



Review article

Current scenario of and future perspective for scientific research in Nepal

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ABSTRACT

Scientific research can act as the 'bedrock for development' which can provide a solid foundation for the overall socioeconomic transformation in a country through invention and innovation. The inclusion of seven groups of Nepalese monuments in the United Nations Educational, Scientific and Cultural Organization (UNESCO)'s world heritage sites provides evidence of the richness in architecture and civil engineering in the country, which also show how Nepal was influenced by arts and religious philosophy. The government of Nepal (GoN) has established different scientific departments, universities, and research institutions, and has tried to emphasize the application of science and research for the development of the nation. These institutions, however, have inadequate resources, exist in a poor academic and research environment and are subject to overt political influence. Despite these various problems, a variety of pioneer research and development activities have been conducted, which show positive rays of hope. This review presents history, current situation, progress and future perspective for scientific research and development in Nepal.

1. Introduction

Scientific research refers to the systematic collection, interpretation and evaluation of data in an appropriate manner to verify, improve or revise current knowledge through new evidence [1]. Scientific research can act as the 'bedrock for development' of a nation as it can solve problems of different sectors including agriculture, health and industries [2]. In addition, properly implemented scientific research can bring beneficial societal changes and facilitate socioeconomic transformation in a country through invention and innovation. Countries like Taiwan, South Korea, and Israel have made progress by investing in basic and applied research which allowed them to advance in agriculture, medical science, engineering and other fields [3, 4]. The United Nations (UN) has also highlighted the needs for increased public and private investment in scientific research to achieve sustainable development goals (SDGs) [5, 6]. The progress made in the field of scientific research by a nation can be considered as a key catalyst for its overall social and economic growth.

This review summarizes the history, present situation and future perspectives for the scientific research and development in Nepal.

2. Historical perspectives of scientific research and development in Nepal

In ancient times, Nepal had a self-sustaining and well-developed expertise in technological and medical knowledge, liberally influenced by arts and religion philosophy comparable to that in contemporary nations [7]. The inclusion of seven groups of monuments and buildings from Kathmandu valley of Nepal in the UNESCO's list of world heritage sites is evidence for the richness in architecture and civil engineering know-how in Nepal in these ancient times [7]. Likewise, pagoda-style temples in South Asian Buddhist countries are likely linked to Nepal, which is evidenced by the fact that Arniko, an artist from Nepal, and his team was invited to China to build several related architectural monuments before 1800 A.D [7]. The ancient knowledge and expertise in Nepal were mostly focused on the fields of metallurgy, civil engineering,

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textiles, food technology, agricultural farming and medicine [8]. Various dynasties from the Gopals and the Abhirs (around 1000 B.C.) to the Mallas (1200-1768 A.D.) are known for their technological innovations in the field of animal husbandry, water use technologies, building constructions; and the spread of these technological innovations and Nepali architectural design [8]. Most of these ancient technologies, however, were neither supported nor modernized in Nepal. The Rana dynasty (1845-1950 A.D.) introduced some of the European engineering technologies into the country and is also known for the establishment of a formalized science education system i.e. establishment of natural science education at Trichandra College (The first science college in Nepal) in 1948 A.D., and an agricultural experiment station [8]. Natural science education system was upgraded after the establishment of Tribhuvan University (TU) in 1959. But, this natural science education system was a traditional teaching methodology to produce 'science teachers' and did not include structures to support research [9]. In addition, the percentage of students enrolled in the Science, Technology, and Engineering and Mathematics (STEM) streams is very low (Figure 1), which ultimately leads to a very low number of scientists in the country.

The inclusion of science and technology as a proper component of the country's developmental strategy began in the mid-1950s, following the establishment of democracy, when the GoN started implementation of five-year development plan [7, 8]. This plan acknowledged the necessity for developing infrastructures for science and technology and was subsequently followed by the establishment of various government departments including the departments of irrigation, hydrology and meteorology; mines and geology; survey and medicinal plants etc, [7]. A nationwide geographical survey, which is likely to have been the first institutionalized large-scale research program in the country, was conducted in the 1950s under the financial assistance of the United Nations and led by Tony Hagen-a Swiss Geologist [8]. Various professional societies were then established in the 1950s and 1960s including the Nepal Medical Association (1951), Nepal Agriculture Association (1960), Nepal Ayurveda Association (1966), Nepal Engineers' Association (1967) and Nepal Veterinary Association (1969) in order to institutionalize relevant

