an exhaust fan. Figure 1 shows the schematic of the DMOP building used in our study

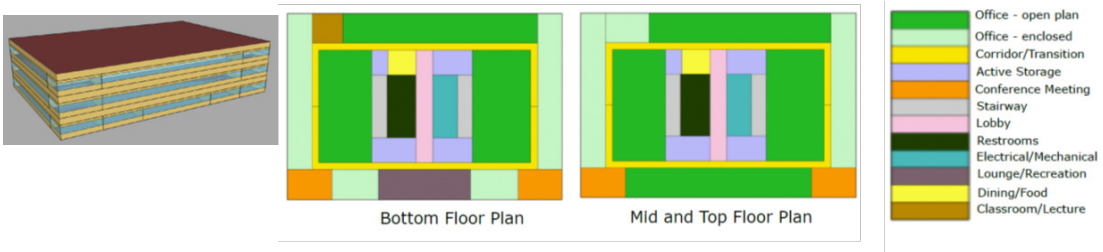

Figure 1: Model and Layout of DMOP Building (Im et al., 2018)

Simulated scenarios include both plenum and ducted returns in the DMOP building. For the ducted returns scenario, investigated cases include both no-plenum cases (only having ducted returns per zone), as well as cases with each zone having a 'dead' plenum space present above the zones (plenums still being present and housing mechanical and electrical components, but not serving as air return zones). Supply and return airflow rates for each zone were balanced (supply = return flow rates). For plenum return cases, return air vents were located in the plenum zone of the CONTAM model over each zone that had a supply diffuser. Air from the zone would then have a connection path to the plenum space via a return air grille opening in the drop ceiling.

SARS-CoV-2 aerosols released were simulated with physical properties closely matching that of water droplet (molecular weight = 18, effective density = 1000 kg/m3, specific heat capacity = 4200 J/kg.K). Mean diameter of the airborne virus aerosols was considered to be 0.1 μm based on the work of Lee et al., 2020. Although it is understood now that infectious respiratory viruses also exist in multiple numbers within larger droplets, our assumption of 0.1 μm mean diameter can be thought of as a worst-case scenario in which the larger droplets have shrunk in volume due to surface evaporation, and the smaller aerosols, of the order of individual virus particles, are suspended in the air (Lee et al., 2020). These smallest particles are bound to have lower terminal velocities induced by gravitational settling, hence will remain suspended in air for longer periods as sources of airborne infection sources inside

buildings. A simplified scenario was simulated in which an index person acting as a source releases the virus at a constant rate of 1 mg/s. With the source located in each of the 65 occupiable zones within the DMOP building, each simulation case resulted in 65 different concentration maps of the building. All 65 concentration maps were then averaged that then gave the overall representative integrated average concentration map of the building due to the presence of the single source.

In order to compare the different simulation cases against each other, vulnerability-based metrics were used for building performance evaluation with respect to the indoor dispersion of airborne pathogens. The building performance evaluation metrics were developed at the Pennsylvania State University (DeGraw, J.W. and Bahnfleth, W.P., 2011), which include:

(1) a graphical representation of the exposure dose (analogous to airborne pathogen concentration in a steady-state case) plotted against the cumulative area deciles of the occupiable zones of the building. Exposure doses are normalized by the release zone exposure dose, the release zone being located in the 10th decile when cumulative area fractions are arranged in ascending order according to the exposure doses; and

(2) a single quantitative figure, named as Exposure Improvement Score (EIS10), where the subscript 10 indicates a decile-based scoring scheme. Mathematically,

$$\mathrm{EIS}_{10} = \sum_{k=1}^{10} \alpha_k \frac{D_{\mathrm{baseline},k} - D_k}{D_{\mathrm{baseline},k}}, \qquad (1)$$

where,
α_k = the decile weight (=10 used for all deciles),
$D_{\mathrm{baseline},k}$ = the baseline exposure in decile k (this is the decile that includes the release zone), and D_k = the candidate exposure dose in decile k.

3. Results

Figure 2 shows the pressure distribution patterns within the building for all three cases: (a) plenum returns, (b) ducted returns but with dead plenum spaces present, and (c) ducted returns without any plenum spaces.

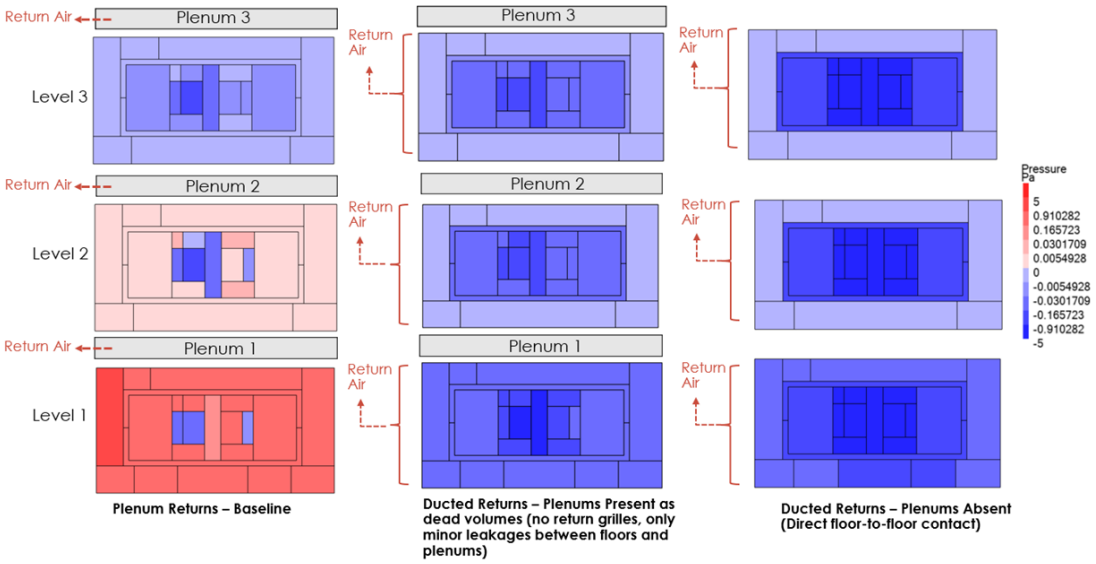

Figure 2: Pressure distribution patterns in all simulation cases of the CONTAM model for (a) plenum return cases (b) ducted return cases but with plenums present, and (c) ducted return cases without plenum spaces.

Figures 3 and 4 illustrate the overall integrated average concentration map of various levels of the DMOP building for the baseline case with plenum returns, as simulated in CONTAM under 0% and 31% outdoor air (OA) percentages supplied through the AHU, respectively.

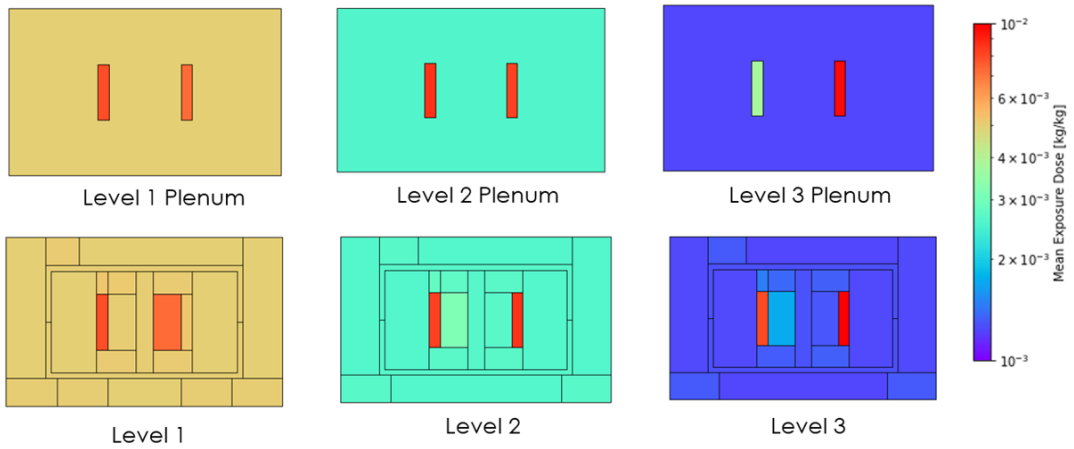

Figure 3: Integrated average exposure dose map of the DMOP building under 0% OA (100% recirculation) -baseline case (plenum returns).

31% OA was simulated because it was the minimum required ventilation rate according to the ASHRAE 90.1-2013 Standard (ASHRAE, 2013). Subsequent increases in OA% gave very similar results to the 31% OA case.

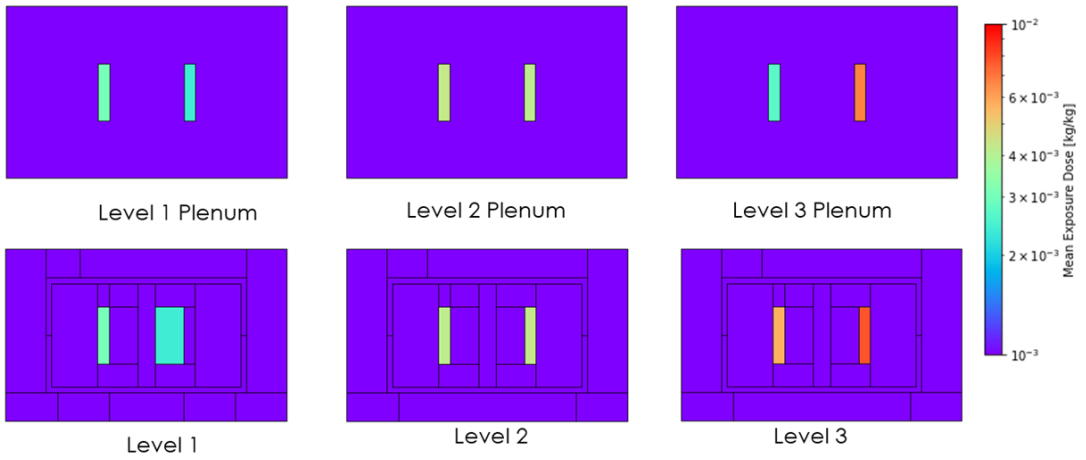

Figure 4: Integrated average exposure dose map of the DMOP building under 31% OA – baseline case (plenum returns).

Figure 5 illustrates the integrated average exposure dose map of the DMOP building under 31% OA for ducted returns case but with plenums still present over each floor as dead spaces.