professional activities [7]. The Royal Nepal Academy of Science and Technology (RONAST), now referred as Nepal Academy of Science and Technology (NAST), was established in 1982 to foster the advancement of science and technology to promote the all-round development of the country and this led to the establishment of various national laboratories to promote research and developments [8]. Prioritizing the notion of being an agriculture-based country, the Nepal Agriculture Research Council (NARC) was established in 1991 which aims to raise the economic status of citizens through advancement in agricultural research [8]. With the establishment of the Ministry of Science and Technology (now referred to as the Ministry of Education, Science and Technology) in 1996, the field of science and technology started to get regular space in the budgets and national developmental plans [7]. Similarly, different policies and directives such as National Science and Technology Policy (2005 A.D.) [11], National Nuclear Policy (2007 A.D.) [12], and Directive on Regulation of Nuclear Materials (2015) [13,14] have been enacted and put into operation. These efforts have resulted in the development of basic scientific infrastructures and manpower necessary for the country's development [8]. Recently, a National Science Technology and Innovation Policy (NSTIP) 2019 has been formulated with the target of achieving the goal of sustainable development by optimum utilization of science, technology and innovation [14], but it lacks a clear-cut idea on how to properly utilize Science and Technology for the development of nation. Still a lot has to be done in the field of science and research here as Nepal is a virgin land for research and innovation in field of natural science [9].

3. Current perspectives and underlying problems of scientific research and development in Nepal

Different governmental and non-governmental organizations are involved in conducting scientific research and development activities in Nepal in recent years [7, 8, 15, 16]. The GoN has also emphasized the application of science and research for the overall development of the country in their policy papers [17], but in actual reality research and

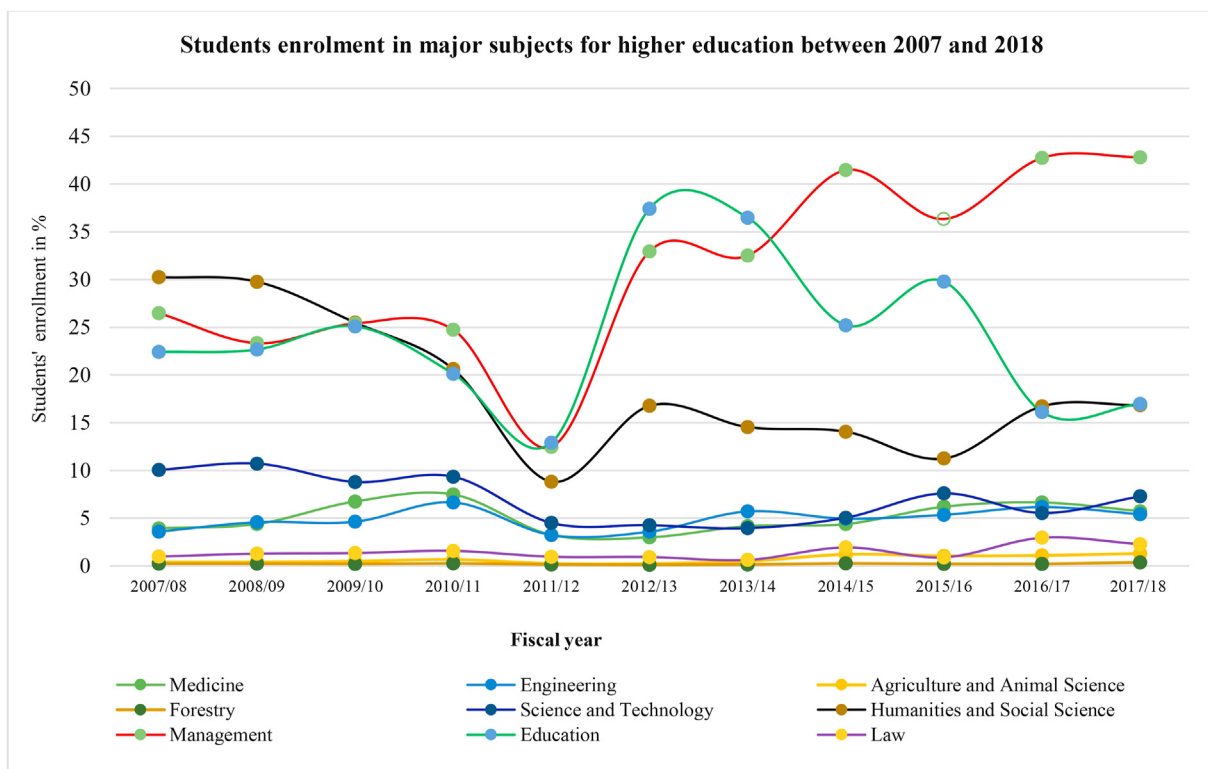


Figure 1. Proportion of students enrolled in major subjects in Nepalese universities between 2007 and 2018. (Source: MoF [10]).

development is not a government's priority as shown by very low budget allocation in R & D (Figure 2; Figure 3, Figure 4 and Figure 5). As for example, NARC, an organization for research in agriculture sector, has received a budget in between 0.2 and 0.45% of AGDP (Figure 6), which is one of the lowest in the South Asian context. The recent paper by National Planning Commission, Nepal, proposes a policy to enhance scientific research, and upgrade the technological capabilities by encouraging innovation with provision of increased budget expenditure on R & D [18] (Figure 3).

Most of the research activities in the past used to be published in the form of hard copies, submitted to donor agencies and provided to a limited number of subscribers or relevant individuals. The majority of professionals publish their work either to get grants or enter into an academic position or win promotion into an expected position [15, 31]. Researchers in Nepal hesitate to share information with colleagues working in related field due to a fear of losing competitive advantage, misuse of their data [16], fear of letting people surpass themselves through their shared knowledge, being less relevant anymore as more people have the knowledge and skills, the behaviour of not easily sharing this with someone without letting them experience the same hardship as they have experienced while acquiring knowledge and data. Even getting data from government offices, which has to be made publicly available as per government's rules, is cumbersome (based on author's experience). Often senior researchers fail to encourage and engage the next generations to conduct research and publish generated evidence [15, 31]. Researchers, in most instances, fail to have mutual inter-sectoral collaboration with those in other areas of science, community organizations and other concerned stakeholders [32, 33, 34, 35].

In recent years interest in publishing research activities is increasing in online journals [36, 37]. The increased availability of internet access to journals and awareness about the benefits of publication has attracted many young, and established scientists to publish research activities in online journals. Even though, this accessibility facilitates publication, but researchers face many problems such as high publication charges, rejection of the submitted research paper because the obtained result are not interesting, poor English language and style of presentation. While willingness to publish online is a good sign, it comes with an increased risk of publishing articles in predatory or fake journals and raises questions concerning the credibility of the work being done. To solve this problem, there is a need to increasing awareness about the quality of journals, peer review process and ethics of article publication in Nepal.

The quality of research depends on its design and novelty. Majority of the research in Nepal are often rife with poor research designs, and lack of rigorous research methodology. This can be attributed to the lack of clear-cut ideas, education on good conceptualization, research design,

data analysis, and quality of write-up. Despite having well trained personnel, researchers in some research institutions such as Nepal Agriculture Research Council (NARC), National Agricultural Research and Development Fund (NARDF), Research Center for Applied Science and Technology (RECAST), Tribhuvan University (TU), Nepal Academy of Science and Technology (NAST), lack behind to produce good quality research papers [8, 9]. Incentive for publication is also lacking or inadequate. Promotions do credit publications but marking system changes frequently, mostly to suit vested interests. TU have recently done an exemplary move by appointing professors by speed processing based on research and publication credentials.

Some Nepalese research institutions, however, are deficient in scientist having good scientific capacity due to political appointment and recruitment of relevant personnel. In many cases, researchers are tempted to use simple and easy designs, such as: convenient sampling, quota sampling, and purposive sampling. This leads to bias in the sampling and weakens the conclusion drawn from such studies. In addition to scientific capacity, researcher's ethics is also very important for research. Developed countries have strong regulation on research ethics, and people generally follow these rules whereas, in Nepal, there is a shortage of ethics committees, guidelines and regulatory mechanisms. In addition, the absence of ethical clearance committees creates hurdles in assessing: the relevance of the work, justifiable treatment of animals and humans during clinical trials, treatment of personal information of study participants, inadequate risk assessment and justification on the use of hazardous and risky chemicals and equipment. Moreover, the absence of ethical clearance committees creates problems during the publication process due to its absence.