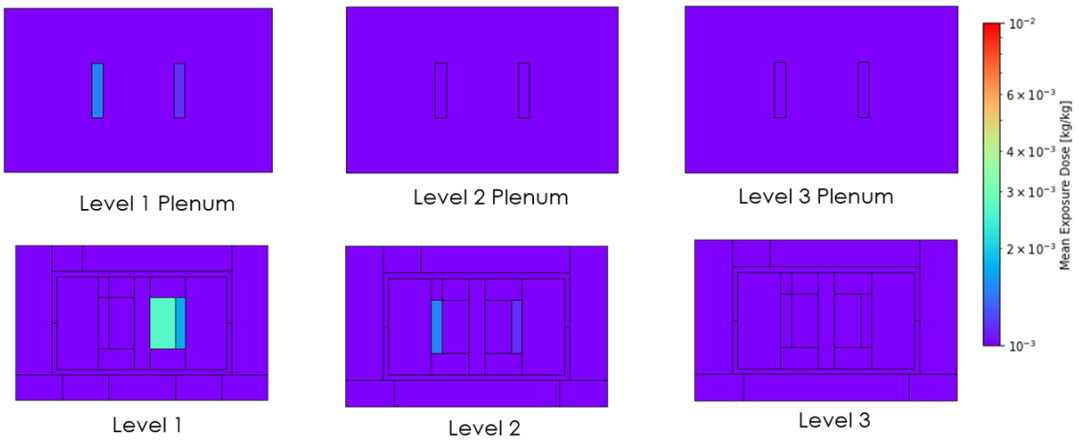

Figure 5: Integrated average exposure dose map of the DMOP building under 31% OA – ducted returns case (plenums present).

Figure 6 illustrates the 31% OA case for the DMOP building with ducted returns, but with plenum spaces removed. The height of the plenum spaces included in the previous cases, was instead, added to the height of the floors below.

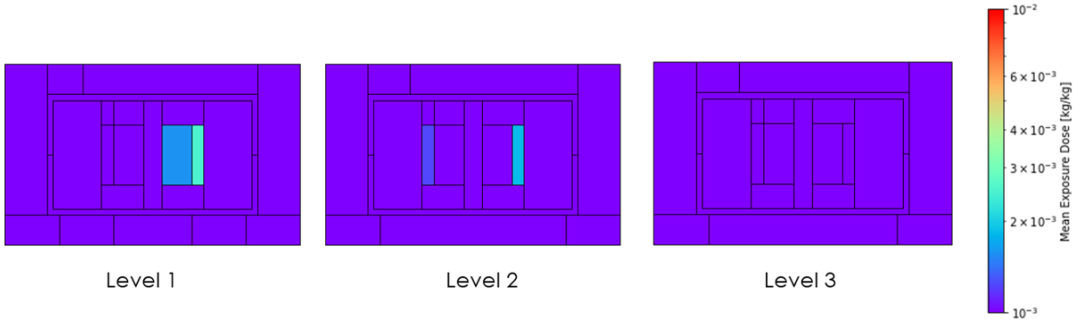

Figure 6: Integrated average exposure dose map of the DMOP building under 31% OA – ducted returns case (plenums absent).

Figure 7 below illustrates the comparative graphical metric of normalized exposure dose plotted against the cumulative area deciles of all simulated cases under 0%, 31%, 50% and 100% OA to show the impact of varying levels of ventilation of the overall building.

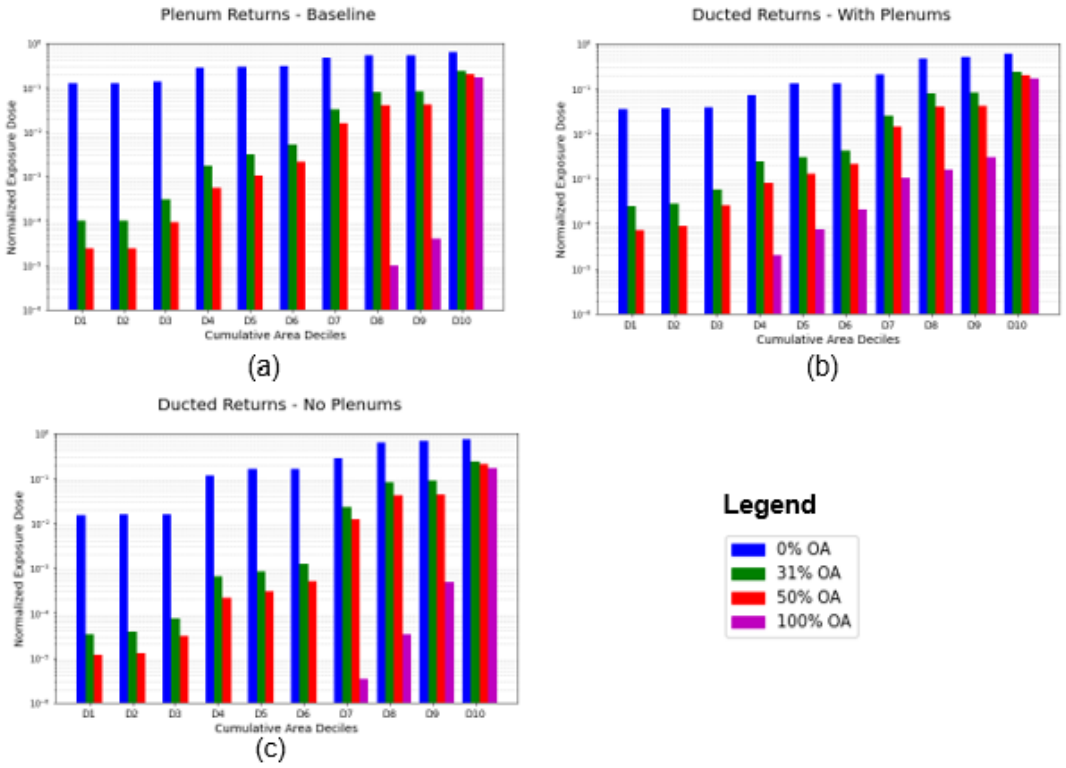

Figure 7: Normalized exposure dose plotted against the cumulative area deciles of the DMOP building for the following cases: (a) Plenum returns (baseline case), (b) Ducted returns (plenums present), and (c) Ducted Returns (plenums absent).

Table 1 summarizes the EIS10 scores for various OA percentages and all three test cases.

OA % supply from AHU	EIS_{10} Score Value		
	Baseline Case (Plenum Returns)	Ducted Returns Case (Plenums Present)	Ducted Returns Case (Plenums Absent)
0 %	63.70	67.54	64.70
31 %	88.70	87.39	87.41
50 %	89.39	88.69	88.71
100 %	90.00	89.93	89.97

4. Discussions

Figures 3 and 7 show that the exposure doses within the simulated DMOP building could vary by orders of magnitude depending on the zone. The stairwells that had no air supply diffusers or associated return grilles, were found to have significantly elevated exposure doses than the rest of the zones for the plenum return (baseline) case.

From Figures 3 and 4, there is a drastic improvement in the risk reduction due to ventilating the building with as low as 31% outdoor air. As the outdoor air percentage is further increased from 31%, all the way to 100%, there is little reduction in whole-building integrated averaging exposure dose map. Also, this results in little change in EIS10 scores (Table 1). This suggests that increase in ventilation rates plays a disproportionate role in exposure risk reduction, and becomes more important when the building is under-ventilated.

From Figures 4, 5 and 6, it can be seen that ducted returns do lead to lower peak exposure doses for each zone under at least 31% OA. This reduction in peak exposure doses can be most significantly noted in the stairwells. However, Figure 7 shows that the proportion of the overall building affected by non-zero exposure doses of the airborne aerosols was not significantly improved in most cases by the ducted air return strategies, both when plenum dead-spaces were present as well as absent. For 100% OA in the air supply mix, ducted return strategies caused a greater portion of the building to experience a non-zero exposure dose than the plenum return case.

To test the argument that ducted returns can offer better confinement of contaminants within the release zone if the release zone is maintained under negative pressure relative to the surrounding zones, special cases were also investigated by increasing the return airflow rates by 10% such that the release zone was maintained under a relative negative pressure of at least 4 Pa. Detailed investigation of the airborne pathogen distribution patterns of the individual runs that targeted the containment of airborne pathogens in the release zone with negative pressurization was achievable almost equally easily with plenum return case as either of the ducted return cases for a 31% OA ventilation rate and above. However, the containment effect was inconsistent for lower OA% across the three cases. For the negative-pressure containment

strategy, the return air flow rate in the release zone was increased by 10% compared to the supply airflow rate that resulted in pressure differentials across adjacent zones of at least 4 Pa. It is to be noted, however, that the negative-pressure containment strategy is more meaningful in healthcare facilities than office buildings due to the lack of predictability of the location of infected sources in office buildings.

5. Conclusion

In conclusion, the methods used in this study for mapping the exposure doses of airborne SARS-CoV-2 aerosols can provide a basis to make alterations to the building occupancy patterns after post-pandemic reopening so as to minimize exposure risk to the majority of the occupants. While re-iterating the importance of increasing ventilation rates as the most important mitigation measure for exposure risk reduction to the occupants, this study also highlighted that air return strategies alone have minimal impact for the risk reduction.

6. Acknowledgements

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7. References

ASHRAE, 2013. STANDARD 90.1-2013 - ENERGY STANDARD FOR BUILDINGS EXCEPT LOW-RISE RESIDENTIAL BUILDINGS [Online]. Available: https://www.ashrae.org/technical-resources/bookstore/standard-90-1.

Bahnfleth, W. and Novosel, D., 2008. IMPACT OF AIR RETURN STRATEGY ON BUILDING ENERGY CONSUMPTION AND INDOOR AIR QUALITY.

DeGraw, J.W. and Bahnfleth, W.P., 2011. Quantifying Chemical/Biological Event Severity with Vulnerability-Based Performance Metrics. ASHRAE Transactions, 117(1).

DOE, U.S., 2020. Commercial Prototype Building Models [Online]. Available: https://www.energycodes.gov/development/commercial/prototype_models [Accessed February 9, 2021].

Dols, W.S. and Polidoro, B.J., 2015. CONTAM User Guide and Program Documentation: Version 3.2.

Harriman, L.G., Brundrett, G.W. and Kittler, R., 2001. Humidity control design guide for commercial and institutional buildings.

Hydeman, M., Taylor, S., Stein, J., Kolderup, E. and Hong, T., 2003. Advanced variable air volume system design guide. California Energy Commission's Public Interest Energy Research (PIER) program, 2.

Im, P. and New, J.R., 2018. Updated OpenStudio (OS) Small Office Prototype Model (No. ORNL/SPR-2018/885). Oak Ridge National Lab.(ORNL), Oak Ridge, TN (United States).

Lee, B.U., 2020. Minimum sizes of respiratory particles carrying sars-cov-2 and the possibility of aerosol generation. International Journal of Environmental Research and Public Health, 17(19), p.6960.

Essence of Multidisciplinary Effort for Sustainable Development: Lessons Learnt from COVID-19 Pandemic

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Abstract

COVID-19 pandemic that has been spreading all over the world after it originated from China in late 2019, claimed millions of lives. It has not only changed the daily lifestyles, perceptions, and behaviour but also has been a benchmark to tackle the biological disaster along with other recurrent disaster events through a multidisciplinary approach. This paper briefly presents the multidisciplinary efforts on developing a risk assessment tool during the pandemic and the scenario of research and practice in engineering disciplines to follow in the future for resilient and sustainable development.

Keywords: COVID-19, engineering and design, multidisciplinary approach, risk and resilience, sustainable development

1. Introduction

China originated Coronavirus disease (COVID-19) outbreak in late 2019 has been spreading worldwide claiming millions of lives (World Health Organization, 2020c). The rapid rate of human-to-human transmission of the virus has been threatening the health and livelihood of the entire world (Shereen et al., 2020). It was declared as a pandemic on 11th March 2021 by the World Health Organization (WHO). Many countries enforced strict lockdown to limit the spread of COVID-19 (Kusum Sharma et al., 2021). WHO issued guidelines for responding to viruses prioritizing actions including maintaining hospital facilities, raising public awareness, and stocking up medical supplies (World Health Organization, 2020b).

Public awareness of causative factors of COVID-19, its intensity, risk level, and consequences can help motivate people to adopt the required public health measures rather than ignoring or over-reacting during this pandemic. Appropriate risk perception and communication could greatly help in reducing fear and increasing knowledge sharing during pandemics (Cori et al., 2020). Several vaccines are rolling out across the world which is limiting the number of hospitalization cases and deaths; however, the fear of virus mutations and the ongoing economic impact is still worrisome.

Pandemic has not only threatened the public health and health facilities but has a direct impact on the daily life of individuals all over the world. The supply chain had greatly affected during the first phase of the pandemic which still is under stress due to reduced capacities to comply with public health regulations. Apart from the manufacturing; logistics, infrastructures to manage the supply chain was very challenging in the early days (Singh et al., 2021). The engineering community has also greatly affected during the pandemic, however, the opportunity in several sectors including Information Technology (IT) was demanding and challenging. The situation clearly shows the importance and direction of a resilient future through advanced and interdisciplinary engineering (National Engineering Policy Centre, 2020).

Engineers from several sectors and other professionals joined their hands together in tackling the pandemic. This paper briefly discusses the multidisciplinary efforts in pandemic management, the role of engineering for a resilient future, and the multidisciplinary approach for sustainable development.

2. Multidisciplinary Effort in Pandemic Management

The unprecedented situation arose due to the pandemic had put the engineering on top of the discipline to manage it, however, most of the engineers are not taken as the frontline workers. IT has been taking a major role in handling the situation. IT sector is evolving with new advancements and uses across the wider population these days, but the current situation stressed it to leap to the next level. Working from home environment has changed the daily lifestyles, it demands more internet facilities to accommodate across the cities. Infrastructure and bandwidth management was crucial when the demand suddenly soared. Logistics management to working environment IT has taken the leading role in pandemic management.

One of the major issues during the pandemic is 'infodemic', cyber threats and misinformation control are the major challenges to the IT sector. People who believe in misinformation and act accordingly not only linger the situation management but also directly harm public health and pay the lives (World Health Organization, 2020a). Knowledge and perception of the public during the pandemic and other disasters play a key role in mitigating the losses and efficacy of management. Risk knowledge and preparedness of citizens against any disaster are lacking in developing countries (Parajuli, 2020).

Engineering has mainly two sides in overall pandemic management. One is facilitation through the information system to provide emergency logistics and other administrative requirements, and the other is providing the proper risk communication to the people.

There are several approaches to communicate with people on providing accurate information, where providing the application to assess the risk and other information regarding the COVID-19 is one of the efficient ways. For example, COVIRA, a COVID-19 risk assessment tool (web application available at www.covira.info) has been introduced to assess the personal and regional risk assessment for Nepal (Parajuli, Mishra, et al., 2020). This tool has been designed to incorporate every aspect of risk factors to pose in the personal and regional level, where public health facilities, socioeconomic conditions, population density, general health condition of people in the region, infected people in the region and neighbourhood are used in a risk model to provide the regional risk. Personal behaviours, age, gender, local regional risk, daily activities, etc are influencing factors in the personal risk model. IT engineers supported on development of the tool where public health and medical experts support the selection of factors and their influences, social science experts provide more insight on socioeconomic conditions, spatial data scientists contributed to spatial analysis. The conceptualized framework proposed by an engineering researcher, supported by researchers from several other disciplines concluded a good asset as a risk assessment tool. Figure 1 shows the snippet of the web application, where people from Nepal and all over the world assessed personal risk, where regional risk (risk at the municipal level) has been assessed for several municipalities.

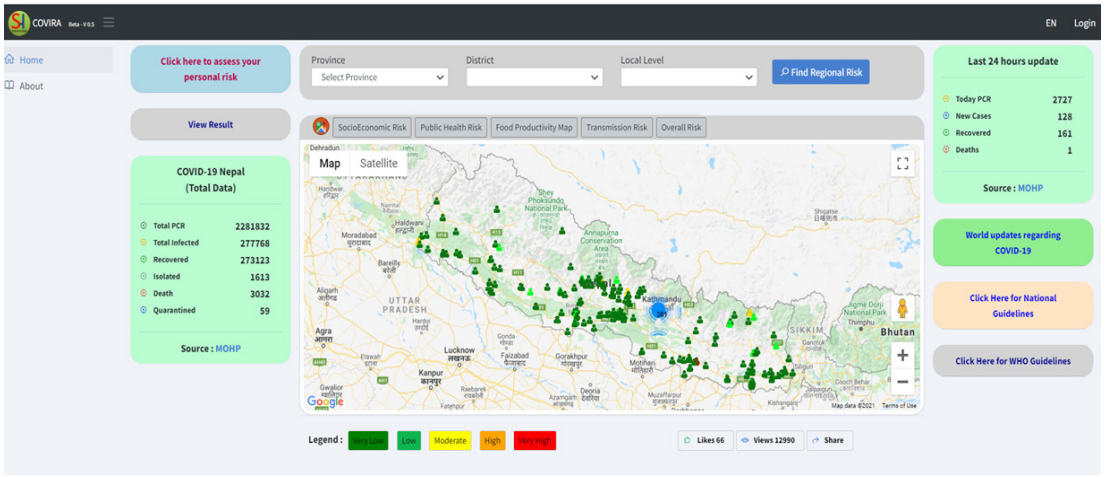

Figure 1: Snippet of the web application COVIRA (www.covira.info)

3. Engineering for Resilient Future

Advancements in science and engineering in every sector are evolving, which demands more contribution from engineering where it connects science to the people through the application. Infrastructure and management of information systems are crucial at the same time engineering community need to be more liable and responsible day by day. Recent developments on controlling fake news and restricting the posts by world leaders on social media platforms have controversies, however, it clearly shows that the future of the world will be more reliant on technology.

Now, the time has come to incorporate users' voices during the early days of project inception. Digital technology can be used to do the surveys in a very short period with minimal cost; to know the views, concept, perception, of any public infrastructure. It will not only provide the information to the public, but they can also feel their ownership, which will ultimately help on project completion and execution.

Resilience is the capacity to cope with any future shocks and stresses in any form. A resilient community would be an ideal community that is ready to withstand any level of shocks (natural or manmade disasters). It depends on the capacity of community members and infrastructures. Participatory and interdisciplinary approaches on risk and resilience assessment of infrastructures and community are going to be implemented in several sectors. The Gorkha Earthquake 2015, Mw7.8 that struck in central Nepal left several lessons to the community (Parajuli & Kiyono, 2015; Keshab Sharma et al., 2017). A study developed a framework and tool (mobile and web application) for educational community resilience assessment that has been proposed for Nepal and implemented in several municipalities (Parajuli, Xanthou, et al., 2020). It shows a good result on social capacity, knowledge, perception, and preparedness on disaster risk. It has now extended to Malawi and is scalable to any other country.

4. Multidisciplinary Approach on Sustainable Development

The COVID-19 pandemic surfaced the essence of multidisciplinary efforts for sustainable development. Natural hazards are the main risk factors to consider in any project design in addition to the internally associated risks. The recent scenario due to the COVID-19 has been demanding additional considerations. For example, work from the home environment has not been thought on the design of houses and flats; fresh air circulation has not been considered as one of the main requirements in public areas. Engineering sectors are looking for interdisciplinary efforts to have a resilient infrastructure as like Cotterill et al did in the water sector in the UK (Cotterill et al., 2020).

United Nations has introduced sustainable development goals (SDG), where 17 different goals are listed to achieve by 2030 (United Nations, 2018). Disaster risk reduction initiatives are further elaborated through Sendai Framework, to support the SDG (United Nations, 2015). Each goal set by the international community should be backed by the engineering sector in collaboration with other disciplines out of engineering. Interdisciplinary efforts on any project would provide a better result, considering wider prospects on design requirements and use, which helps towards sustainability. Some of SDGs for example education(4), water and sanitation(6), energy(7), infrastructure(9), sustainable and resilient cities(11), and climate actions(13) are the thematic areas where the engineering sector has the leading role along with a supportive role in the rest of them.

5. Concluding Remarks

The COVID-19 pandemic dragged the overall development courses all over the world, however, it has been leaving lessons to move forward with a better and resilient future. Public health parameters should be considered in designing the infrastructures where people are expected to gather. The engineering sector has more responsibility for the advancement of technology and its application in the community. It has further shown that multidisciplinary efforts are essential in most of the projects to make the community more resilient. Hence, collaboration among different sectors within engineering and others is vital.

6. References

Cori, L., Bianchi, F., Cadum, E., & Anthonj, C. (2020). Risk Perception and COVID-19. International Journal of Environmental Research and Public Health, 17(9), 3114. https://doi.org/10.3390/ijerph17093114

Cotterill, S., Bunney, S., Lawson, E., Chisholm, A., Farmani, R., & Melville-Shreeve, P. (2020). COVID-19 and the water sector: understanding impact, preparedness and resilience in the UK through a sector-wide survey. Water and Environment Journal, 34(4), 715–728. https://doi.org/https://doi.org/10.1111/wej.12649

National Engineering Policy Centre. (2020). COVID 19 : Engineering a resilient future (Issue June). https://www.raeng.org.uk/publications/reports/covid-19-engineering-a-resilient-future

Parajuli, R. R. (2020). Citizen Disaster Science Education for effective disaster risk reduction in developing countries. Geoenvironmental Disasters, 7(12).

Parajuli, R. R., & Kiyono, J. (2015). Ground motion characteristics of the 2015 Gorkha earthquake, survey of damage to stone masonry structures and structural field tests. Frontiers in Built Environment, 1(23). https://doi.org/10.3389/fbuil.2015.00023

Parajuli, R. R., Mishra, B., Banstola, A., Ghimire, B. R., Poudel, S., Sharma, K., Dixit, S. M., Sah, S. K., Simkhada, P., & van Teijlingen, E. (2020). Multidisciplinary approach to COVID-19 risk communication: a framework and tool for individual and regional risk assessment. Scientific Reports, 10(1), 21650. https://doi.org/10.1038/s41598-020-78779-0

Parajuli, R. R., Xanthou, M., Agarwal, J., & Sextos, A. G. (2020). Resilience of educational communities in developing countries : a multi-disciplinary approach. 17th World Conference on Earthquake Engineering.

Sharma, Kusum, Banstola, A., & Parajuli, R. R. (2021). Assessment of COVID-19 Pandemic in Nepal: A Lockdown Scenario Analysis. Frontiers in Public Health, 9(599280). https://doi.org/10.3389/fpubh.2021.599280

Sharma, Keshab, Subedi, M., Parajuli, R. R., & Pokharel, B. (2017). Effects of surface geology and topography on the damage severity during the 2015 Nepal Gorkha earthquake. Lowland Technology International, 18(4), 269–282.