In developed countries, universities are the center for research excellence and professors and students are the active researchers. However, in Nepal, the majority of professors who should be the leaders in research, abandon research and instead busy themselves with teaching at college/universities, consulting for private companies and even engaging in party politics [16] (Author's experience). Moreover, the academic and research environment in universities and research organizations lack conducting regular research work and publication in a peer-reviewed journal as a mandatory requirement for professional advancements such as institutional promotion criteria or continuing the tenure or faculty position. Some of the universities have made publication a criteria for academic positions, which has promoted to some extent research and publication culture in Nepal [15, 31]. But, majority of university lack such mandatory provisions for an academic position and promotion. One of the research organizations-Nepal Agriculture Research Council (NARC), mandated for research in agriculture-has a record of publication of research papers in the journal as one of the strongest factors for

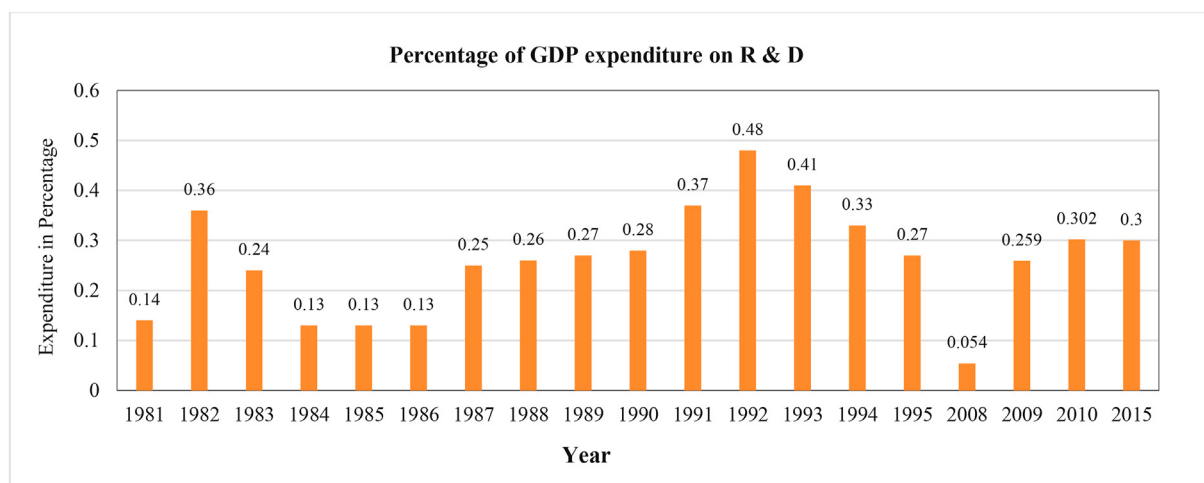


Figure 2. GNP/GDP spending on R & D in Nepal (Source: Bajracharya et al 2006⁸, The World Bank 2010¹⁹; NPC 2015¹⁸).

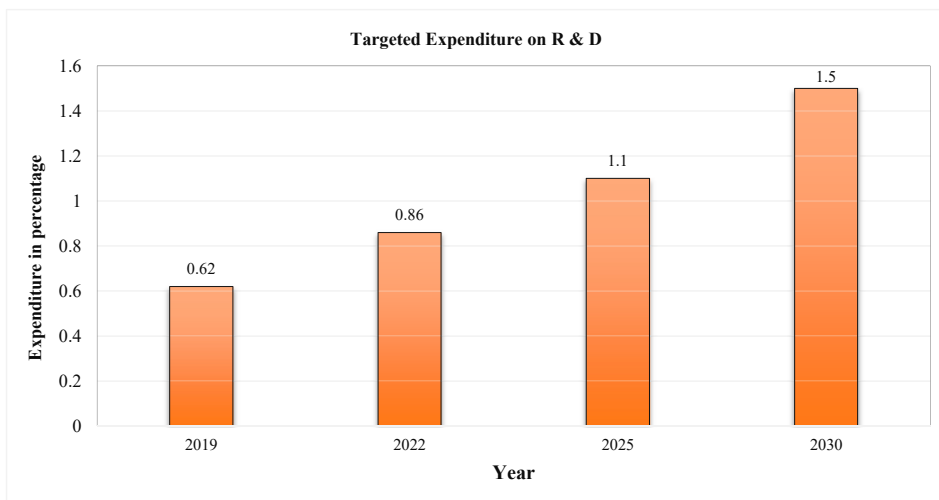


Figure 3. Proposed Gross domestic product (GDP) spending on R & D in Nepal as mentioned in Nepal's Sustainable Development Goals (Source: NPC [18]).

promotion. The value of research papers for promotion in open competition is 3.33 %, internal competition is 20% and vertical promotion is 30% [38]. Moreover, each year on NARC day, best research papers are also awarded, an encouragement for a better research environment and good publications. Also, top level executives are hired based on their contribution in science and value of their published research works. However, despite having these criteria, sometimes a scientist with papers in national and mediocre journals gets promoted while a good researcher with publication in reputed journals gets sidelined. Similarly, there is a lack of provision of performance-based incentives to attract, motivate and retain brilliant young minds with scientific ideas [29], which is reflected by the scenario of young agricultural brilliant researchers and scientists leaving the country in search of opportunities in developed countries [29]. Favouritism, nepotism and corruption all repel capable minds and waste resources.