Shereen, M. A., Khan, S., Kazmi, A., Bashir, N., & Siddique, R. (2020). COVID-19 infection: Origin, transmission, and characteristics of human coronaviruses. Journal of Advanced Research, 24, 91–98. https://doi.org/10.1016/j.jare.2020.03.005

Singh, S., Kumar, R., Panchal, R., & Tiwari, M. K. (2021). Impact of COVID-19 on logistics systems and disruptions in food supply chain. International Journal of Production Research, 59(7), 1993–2008. https://doi.org/10.1080/00207543.2020.1792000

United Nations. (2015). Sendai Framework for Disaster Risk Reduction 2015-2030.

United Nations. (2018). Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development. https://unstats.un.org/sdgs/indicators/Global Indicator Framework after refinement_Eng.pdf

World Health Organization. (2020a). Managing the COVID-19 infodemic: Promoting healthy behaviours and mitigating the harm from misinformation and disinformation. WHO. https://www.who.int/news/item/23-09-2020-managing-the-covid-19-infodemic-promoting-healthy-behaviours-and-mitigating-the-harm-from-misinformation-and-disinformation

World Health Organization. (2020b). Responding to community spread of COVID-19. In Interim Guidance 7 March (Issue March).

World Health Organization. (2020c). Situation Report. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports

COVID-19 impacts on energy systems in Nepal: Implications for SDGs

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Abstract

The COVID-19 pandemic has caused severe interruption to the energy sector, leaving impacts that will be felt for years to come. Nepal is also one of the signatory countries of the 2030 agenda for Sustainable Development (SDG). The world faces enormous challenges to provide resilient electricity to their 30 million people under goal 7.1 universal access to affordable, reliable and modern energy service. Furthermore, the government follows the UN's 2030 Agenda for Sustainable Development with the robust national commitment to transformative change in the country through its integrated approach and the principle of 'Leaving no one behind'. However, multidimensional poverty, structural challenges of the economy, complicated geophysical features, and fragile environmental situations continue to pose severe challenges for promoting rapid, inclusive, equitable, and sustainable development of the energy sector in Nepal. This article reflects the impact of COVID-19 on the energy sector in Nepal and the implication for the SDGs. That weakened global cooperation reducing the chance of fast-tracking and streamlining the low-carbon transition worldwide. First, the researcher analysed the worldwide impact, and linked and compared it with Nepal's results in detail. Nepal will need US$ 20.25 billion to meet different SDGs.This research focused on literature, observation, and data analysis from various sources. After reviewing the progress, the researcher concluded that the overall development was affected by the COVID-19 pandemic, creating additional problems in achieving the SDGs target. According to the cost estimates, US$ 5.39 billion a year was insufficient.

Keywords: COVID-19 pandemic, energy security, energy sovereignty, renewable energy, sustainable development goals, system resilience

1. Introduction

Energy has become a central policy focus in the COVID-19 crisis. This pandemic has caused more severe interruption to the energy sector, leaving impacts that will be felt for years to come (International Energy Agency, 2020).The COVID-19 pandemic has obliged governments worldwide to impose strict daily life restrictions to avoid spreading the virus. During these restrictions, roads and airports are nearly empty, shops and restaurants are closed, and industrial activities are principally at a halt globally (Aruga, Islam, and Jannat, 2020).Therefore, energy demand has plummeted by record levels. Global energy demand is set to plummet by 5% in 2020, energy-related CO2 emissions by 7%, and energy investment by 18%. The impacts vary by fuel. The approximate falls of 8% in oil demand and 7% in coal use stand in sharp contrast to a slight rise in renewables' contribution. The reduction in natural gas demand is about 3%, while global electricity demand looks set down by a relatively modest 2% for the year. The impact of COVID-19 on energy demand in 2020 was more than seven times larger than the effects of the 2008 financial crisis (IEA, 2020).

Nepal, least developed and a landlocked nation located in South East Asia has also been witnessing many unpleasant impacts of COVID-19, - more than seven thousand deaths and total COVID-19 cases have passed five hundred and eighty thousands as of 5th June 2021 (Worldometer, 2021). Nepal Government Imposed the 1st lockdown in the last week of March 2020 to control the Coronavirus and again 2nd lockdown in 1st week of May 2021. The lockdown has fully affected the country and peoples that created a huge challenge to achieve the national and international targets. It has also negatively impacted in energy sector. Similarly, Nepal also faces a question as to whether the real crisis of COVID-19 could setback to the achievement of the SDGs by 2030.

Nepal follows the 2030 Agenda for Sustainable Development with the robust national commitment to transformative change in the country through its integrated approach and the principle of 'Leaving no one behind' (National Planning Commission, 2020). However, multidimensional poverty, structural challenges of the economy, complicated geophysical features, and fragile environmental situations continue to pose severe challenges to promoting rapid, inclusive, equitable, and sustainable development in Nepal (National Planning Commission, 2020). Nepal's average economic growth rate was 7.3 percent in the past three years (CBS, 2020a). Furthermore, Nepal has an enormous hydropower potential, which could be harnessed further to boost sustainable energy, accelerate economic growth, and reduce greenhouse gas (GHG) emissions (National Planning Commission, 2020). Going for hydropower development blindly is not the only solution for sustainability. Such as West Africa commissioned the largest solar park to reduce the country's dependence on hydroelectricity-currently jeopardised the country's natural forests (Gwenaelle Deboutte, 2020).

Nepal is a very vulnerable country by the risk index of a natural disaster for 2020, by earthquake 9.9 out of 10, Food by 6.7, Epidemic by 6.6, drought 2.8, and tropical cyclone by just 0.2 (Statista, 2020). Nepal Government should take a robust stand, as reflected in its whitepaper's motto for renewable energy, "Harek Ghar Urja Ghar," meaning every house is a powerhouse. It is now the time to put climate first and implement real action post COVID-19 situation (Poudyal, 2021).

The primary objective of this research was to examine the COVID-19 impacts on energy systems in Nepal: Implications for SDGs, specially in SDGs 7. This article has focused on how energy system is being impacted and how effective measures taken by the government authority to deal with the COVID-19 on energy system and finding the target of SDGs.

The energy industry is feeling the financial impact throughout value chains, with most energy companies losing substantial revenues. In effect, they are being hit twice, first by lower demand for their products – including oil, gas, coal, and electricity – and again by lower prices for these products (Energy Agency, 2020).

Despite Nepal's significant growth in meeting targets set by SDGs, the COVID-19 pandemic has made underpinning efforts to implement SDGs more imperative. Although Nepal has not assessed the full implications of COVID-19, this article will help that gap. The signs are apparent that it will have a comprehensive impact, rigorously weakening Nepal's capacity to implement SDGs (South Asia Watch on Trade, 2020). Furthermore, progressing on the SDGs is more significant for Nepal since it aspires to graduate to a developing country from a least developed country by 2022. Making rapid development in reaching the SDGs in the remaining 9 years would be a mounting task even in typical situations. But just when the country was beginning to appear from the devastating impacts of the 2015 earthquake, the COVID-19 came forward (South Asia Watch on Trade, 2020).

Following this introduction, section 2 illustrates the Methods and data sources, primary and secondary data collection. Section 3 describes Literature Review, section 4 contains the finding and discussions, followed by Conclusion and Policy Recommendation in section 5.

2. Methods and Data Sources

The methodology of this paper integrate various phases like literature review, collection of data from different sources, analysis and graphical interpretation of collected data. During the collection of required data and suitable literature studies, international journal articles, newspapers and magazines, annual reports of Nepal Electricity Authority (NEA), Nepal Oil Corporation (NOC), IEA, WHO, UNDP, ADB and the worldometers have been searched thoroughly. After the study, it is found that no study has been conducted to analyse the impact of COVID-19 on energy sector and it's interlinked with SDGs of Nepal in detail. Therefore this article helps to fill that research gap in the related literature.

2.1 Data collection

For this research, primary data were collected by using different data collection techniques such as the international organisations and government organisations like Worldometer, United Nations, NEA, NOC, and the Ministry of Energy, Water Resources and Irrigation. Various newspapers and magazines like The Kathmandu Post, The Rising Nepal, The Himalayan Times, Kantipur, Gorkhapatra, Nagarik, Naya Patrika, Vidyut journals of NEA, Himal Khabar are consulted for updated situation. Interviews of various chiefs of energy related personnels and zoominar, Nepal Engineers Association, NRNA knowledge conferences, Institute of Engineering (IOE) Graduate conferences are observed for the secondary data and the updated views.

3. Literature Review

In preparation for the study, related literature was reviewed, documents analysed, and extensive discussions were held with the relevant stakeholders. However, very limited research has been considered in this field, such as Cheshmehzangi (2020), Qarnain, Muthuvel and Bathrinath (2020), Wang and Su (2020), Klemeš, Fan and Jiang (2020), Bahmanyar, Estebsari, and Ernst (2020), Rugani and Caro (2020), Graff and Carley (2020), Aruga, Islam and Jannat (2020), Singh, D.B. and Sah D.K (2021). Therefore this article will fill the gap in the energy sector impact of COVID-19. The COVID-19 pandemic has adverse impacts on nearly all SDGs, which may subside in the medium and long terms. Major looming factors causing the negative impacts include lockdowns, unemployment, and diluted focus for non-COVID-19 issues. However, this pandemic also has available opportunities for sustainable transformation, short-lived and will get overtime. (Pradhan, P. et al., 2020). Lockdown had severe effects on accomplishing SDGs 1 and 2. The absence of the right policies to support food production and its security during the crisis was exposed (Adhikari, J. et al., 2020).

As severe lockdowns were imposed worldwide from 24 March 2020, a 20-25 % decline in electricity and petroleum products (petrol, diesel, and aviation fuel) demand was declined by 70%, and Liquefied Petroleum Gas (LPG) has decreased by 34%.

COVID-19 has disclosed how the global energy systems can become vulnerable and lead to increased energy insecurity and loss in production, and GDP loss. The drop in economic movement due to the pandemic is estimated to impact the industry's heat consumption more than in buildings (IEA, 2020). Giacomo Luciani (Luciani, 2020) argues that the shock of COVID-19 on energy transitions cannot be considered unless other approaching crises are also considered.

Interestingly, the COVID-19 emergency has helped us to curb down the CO2 emission at a record level. Global CO2 emissions are expected to decline by 8%, or approximately 2.6 gigatonnes (Gt), to levels of 10 years ago. Such a year-on-year decline would be the biggest ever, six times larger than the previous record reduction of 0.4 Gt in 2009, caused by the global financial crisis, and twice as large as the combined total of all earlier deductions since the end of World War II (IEA, 2020). However, the bounce back in emissions may be out-sized than the decline unless the wave of investment to restart the economy is committed to a cleaner and more resilient energy infrastructure (IEA, 2020).

Sustainable Development Goal 7 (SDG7) aims to "ensure access to affordable, reliable, sustainable and modern energy for all" by 2030 and has well-defined targets such as establishing universal access to modern energy services, increasing the global proportion of renewable energy, and doubling the enhancement in energy efficiency improvement. The world is making improvements towards Goal 7 (United Nations, 2019), with cheering signs that life is becoming more sustainable and extensively available. Access to modern energy in poorer countries has begun to accelerate, energy efficiency continues to recover, and renewable energy is making notable gains in the electricity sector. Nevertheless, more focused awareness is needed to improve access to clean and safe cooking fuels and technologies for 3 billion people, expand the use of renewable energy beyond the electricity sector, and boost electrification in sub-Saharan Africa (United Nations, 2017). Moreover, energy security has been the most significant goal for achieving sustainable development (Le and Nguyen, 2019). Energy security plays a central role in assuring the stable development of countries. Therefore, energy security must be an integral part of national security (Proskuryakova, 2018).