Many of these failings could be made worse by policy described in Recruitment Procedure-2061 [38], which provides sufficient loopholes for a paper evaluation committee to overlook the publication quality before giving the overall markings. There is widespread corruption, nepotism and favoritism in provision of national research grants. Some researchers from NARC have reported biases in being awarded research grants which is mainly associated with lack of blind proposal review system, and personal biases of proposal review committee members.

Lack of research training and culture is widely prevalent in universities in Nepal as mentioned by Gartaula and his colleague [35]. This is partly due to a belief that the responsibility of teaching institutions is only to teach, and not necessarily to engage in research [8]. Additionally, there is a policy of separating teaching and research activities. For example: Tribhuvan University (TU) is given a mandate of teaching with no emphasis on research while NAST is given a mandate for conducting

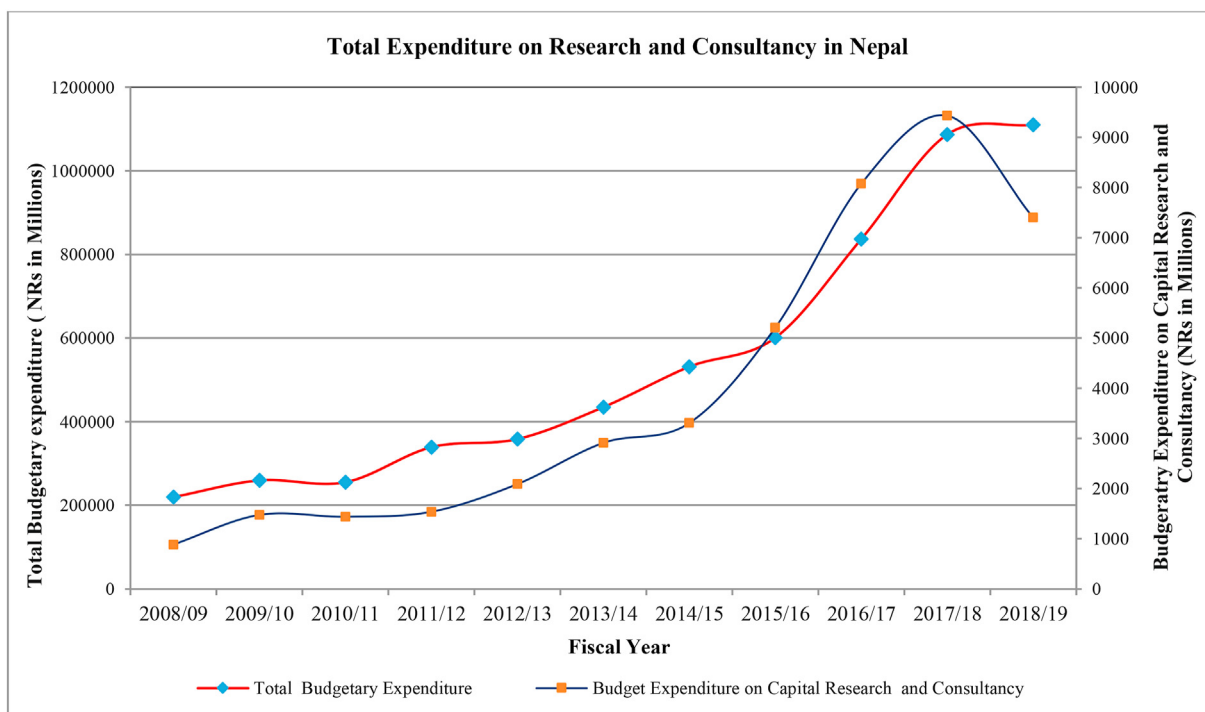


Figure 4. Total expenditure on Research and Consultancy services in Nepal between 2008 and 2019. (Source: MoF [20, 21, 22, 23, 24, 25, 26, 27, 28]).