"There are so many problems within our system, so much ambiguity, and COVID-19 came in between. If the government fails to come up with a solid rescue plan without delay, the whole power sector will fall in no time," said Shailendra Guragain, former President of the Independent Power Producers of Nepal (IPPAN) (Bhusal, 2020). He also said "aside from the bureaucratic and other delays in project initiation, the lockdown, and floods have delayed projects that would have started within the coming year," (Baskota, 2020). Longer-term projects worth 300MW are also stuck at the financial closure stage because of the pandemic. Then there are other private sector projects totaling 18,000 megawatts awaiting a Power Purchase Agreements (PPA) entangled in bureaucracy (Baskota, 2020). The 14th Plan (2016/17–2018/19) was the first periodic plan to mainstream and internalise the 2030 Agenda. The recently released 15th Plan (2019/20-2023/24) has continued to align and mainstream the SDGs (National Planning Commission, 2020).

The Government of Nepal and the World Bank Board signed a $100 million Development Policy Credit (DPC) to improve the energy sector's financial viability and governance and recover from the COVID-19 crisis (The World Bank, 2020). "This operation will help Nepal develop a reliable, affordable, and sustainable energy sector that supports poverty reduction and shared prosperity in the country." - Faris Hadad-Zervos, World Bank Country Manager for Nepal.

The leaders of 75 nations set out their new Climate Ambition at a UK-COP26 hosted Summit. Significantly 24 of them, including Nepal, and the UK, set out the dates by which they will be 'net-zero' carbon emitters. In Nepal, Prime Minister K P Oli made Nepal's ambition to achieve net-zero emissions by 2050. He also proclaimed that Nepal would develop 15GW of clean hydropower, maintain 45 percent forest cover, and ensure that 90% of new vehicles be electric by 2030 (Pollitt, 2020). In the UK, Prime Minister Boris Johnson dedicated the UK's new 10-point climate action plan. The policy in the action plan is likely to a 68% reduction in emissions by 2030. He also publicised that the UK would ban all petrol and diesel car sales, protect 30% of its land and sea by 2030, and use its notably chaotic weather to turn the UK into the global wind power leader (Pollitt, 2020).

The latest Renewable energy statistics comes as we struggle with the most effective way to rebuild our economies while perusing the goals of SDGs and the Paris agreement. Energy is the keystone of the sustainable future, and while the direction of travel is clear a much faster energy transition is essential. Amid the great challenges and uncertainty of COVID-19, The case of an accelerated transition is attractively increasing. Costs are falling, clean tech markets are booming and never have the benefits of the energy transition been so clear. The world added more than 260GW of renewable energy in 2020, exceeding expansion in 2019 by 50 % (IRENA, 2021).

4. Finding and Discussion

The SDGs Report 2020 conveys the latest data to present that progress remained uneven before the COVID-19 pandemic and not on track to meet the Goals by 2030. Further, due to COVID-19, exceptional health, economic and social crises threaten lives and livelihoods, making the realisation of SDGs even more challenging.

The Coronavirus pandemic has posed an additional challenge to Nepal, as the country has no proper healthcare system and resilient health infrastructure which has usually found it difficult to meet the United Nations' development targets by 2030. Reviewing the implementation of the strategy formulated by the Government of Nepal to achieve the SDGs, the National Planning Commission (NPC) has stated that the challenge has been added due to the epidemic. Reviewing last year's progress, the commission concluded that the overall development was affected by the pandemic, creating additional problems in achieving the SDGs target. Due to lack of data and lack of tracking system, there is a problem in formulating future strategy by analysing the progress.

The commission estimates that Nepal will need US$20.25 billion every year for 12 years to meet 17 different goals. The commission estimated that 55% of the total investment required each year, or US$13.5 billion, would come from the government and the remaining 45% from

the private sector. Even if 10% of the required investment comes from development assistance, the commission estimates that the acquisition of US$5.39 billion will be insufficient annually, according to the recent report from National Planning Commission

Table 1: Import of petroleum products 2019 – 2020 (NOC,2020)

	unit	January	February	March	April	May	June	July
2019								
Petrol	KL	46,880	43,400	47,348	48,604	53,564	49,676	48,948
Deisel	KL	151,976	140,144	151,140	159,092	177,932	166,932	148,352
Kerosene	KL	1,948	2,028	1,944	2,060	2,008	2,508	2,252
Aviation Fuel	KL	16,006	15,332	18,164	19,756	17,232	14,304	14,664
LPG	MT	40,457	35,754	40,814	37,615	35,645	33,925	37,697
2020								
Petrol	KL	50,036	49,636	47,008	4,684	20,208	34,848	44,488
Deisel	KL	162,888	157,912	117,736	39,848	93,076	142,588	100,460
Kerosene	KL	1,504	1,512	1,040	40	60	1,104	1,940
Aviation Fuel	KL	17,156	15,884	10,256	120	160	368	1,908
LPG	MT	39,127	41,115	45,300	35,218	31,677	31,576	30,853

	unit	August	September	October	November	December	Total
2019							
Petrol	KL	54,364	48,288	55,880	54,252	49,316	600,520
Deisel	KL	110,988	102,236	125,164	143,168	162,448	1,739,572
Kerosene	KL	2,764	2,904	1,192	2,332	2,012	25,952
Aviation Fuel	KL	13,696	15,876	21,036	17,424	16,488	199,978
LPG	MT	31,563	40,265	36,952	42,168	41,885	454,740
2020							
Petrol	KL	35,672	36,736	54,912	51,364	60,596	490,188
Deisel	KL	61,632	90,796	128,896	131,832	189,672	1417336
Kerosene	KL	892	824	2,880	2420	2,740	16,956
Aviation Fuel	KL	2,888	3,248	6,800	6,080	8,672	73,540
LPG	MT	34,143	38,530	36,184	38,655	40,809	443,187

The impact of lockdown can be seen in import of petroleum products as per the data shown in Table 1. The decrease in import of petrol has also decreased the revenue paid to IOC in FY 2076/77 to 6 billion which accounts for the decrease of 20.04%. If the COVID-19 would not have persisted, with the on-going increasing trend in previous years, the import in FY 2076/77 would have been nearly about 13.38% more, and revenue to be paid to IOC would have been 15.35% more than in 2075/76. In FY 2075/76, NOC imported 1,717,517KL of diesel which is 117.42% more than import in 2072/73. The increase in import of diesel has been increased the revenue paid to IOC by 79 billion in FY 2075/76. Whereas due to Pandemic in FY 2076/77 only 1473427.58 KL of diesel was imported in Nepal which is a decrease by 14.21% than in FY 2075/76. The decrease in import of diesel has also decreased the revenue paid by NOC in FY 2076/77 to 30 billion which accounts for the decrease of 26.94%. If the COVID-19 would not have persisted, the import in 2076/77, with the increasing trend, would be nearly about 11.59 % more, and revenue to be paid would have been increased by 15.18% than in 2075/76 (Singh, D.B.and Sah, D.K., 2021).

Table 1 shows the data of Nepal Oil Corporation situations about the impact on petroleum products due to COVID-19. We can observe that importing petroleum products has plummeted significantly in April, May, and June 2020.This would be greatly affected in implications on the SDGs of Nepal. Whereas July, August, and September have got better slowly with the easing in lockdown. Impact of COVID-19 on industries and businesses have been enumerated in Figure 1 and the Table 2.

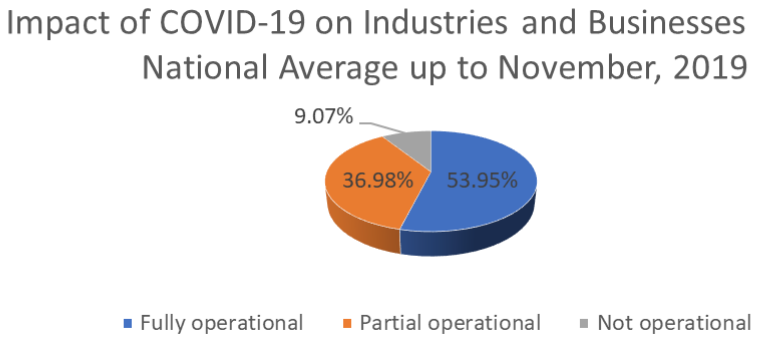

Figure 1: Impact of COVID-19 on industries and businesses in Nepal (NRB, 2020)

Table 2: Impact of COVID-19 on industries and businesses in Nepal (NRB, 2020)

Size of industries/Businesses	% of Non-operational	Partial Operation	Fully operational
Domestic industries	16.79	36.74	46.56
Small domestic/small retailers	8.17	40.31	51.55
Small industries up to 150 million fixed capital	14.08	47.18	38.73
Medium industries 150-500million fixed capital	12.24	38.78	48.98
Big industries>500 million fixed capital	8.33	16.67	75.00
National average	9.07	36.98	53.95

Goal 13 Climate Action (Take urgent action to combat climate change and its impact) and its target of reduction up to 2030 has been illustrated in Figure 2. An analysis of the indicators in the worldwide SDGs indicators database discloses that for 4 of the 17 goals, less than half of 194 nations or areas have globally comparable data. This data deficit is incredibly annoying for Goal 5 (gender equality), where on average, only about 4 in 10 countries have data available. Country-level data deficits are also vital in (Goal 12) sustainable production and (Goal 13) consumption and climate action. Sadly, even countries with up to date data have only a small number of observations over time, making it hard for policy makers to monitor progress and identify trends. Data coverage proportion of countries or areas with available data (weighted average across indicators) by Goal % are illustrated in Figure 2.

According to the SDGs progress report 2016-2019 SDG 1- End Poverty: Nepal's progress in reducing poverty has been remarkable. SDG 2- Zero Hunger: Although progress in per capita food grain production has been satisfactory, the food security index shows a score of 46. SDG 7- Affordable and Clean Energy: Proportion of population with access to electricity is now 88 percent, per capita energy consumption is 20 gg, electricity consumption overall has gone up to 260 kWh and installed hydro-electric capacity is 1,250 MW. (Poudel, Manwell and McGowan, 2020)

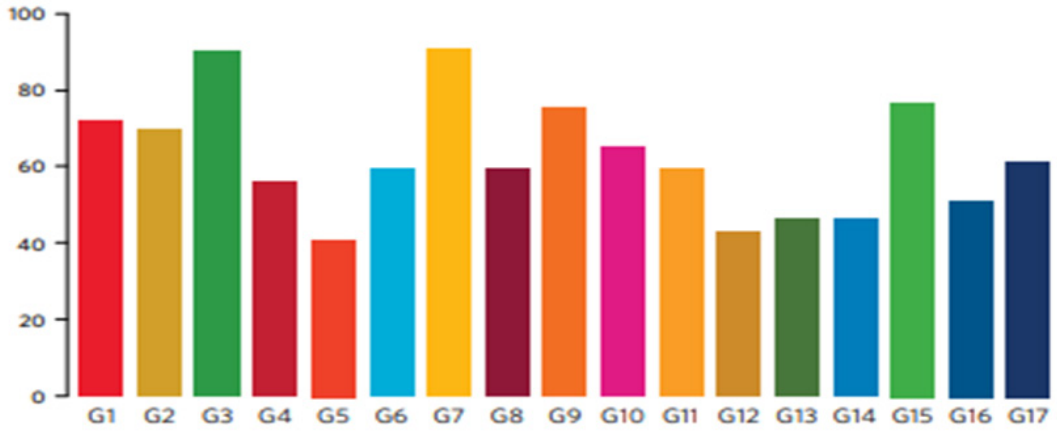

Figure 2: Data coverage proportion of countries or areas with available data (weighted average across indicators) by Goal % (United Nations, 2020)

Nepal is naturally an agricultural country, so policy should enhance this sector to get SDGs achieved. According to the World Institute Climate Analysis Indicators, half of Nepal's 2014 GHG emissions were from the agricultural sector. Whereas 54% of emission were from enteric formation of livestock.

It can be observed that energy consumption has been raised during day time because of the strict lockdown. Many people stayed home and did their business and household activities, so the energy demand had surged at day time.

5. Conclusion and Policy Recommendation

By analysing a review of the COVID-19 impact on Nepal's energy systems, implications for SDGs by literature reviews and observation approaches, it has been possible to obtain some very significant policy recommendation to achieve the sustainable energy transition and minimise the carbon footprint as SDGs up to 2030. Moreover, describing the impacts of COVID-19 and the need for policy recommendation, an evaluation of the severe implications for achieving SDGs was conducted. Identifying SDG 7 sustainable energy, SDG 13 climate actions are vital future resources. The well-integrated SDGs will only be accomplished through exclusive transformative alterations in our societies. Recent researches on the interactions between the SDGs identify the preservation of biodiversity as one of the most effective levers to obtain sustainability. The biodiversity-focused SDGs 14 (life below water) and SDGs 15 (life on land) appear as multipliers of co-benefits across the 17 sustainable goals.

Based on the findings and conclusion, there is no doubt that the pandemic has traumatised the 2030 agenda for SDGs to its core. However, everybody must hold firm convictions and not let the crisis derail the world's hopes and ambitions. Indeed, the principles on which the SDGs were ascertained are key to bouncing back better in the post-COVID-19 recovery.

Policy makers, energy experts, and scientists rely on experiential evidence to widen their theories and test scenarios. The COVID-19 scheme has obliged us to identify that the Earth is a closed system, evidenced by the spread of the virus worldwide. This universal crisis is a significant analogue of climate change's challenge, also occurring in our universe's shared space.

The Nepal Government and world leaders should pay attention to the lesson learned from this wake-up call to put together the kinds of transactions needed to build a more resilient, healthier, and more sustainable world. Therefore, everyone should have to follow the international experiences and trends to enhance its energy system and minimise the impact of carbon emission to achieve SDGs within 9 years. Nepal government has to choose the right direction, and follow science to care the pandemic. It is very necessary that policymakers and scientists are obliged to teach them urgently. A shared approach to climate change is necessary among all the scientists and policymakers worldwide to combat these common challenges.

There are few limitations to this research. As the COVID-19 crisis is a situation in instability, the data referred to needs to be updated to reflect the ongoing impacts of the severe impact that might influence the future study. Data deficiencies specially the real-time data of electricity consumption are also another critical issue of this research. Government data are not open or not sufficiently available, and the officials are not keen to provide them even after several requests. However, this small contribution is an attempt to initiate the discussion on the government policy toward post COVID-19 initiation with regards to achieving SDGs in energy sector.

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7. References

Renewables 2020 - Analysis and forecast to 2025. Available at: https://webstore.iea.org/download/direct/4234 (Accessed: 19 November 2020).

Aruga, K., Islam, M. M. and Jannat, A. (2020) 'Effects of COVID-19 on Indian energy consumption', Sustainability (Switzerland). MDPI AG, 12(14). doi: 10.3390/su12145616.

Bahmanyar, A., Estebsari, A. and Ernst, D. (2020) 'The impact of different COVID-19 containment measures on electricity consumption in Europe', Energy Research and Social Science. Elsevier Ltd, 68. doi: 10.1016/j.erss.2020.101683.

Baskota, R. (2020) Nepal hydroelectricity sector gets COVID-19 shock | Nepali Times, Nepali Times. Available at: https://www.nepalitimes.com/latest/nepal-hydroelectricity-sector-gets-covid-19-shock/ (Accessed: 20 November 2020).

Bhusal, R. (2020) COVID-19 threatens to take Nepal's power sector back to the Dark Ages | Earth Journalism Network, https://earthjournalism.net/. Available at: https://earthjournalism.net/stories/covid-19-threatens-to-take-nepals-power-sector-back-to-the-dark-ages (Accessed: 20 November 2020).

Cheshmehzangi, A. (2020) COVID-19 and household energy implications: what are the main impacts on energy use? - ScienceDirect, Heliyon. doi: https://doi.org/10.1016/j.heliyon.2020.e05202.

Global Energy Review 2020. Available at: www.iea.org/corrigenda (Accessed: 18 July 2020).

Graff, M. and Carley, S. (2020) 'COVID-19 assistance needs to target energy insecurity', Nature Energy. Nature Research, pp. 352–354. doi: 10.1038/s41560-020-0620-y.

Gwenaelle Deboutte (no date) Akuo commissions 50 MW solar plant in Mali – pv magazine International. Available at: https://www.pv-magazine.com/2020/11/20/akuo-commissions-50-mw-solar-plant-in-mali/?utm_source=dlvr.it&utm_medium=twitter (Accessed: 20 November 2020).

International Energy Agency (2020) 'World Energy Outlook 2020 - Event - IEA', World Energy Outlook 2020 - Event - IEA.

IRENA (2021) Renewable capacity statistics 2021 statistiques de capacité renouvelable 2021 estadísticas de capacidad renovable 2021. Available at: www.irena.org (Accessed: 4 May 2021).

Klemeš, J. J., Fan, Y. Van and Jiang, P. (2020) 'The energy and environmental footprints of COVID-19 fighting measures – PPE, disinfection, supply chains', Energy. Elsevier Ltd, 211. doi: 10.1016/j.energy.2020.118701.

Le, T. H. and Nguyen, C. P. (2019) 'Is energy security a driver for economic growth? Evidence from a global sample', Energy Policy. Elsevier Ltd, 129, pp. 436–451. doi: 10.1016/j.enpol.2019.02.038.

Luciani, G. (2020) COVID-19 AND THE ENERGY TRANSITION. Oxford. Available at: https://www.oxfordenergy.org/wpcms/wp-content/uploads/2020/07/OEF123.pdf (Accessed: 6 June 2021).

National Planning Commission, (2020) 'National Review of Sustainable Development Goals',Report,p.104. Available at: https://sustainabledevelopment.un.org/content/documents/26541VNR_2020_Nepal_Report.pdf

Pollitt, N. (2020) 'Climate cliff hanger', myRepublica - The New York Times Partner, Latest news of Nepal in English, Latest News Articles, 18 December. Available at: https://myrepublica.nagariknetwork.com/news/climate-cliff-hanger/ (Accessed: 14 January 2021).

Poudel, R. C., Manwell, J. F. and McGowan, J. G. (2020) 'Performance analysis of hybrid microhydro power systems', Energy Conversion and Management. Elsevier Ltd, 215, p. 112873. doi: 10.1016/j.enconman.2020.112873.

Poudyal, R. (2021) 'Renewable Energy After COVID-19 Recovery', The Rising Nepal, March, p. 12. Available at: https://risingnepaldaily.com/mustread/renewable-energy-after-covid-19-recovery (Accessed: 4 May 2021).

Proskuryakova, L. (2018) 'Updating energy security and environmental policy: Energy security theories revisited', Journal of Environmental Management. Academic Press, 223, pp. 203–214. doi: 10.1016/j.jenvman.2018.06.016.

Qarnain, S. S., Muthuvel, S. and Bathrinath, S. (2020) 'Review on government action plans to reduce energy consumption in buildings amid COVID-19 pandemic outbreak', Materials Today: Proceedings. Elsevier BV. doi: 10.1016/j.matpr.2020.04.723.

Rugani, B. and Caro, D. (2020) 'Impact of COVID-19 outbreak measures of lockdown on the Italian Carbon Footprint', Science of the Total Environment. Elsevier B.V., 737. doi: 10.1016/j.scitotenv.2020.139806.

South Asia Watch on Trade, E. and E. (SAWTEE) (2020) Trade, Climate Change and Development Monitor Monthly E-Newsletter of South Asia Watch on Trade, Economics and Environment (SAWTEE). Kathmandu. Available at: http://www.sawtee.org/newsletters/Trade-Climate-Change-and-Development-Monitor_July_2020.pdf (Accessed: 14 January 2021).

Statista (2020) Nepal: risk index for natural disasters 2020 | Statista, Statista. Available at: https://www.statista.com/statistics/921029/nepal-risk-index-for-natural-disasters/ (Accessed: 14 January 2021).

The World Bank (2020) Government of Nepal and World Bank sign $100 million credit agreement to reform Nepal's energy sector and boost recovery from COVID-19 crisis, The World Bank. Available at: https://www.worldbank.org/en/news/press-release/2020/06/24/government-of-nepal-and-world-bank-sign-100-million-credit-agreement-to-reform-nepals-energy-sector-and-boost-recovery-from-covid-19-crisis (Accessed: 20 November 2020).

United Nation (2017) Energy – United Nations Sustainable Development, United Nation. Available at: https://www.un.org/sustainabledevelopment/energy/ (Accessed: 20 November 2020).

United Nation (2019) SDG Indicators, United Nation. Available at: https://unstats.un.org/sdgs/report/2019/goal-07/ (Accessed: 20 November 2020).

United Nations (2020) The Sustainable Development Goals Report. Available at: https://unstats.un.org/sdgs/report/2020/The-Sustainable-Development-Goals-Report-2020.pdf (Accessed: 4 May 2021).

Wang, Q. and Su, M. (2020) 'A preliminary assessment of the impact of COVID-19 on environment – A case study of China', Science of the Total Environment. Elsevier B.V., 728. doi: 10.1016/j.scitotenv.2020.138915.

Change Management and Introduction of LPE Facilitator(s) within Process, Departmental and Organisational level.

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Abstract

Change facilitators are individuals who utilize change philosophy to make a positive change to organizations. The application of change facilitators can be seen in various change models; Lewin, Lippitt, etc. The facilitators within numerous change models are considered as internal/ external consultants. Whilst most of the scholarly papers consider change facilitation as a consensus attempt to improve organization, there is a need to develop a clear link between both the organization and the change facilitator for creating a self-sustaining change environment. This research paper's aim is to introduce the development of wheel-on-wheel concept by considering change Leaders, Planners, and Executers (LPE), at various organizational levels (Process, Departmental, and Organisational). The concept of LPE is derived by exploring interrelated characteristics between facilitator(s) and the organization through qualitative research for understanding change management techniques and facilitator(s), behavioural aspect from existing Change Management models and Organisational behaviour works of literature. The introduced LPE concept (i.e. Wheel-on-wheel concept) assists in highlighting and identifying the roles and responsibilities of change team to successfully deliver the change initiative within any organization(s).