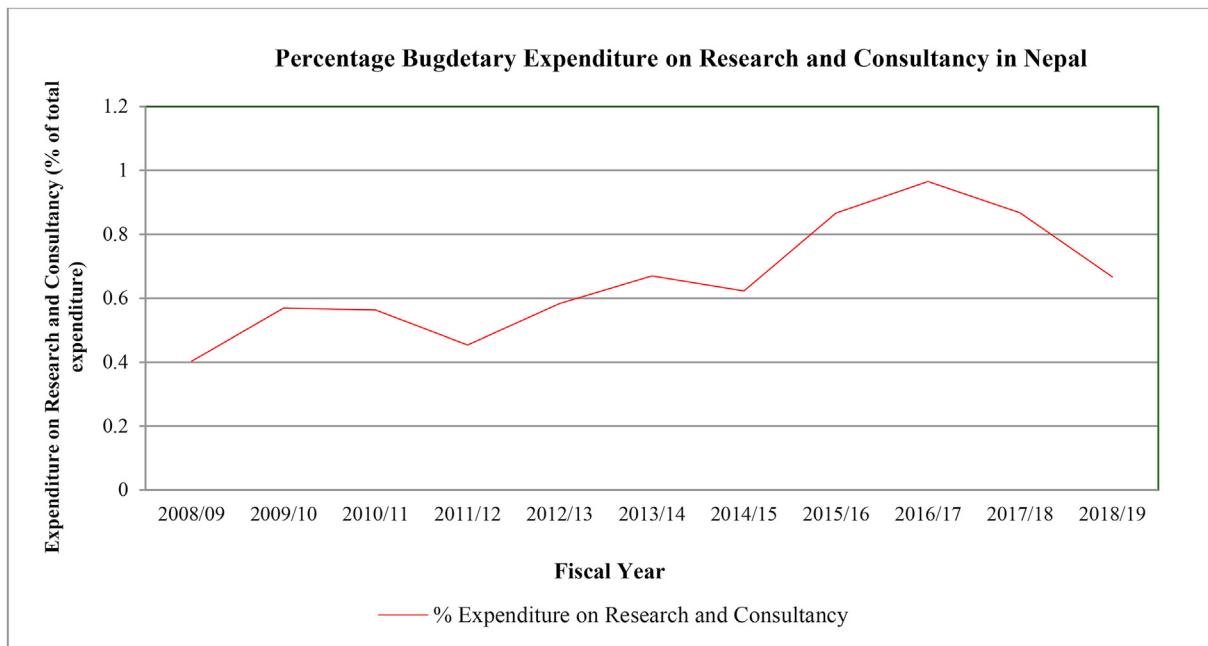


Figure 5. Percent budgetary expenditure on Research and Consultancy in Nepal between 2008 and 2019. (Source: MoF [20, 21, 22, 23, 24, 25, 26, 27, 28]).

research without degree oriented academic programs [8]. This policy of separating teaching and research institutions has detrimental effects on the academic and research environment as well as to the quality of research outputs [8]. Despite this, some research is being conducted in the universities which come in the form of thesis and dissertations, but are often not published in journals or online platforms [8]. This lack of publication can result in the duplication of similar research topics, in some instances even the same research in the same locations. This is a waste of resources which otherwise could have been used in other important sectors for socio-economic development. Furthermore, this

lack of publication has created a scenario where even basic information and knowledge in the context of Nepal are missing.

The scientific research and development in Nepal also suffers from a lack of sufficient funding, integrated infrastructure/research lab [8, 35], research oriented training, research culture, social security/reward for researchers; and associated brain drain [29]. In the developed countries, there are sustainable institutionalized frameworks for research funding. However, in Nepal research works are: solely depend on yearly funding from government of Nepal which is less than one percent of GDP [19, 39, 40, 41], self-fund the research (especially in case of students) or are completely reliant on international donors which come with limited-time