Keywords: Change Initiative, LPE Framework, Change Facilitator(s)

1. Introduction

Competition has led organisations to find ways to improve its competitive advantage, which directly or indirectly results in consideration of change. Research carried by Stickland (1995) to understand the nature and dynamics of change suggest "Nothing remains what, where and as it was, but everything moves, changes, comes into being and passes away" (Stickland, 1995). For this reason, organisations undertake change, of which 30% are successful (Burnes and Jackson, 2011; TodnemBy, 2005). Whilst the causes of failure vary, most of the organization utilises change theories and models to introduce change within their organisations. Whilst Change literature shows consideration of change facilitators within its change environment, this research aims at introducing LPE concept to successfully undertake change via introduction of change facilitators as change Leader, change Planner, and change Executer (LPE) within various levels of an organisation (i.e. Process level, Departmental level, and Organisational level).

2. Literature

Organisations both nationally and internationally are undergoing rapid adjustments to improve their competitive advantage for maintaining its position within today's dynamic and competitive environment. TodnemBy (2005) suggests changes have become an inevitable part of any organisation. Paton et al. (2016) suggests Change Management as ability to effectively manage and exploit change situation by being innovative in thoughts/action to achieve competitive advantage. Whilst Green (2007), suggests Change Management as a way to consider and manage change, based on various models that have stood the test of time and demonstrated its usability by combining it with current organisational strategic thinking. Nevertheless, on additional considering of literature from Cameron and Green (2015), Hughes (2006), and Roth and DiBella (2016), it can be understood that the change within an organisation is a concept of constantly evaluating ways to develop, manage, and sustain changes to attain organisational future and planned strategic position within its competition.

However, initiating change is not an easy task as shown in numerous scholarly papers aimed at providing methods to successfully initiate, implement and manage change. Literature suggests 70% of the change programmes fail (Burnes and Jackson, 2011; TodnemBy, 2005).

Academics have defined failure in various ways and there is a very little consensus on what failure precisely means (Mellahi et al., 2002). Mellahi and Wilkinson (2004) suggest Industrial Organisation (IO) and Organisational Ecology (OE) locates causes of failure within external environment, whilst Organisational Studies (OS) and Organisational Psychology (OP), locates causes of failure within management ineffectiveness or inefficiency.

2.1 Change Theory and Change Models

Change within a system requires application of concepts that can successfully assist to achieve the required transformation. These concepts as seen in literature can be classified as Change Theories and Change Models (Jones and Brazzel, 2012; Van et al., 2011).

Change Theories as suggested by Jones and Brazzel (2012), occurs in numerous change scenarios, which further provides robust foundation for creating organisation change models, through application of multiple change theories. Change Theories further assist to understand, explain, and predict organisational change. There are various types of change theories as per change application. These change theories can be following among many more (Jones and Brazzel, 2012; Van et al., 2011).

- Adaptive and Unpredictable change
- Planned change
- Developmental and Stage-Based change
- Conflictive and Power-based change
- Narrative-Based change

Change Models, however, provide framework for managing change, by recognising distinct stages within change. Change models can be useful way to describe and simplify the process for understanding and applying aspect of change. i.e. in order to successfully initiate, manage, implement, and sustain change, it is vital to focus on suitable plan of action, organizations utilise change models, which provides structured approach for ensuring that changes are smooth and that the desired benefits are achieved.

Change theories and change models can be seen as selectively picked by the organisation as per their organisational needs. This is as a result of universal compatibility between change models and theories. Nevertheless, it could be understood that any change models can be utilised to approach the required change theories (e.g. whether it be planned change or unpredicted change).

However, selecting the right change models by the organisation, i.e. the key here is to apply the most relevant change model that is applicable to the organisation, and how it wishes to approach the organisational change.

Although Lewin change model focuses at organisational activities through unfreezing, changing, and refreezing (Burnes et al., 2013; Cameron and Green, 2015), the model developed by Schein and Bennis (1961) looks into employee's psychological resistance to change through unfreezing, changing, and refreezing. From here, it can be understood that the tactics utilised to achieve the required change from Lewin change model is done through consideration of organisational activities, whereas Schein and Bennis model approach is done through consideration for the psychological aspect of employees towards the required change.

Additionally, Kolb and Frohman's planned change model is based on total organisational development programme (Kolb and Frohman, 1970). Whereas, the model developed by Devanna and Tichy (2003) approaches change by institutionalising a teaching environment within the organisation which also develops leaders while approaching change within the organisation.

Furthermore, model produced by Kotter which also claims Lewinian heritage, shows it can be utilised for any change environment, as the model was attempted to capture change aspect which are visible within other change models shown above (Cummings et al., 2016; Kotter, 1996). Additionally Lean change model is considerably new within the change management environment. As very few book and journals are available on Lean as a change management concept, it still attempts to provide and capture change attributes which are visible within various change models (Vainalis, 2012; Wojciechowski et al., 2016).

The confusion does not completely lie within the change management for institutionalising the required change; the confusion could be seen in selecting the change model that might be most effective for the organisation. For example, Whilst Kotter change model approaches change through its 8 steps, Tichy and Devanna approaches change by developing leaders through institutionalising teaching method. Nevertheless, any change would require facilitators to effectively initiate and sustain change.

2.2 Change Facilitators

"Facilitation is a term used for a set of principles, skills and practices aimed at helping people make changes and get the results they want from their life and work" (Sibbet, 2002), whist an individual facilitating the change task is called facilitator. Facilitator's role includes assisting people to work together and guides them towards the planned goal whilst managing or removing the barriers to change by sharing understanding and building commitment from the relevant process stakeholders (Sibbet, 2002). Stakeholders here, are those individuals who are either directly or indirectly affected by the proposed change. In addition to this, Emiliani (2008) and Sibbet (2002) suggest a facilitator has to be an effective leader who appreciates the group accountability and adapts itself with all members of the group. This in return would produce an effective change environment within team(s).

Facilitator, however, is a word that is broadly used to initiate/ implement change. Therefore, in order to successfully understand the change facilitator's role within an organisation, scholars/ researchers have given consideration to types of team(s) and facilitator(s) in organisation that successfully help initiate/ implement the desired change.

- Kolfschoten (2012) within his research to define facilitator's roles and responsibility within an organisation provides 3 types of facilitator which looks into: (1) Design and deployment, (2) The application, (3) The management or administration.

- Miller (2005) also suggests there are three hierarchical levels of team within an organisation: (1) Team members, (2) Mid-level management teams, (3) Senior management teams.

- Kreimeier (2014) suggest all people within the organisation can learn change understanding (through Lean) by placing them within three grid: (1) Fundamental, (2) Technical, (3) Strategic.

- Tennant (2001) and Witcher (2001) suggest Hoshin Kanri policy deployment method can be utilised for ensuring strategic goal of a company across all levels of the organisation. This is done through organic flow of information (both; top-down and bottom-up) by aligning (1) employees operations (2) tactical plan of mid-level management, (3) corporate strategic goal.

3. Introduction to LPE

The facilitator's attributes shown above can be combined to form an effective LPE (Leader, Planner, and Executer) that can assist facilitators within an organisation in terms of their role and responsibility for the desired change. Table below shows an alignment of proposed LPE towards policy deployment, learning change, teamwork, roles/responsibilities, as captured from above section.

Table 1: Alignment of LPE towards facilitator(s) attributes

	Facilitator's attributes towards			
LPE	Roles and Responsibility	Teamwork	Learning change	Policy deployment
	Kolfschoten et al. (2012)	Miller (2005)	Kreimeier et al. (2014)	Tennant et al. and Witcher et al. (2001)
Leader	The management or administration	Senior management teams	Strategic	Corporate strategic goal
Planner	The application	Mid-level teams	Technical	Tactic plan of mid-level management
Executer	Design and deployment	Team members	Fundamental	Employees operations

4. Development and justification of LPE

LPE is an abbreviation of Leader, Planner and Executer within Change environment. In order to show that concept of LPE can be justifiable towards any of the change theories/ models, proposed LPE concept has been discussed below.

4.1 LPE

Leaders are those facilitators within an organisation who look into "why of change". A Leader can either be executive member of the organisation, departmental leader, or a process leader. These Leaders within their job level have authority to establish the "why of change".

Planners are those facilitators within an organisation who look into "how of change". A Change Planner's role is vital within an organisation as it is a link between the Change Leaders and Change Executers.

- A Change Leader can also act as a Change Planner at its job level. This is because a Change Leader has to understand the top-level planning attributes to make an effective organisational/ departmental/ process change.
- A Change Planner also has to understand the process attributes of change, which is done by working in close relationship within Change Executers.

Executers are those facilitators within an organisation who look into "executing change". A Change Executer's role is very vital within any change environment as it is the executers who understand the process pros and cons in detail. For this reason, they work in close relationship with Change Planners.

Table 2: Change facilitator(s) role explanation through scenario

LPE	Change Facilitators role explanation through scenario	
Change Leaders	Organizational Level	Organisational Change Leaders are those leaders who have ability to move the organization to new vision through a new strategic approach.
	Departmental Level	Departmental Change Leaders are those leaders who have ability to move departmental contribution towards strategic need set by the organisational Change Leader.
	Process Level	Process Change Leaders are those leaders who have ability to move process contribution towards the departmental needs that can further contribute towards the organisational strategic needs.
Change Planners	Organizational Level	Organisational Change Planners are those individuals who plan "how to change" organisational needs and develop "ways of working" at organisational level.
	Departmental Level	Departmental Change Planners are those individuals who plan "how to change" departmental needs and develop "ways of working" at departmental level, which contributes towards organisational strategic needs.
	Process Level	Process Change Planners are those individuals who plan "how to change" process needs and develop "ways of working" at process level, which contributes to departmental needs and further towards organisational strategic needs.
Change Executers	Organizational Level	Organisational Change Executers are those individuals who execute change at organisational level as per organisational needs.
	Departmental Level	Departmental Change Executers are those individuals who execute change at departmental level as per department needs, which contributes towards organisational strategic needs.
	Process Level	Process Change Executers are those individuals who execute change at process level as per process needs, which contributes to departmental needs and further towards organisational strategic needs.