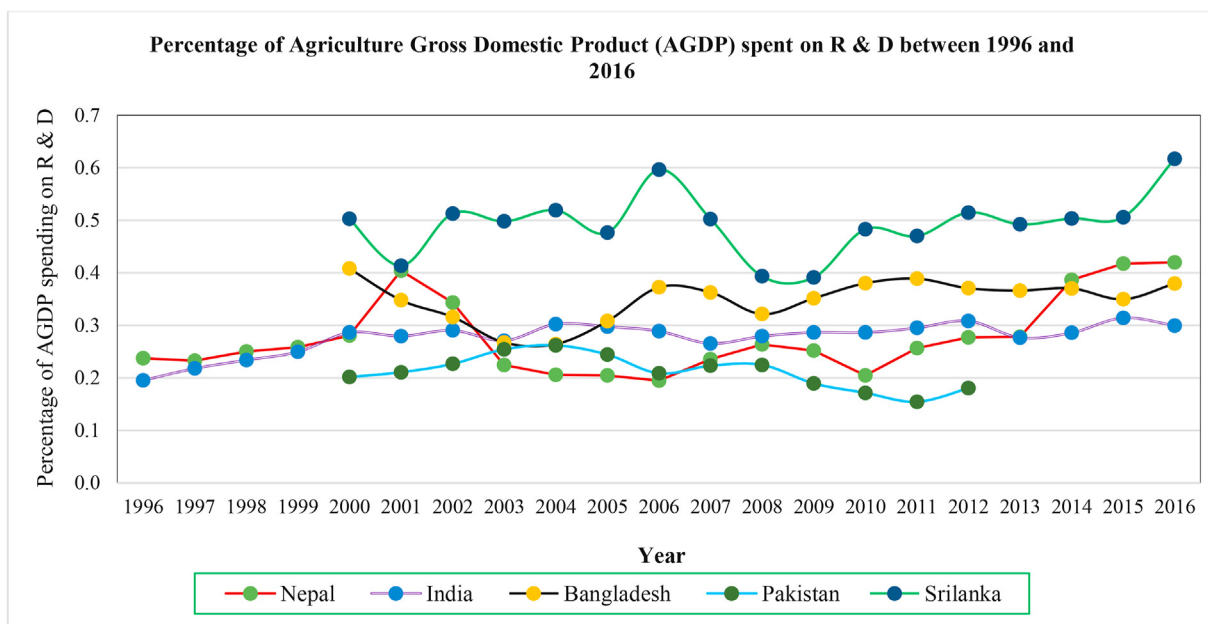


Figure 6. Agricultural research spending as a share of Agriculture GDP (AGDP) in Nepal in comparison to Bangladesh, India and Srilanka (Source: Stads et al., 2019 [29] and ASTI [30]).

resources, constraints or are directed towards foreign vested interest that lack sustainability. Funding from the country's private sector or local levels is very rare. Importantly, there is a weak link between science and technology teaching, research and industries. As a result, there is no supply of suitable jobs for researchers and universities are producing jobless educated manpower (aka '*Sikshit Berojgar*' in Nepali). Nepalese universities still have traditional curriculums and have not incorporated new courses such as Nano-technology, Artificial intelligence, Robotics, Chemical engineering, Drug research, Medicinal chemistry, Genomics, and Proteomics, which have higher jobs in the global job market.

Often there is overt political interference in government-run institutions that affect the quality of research and, additionally, there is unnecessary bureaucratic involvement in the processes of doing research (getting permission, conducting the research and dissemination of data or the technology transfer). The posting, transfer or assignment of professionals to different departments of the government or universities is commonly due to bureaucratic or political influence rather than their experience or educational background i.e. masters or PhD or relevant research experience. This creates a situation where the right manpower is not developed for the areas where it is needed. Also, the passing of time diminishes the skill of those manpower due to lack of involvement and practice in their field of expertise. Even in universities, there are fewer taught research modules than in developed countries. As a result, students are not well versed in the importance, knowledge and skill required for research work. In some instances, the assignment of relevant supervisors doesn't always happen. This is usually problematic for a student researcher when a non-experienced supervisor, non-relevant expert or a non-scientific/research institution is assigned to the student which leads to the below average mentoring of the student. This system might also fail to introduce the young researcher to the importance of scientific studies and to generate an interest on research in them. In addition, the traditional governmental recruitment procedure serves as a barrier for the Nepalese scientists who have honed their skills in science abroad and wish to return to Nepal and work for the country. The age limitation, the requirement to start from the bottom in the bureaucratic system, the political assignment etc. plays a barrier. It is very hard for a person to enter the government services and obtain a position justified by their qualification and experience. Although the will to return to Nepal and work is strong, the struggle to find a place in the already scarce governmental system and the already well-established career paths available abroad makes it a difficult choice for these experts to return.

Besides the above-mentioned situations, research institutions in Nepal are often under-staffed, inadequately equipped, and under resourced [8, 29, 33, 42, 43]. The majority of the officials and technical staff are not accustomed to utilize modern equipment, even if this is available in the facility. Concerned researchers are not getting an opportunity to participate in international trainings or symposia to update themselves and their scientific knowledge. Similarly, there are difficulties in acquiring the additional chemicals and reagents for the operation of modern equipment and a lack of qualified personnel to calibrate and repair them. Outdated, under resourced and insufficient library stocks, high journal subscription fees, poor internet access [44], and a lack of expensive analytic software such as R Studio, SAS that require a subscription fee to use, are other serious limitations. In addition, the level of commercialization of research and development from local science and technology is not encouraging mainly due to lack of well-equipped R&D institutions and policy frameworks [8]. In general, scientific research and development is a neglected topic in Nepal and political instability has overshadowed the need to prioritize funding for this sector [17, 29].