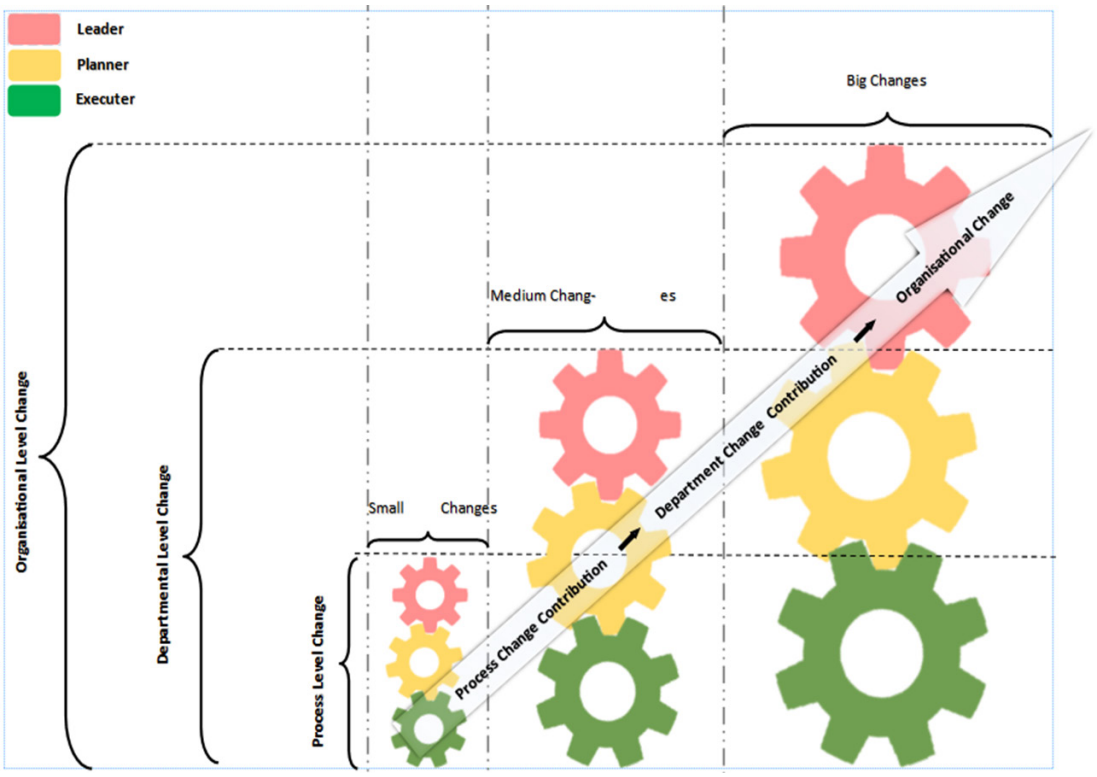

Figure 1: LPE Change contribution towards Organisational level change.

5. Conclusion

Change Leader, Planner and Executer can be present at any level within the organisation and contribute towards the desired change whether it is Organisational level change, Departmental level change or Process level change. A detail view of this concept can be seen in Figure 1, provided information that Change facilitator(s). LPE work in close relation with each other, i.e. the contribution obtained from the process level change influences/ contributes towards the departmental level change and the departmental level change influences/ contributes towards the organisational level change. From here, it can be understood that the concept of change facilitator(s) is wheel-on-wheel concept (LPE concept) which steers each other in an iterative phenomenon within any organisation.

6. References

Stickland, F. (1995) The Nature and Dynamics of Change: A Systems Approach to Exploring Organisational Change [online].

Burnes, B. and Jackson, P. (2011) Success and failure in organizational change: An exploration of the role of values. Journal of Change Management [online]. 11 (2), pp.133-162.

TodnemBy, R. (2005) Organisational change management: A critical review. Journal of Change Management [online]. 5 (4), pp.369-380.

Paton, R.A., Sieer, S., and McCalman, J. (2016) Change Management: A Guide to Effective Implementation [online].

Green, M. (2007) Change Management Masterclass: A Step-by-Step Guide to Successful Change Management [online]. Kogan Page Publishers.

Cameron, E. and Green, M. (2015) Making Sense of Change Management: A Complete Guide to the Models, Tools and Techniques of Organizational Change [online]. Kogan Page Publishers.

Hughes, M. (2006) Change Management [online]. Chartered Institute of Personnel & Development.

Roth, G. and DiBella, A. (2016) Systemic Change Management: The Five Capabilities for Improving Enterprises [online]. Springer.

Mellahi, K., Jackson, P. and Sparks, L. (2002) An exploratory study into failure in successful organizations: The case of Marks & Spencer. British Journal of Management [online]. 13 (1), pp.15-29.

Mellahi, K. and Wilkinson, A. (2004) Organizational failure: a critique of recent research and a proposed integrative framework. International Journal of Management Reviews [online]. 5 (1), pp.21-41.

Jones, B.B. and Brazzel, M. (2012) The NTL Handbook of Organization Development and Change: Principles, Practices, and Perspectives [online]. John Wiley & Sons.

Van de Ven, Andrew H and Sun, K. (2011) Breakdowns in implementing models of organization change. The Academy of Management Perspectives [online]. 25 (3), pp.58-74.

Burnes, B. and Cooke, B. (2013) Kurt Lewin's Field Theory: A Review and Re-evaluation. International Journal of Management Reviews [online]. 15 (4), pp.408-425.

Schein, E.H. (1961) Management development as a process of influence. Industrial Management Review (Pre-1986) [online]. 2 (2), pp.59.

Kolb, D.A. and Frohman, A.L. (1970) An organization development approach to consulting. Sloan Management Review (Pre-1986) [online]. 12 (1), pp.51.

Kolb, D.A. and Frohman, A.L. (1970) Organizational development through planned change: a development model. [online].

Tichy, N.M. (2003) Getting the power equation right. Leader to Leader [online]. 2003 (29), pp.28-34.

Cummings, S., Bridgman, T. and Brown, K.G. (2016) Unfreezing change as three steps: Rethinking Kurt Lewin's legacy for change management. Human Relations [online]. 69 (1), pp.33-60.

Kotter, J.P. (1996) Leading change [online]. Harvard Business Press.
Vainalis, R. (2012) Change Management with Lean approach-How the benefits from Lean can be applied in Change Management. [online].

Wojciechowski, E., Murphy, P., Pearsall, T. and French, E. (2016) A case review: Integrating Lewin's theory with lean's system approach for change. Online Journal of Issues in Nursing [online]. 21 (2),

Sibbet, D. (2002) Principles of Facilitation: The Purpose and Potential of Leading Group Process [online]. Grove Consultants Internationall.

Emiliani, B. (2008) Practical lean leadership: A strategic leadership guide for executives. Training [online]. 2011 pp.03-04.

Kolfschoten, G.L., Niederman, F., Briggs, R.O. and De Vreede, G. (2012) Facilitation roles and responsibilities for sustained collaboration support in organizations. Journal of Management Information Systems [online]. 28 (4), pp.129-162.

Miller, LM. (2005) Lean Teams Developing the Team- Based organization: the skills and practices of high performance business teams. Miller Management press, LLC.

Kreimeier, D., Morlock, F., Prinz, C., Krückhans, B., Bakir, D.C. and Meier, H. (2014) Holistic learning factories–A concept to train lean management, resource efficiency as well as management and organization improvement skills. Procedia CIRP [online]. 17 pp.184-188.

Tennant, C. and Roberts, P. (2001) HoshinKanri: a tool for strategic policy deployment. Knowledge and Process Management [online]. 8 (4), pp.262-269.

Witcher, B.J. and Butterworth, R. (2001) HoshinKanri: policy management in Japanese-owned UK subsidiaries. Journal of Management Studies [online]. 38 (5), pp.651-674.

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On the publication of the third proceedings, it is an honour to support SONEUK's initiative towards an innovative and flourishing Nepal. As a member, I would like to convey my best wishes for their future endeavours.

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It is a great honour and pleasure for me to support the publication of 6th SONEUK Conference 2021 proceedings

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Dr. Bidur Ghimire
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Mr. Sanyukta Shrestha
SONEUK Chairperson

It is my great pleasure to welcome you to the 6th SONEUK conference 2021.

I am proud to be a member of the team publishing the conference proceedings dedicated to COVID-19 pandemic.

Best wishes for SONEUK's future endeavours.

Mr. Narad Bhandari
SONEUK Vice-Chairperson and
Coordinator, Conference Committee

I am proud to be a member of the team publishing conference proceedings.

Best wishes for SONEUK's future endeavours.

Dr Birendra Shrestha

Member of SONEUK Conference Organising Committee

Congratulations to SONEUK On the publication of the 6th conference proceedings.

I am very proud of SONEUK for its contribution on friend's networking and for being a change agent to engineering practices in Nepal via various activities.

Mr. Krishna Kishor Shrestha

Chartered Highway Engineer,

Highways England

It is my great pleasure to welcome you to the SONEUK conference 2021.

SONEUK is bringing together scholars and practitioners to share and exchange ideas and technologies to tackle the unprecedented situation caused by the COVID pandemic. The conference is providing an opportunity to learn engineering practices in the new situation. I am very happy to support this event and wish to express my gratitude to the organisation committee and all participants.

Professor Keshav Dahal,

University of the West of Scotland, UK

I am delighted to be given the opportunity of conveying my best wishes to SONEUK.

I congratulate the SONEUK UK and its entire team on the publication of the conference proceedings focused on COVID-19 pandemic, its engineering challenges and opportunities.

Professor Hom Nath Dhakal

BEng (Hons), MSc, PhD, CEng, FHEA, FIET, FIMMM

Professor of Mechanical Engineering,

School of Mechanical and Design Engineering,

University of Portsmouth, UK

It is a pleasure to support the publication of the proceedings for 6th SONEUK Conference.

I would like to covey my best wishes to SONEUK for all future endeavours.

Dr. Ramesh Marasini
CEng, FCABE, MIED, MCIOB, SFHEA
Associate Head of School,
Buckinghamshire New University, UK

Great British Weather

"The Blue Sea stretched to the horizon, mirroring the sun rays in its elusive aura. The brightness of the rays that reflected enhanced the pleasant atmosphere. The beach was crowded that day. Beach fans, bikini lovers, and the sandcastle experts were present everywhere as far as the eye could see."

Congratulations and Best Wishes to SONEUK and its entire Team for all future endeavours.

Dr Ramhari Poudyal,
Swansea University, UK

I feel so proud to be able to support the publication of the proceedings for 6th SONEUK Conference.

I would like to covey my best wishes to SONEUK for all future accomplishments.

Dr Deepak GC
PhD, FHEA, MIEEE
Kingston University, London

Congratulations to SONEUK

On the publication of the conference proceedings focused on COVID-19 pandemic, its engineering challenges and opportunities. As members of the committee, we would like to covey our best wishes to SONEUK for all future endeavours.

Dr Jaya Nepal
BSc MSc PhD PGCertEd FHEA
Senoir Lecturer,
University of East London, UK

&

Mr Hari Nepal
BEng. MSc. CEng MIET
Senior Design Engineer,
Babcock International Group,UK

It provides me an immense satisfaction to be able to support the publication of the proceedings for 6th SONEUK Conference.

Congratulations and Best Wishes to SONEUK and its entire Team for all future endeavours.

Dr. Roshan Bhattarai
Senior Distribution System Expert,
TRACTEBEL - Middle East - ENGIE Impact
SONEUK Secretary

Congratulations!

It provides me an immense satisfaction to be able to support the publication of the proceedings for 6th SONEUK Conference.

Congratulations and Best Wishes to SONEUK and its entire Team for all future endeavours.

Mr Bed P. Bhattarai
Building Services/Mechanical Engineering
Lecturer, LIV
South Thames College Group
Visiting Lecturer,
Lambeth College, London

Congratulations to SONEUK

On the publication of the conference proceedings focused on COVID-19 pandemic, its engineering challenges and opportunities.

I would like to covey my best wishes to SONEUK for all future endeavours.

Mr. Rajesh Pathak
MBA, CEng MICE, ChPP MAPM
Founder and Ex-General Secretary,
SONEUK

Congratulations to SONEUK for another big achievement.

My best wishes for all future endeavours.

Mr. Bishal Rana
BEng, MSc
Membership Co-ordinator
SONEUK

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