4. Positive rays of hope

Despite the problems mentioned above, there are some positive rays of hope in terms of the current research progress in Nepal. For example, the government of Nepal has increased the budget for R & D in recent years from 0.054% in 2008 to 0.3% in 2015 [45,46]. For the year 2016,

the expenditure for science and research has reached to around 37.12 billion Nepali rupees [46]. Moreover, the research institutions have bought and started to use high tech equipment such as a DNA sequencer, High Performance Liquid Chromatography (HPLC) and other bio-molecular tools. In addition, governmental institutions like the Central Veterinary Laboratory (CVL), which used to perform only sero-surveillance studies and survey till few years back, now uses applied molecular techniques like polymerase chain reaction (PCR) to identify viral strains of Avian Influenza, and immunofluorescent assay (IFA) testing for diagnosis of Rabies. Similarly, teaching institutions like the Agriculture and Forestry University (AFU) have recently procured advanced scientific equipment and some pioneer works have been started there [47, 48]. The National Livestock Breeding Office (NLBO), the only organization responsible for producing animal semen straw, has now adopted a new Computer Assisted Semen Analyzer (CASA). Embryo transfer technology is being currently employed to produce semen donor male calves and heifer-the future mother cow Also, an embryo transfer laboratory for producing frozen embryo, is being established at NLBO. Along with these developments, there has been an increase in the number of research institutions involved in scientific research and increased international collaboration. Nepal has itself produced 12 types of vaccines for different animal and poultry diseases and these have been effective in preventing and controlling disease in field conditions. Previously, vaccines were made by traditional methods but these have been upgraded to tissue culture methods. Research institutions, academic institutions, private sectors and individual researchers are working to address local and some global issues in the recent years. Some private institutions like Centre for Molecular Dynamics (CMDN) are working on genomic research in field of Avian Influenza and fish diversity [49, 50] while non-governmental organizations such as Local Initiatives for Biodiversity research and Development (LI-BIRD), FORWARD Nepal conduct research related to natural resources, biodiversity and ecosystem services, crop dairy and socioeconomic fields, respectively [29]. Similarly, other private research organizations such as National Zoonosis and Food Hygiene Research Center (NZFHRC), Zest Laboratories and Heifer International are promoting locally-based research and developing the scientific capabilities of Nepal, respectively [51, 52, 53, 54, 55, 56, 57]. Individual efforts like the National Innovation Center, which is a non-profit organization established on 9 November 2012 by Mahabir Pun, is another good example (<https://nicnepal.org/about/>). These organizations have worked on applied research in collaboration with many international organizations like Gates Foundation, USAID, WWF, JAICA, GIZ, etc. In doing so, they have produced some cutting-edge results such as the genotyping of *Panthera tigris* and *Panthera uncina*, establishing their own intellectual property rights in the process [55, 58, 59, 60]. In addition, some interesting collaborations on medical research and innovations in treatment are being conducted in medical sciences [61, 62, 63, 64, 65, 66]. Recently at Tribhuvan University Teaching Hospital (TUTH), led by Dr. Ramesh Singh Bhandari involving expert surgeons, anesthetists, hematologists, radiologists and pathologists, have successfully conducted several liver transplant services, for the first time in the country [67].

In addition, some good quality works have been conducted by Nepalese scientists working abroad, which have addressed important scientific questions in their country and beyond [68, 69, 70, 71, 72]. For example, Dr. Sangeet Lamichhaney, a veterinarian from Nepal, and his team have scientifically proved Darwin's theory of evolution through use of molecular genomics [72, 73]. Similarly, Nepalese students are involved in research outside the country and they are also interested to return to Nepal that needs to be encouraged to allow cross-fertilization of skills and ideas.

Similarly, there have been significant achievements in the field of eye treatment, community forest, and small-scale hydropower by successful application of novel technology and knowledge. Some of the governmental departments like Agriculture and Forestry have come up with some tangible technologies that are well suited to field conditions. For example, the success of community forestry in Nepal is a global lesson on

how sustainable development can be achieved through conservation of natural resources by local people [74, 75]. All these scientific projects, and the proactive and leading role of Nepalese research institutes and Nepalese researchers in the international scientific arena have thrown some rays of hope for greater scientific contribution from Nepal. The recent advancements and accessibility in the communication and internet has helped aspiring Nepalese researchers to reach out to the international community and to learn necessary skills. Along the way, recent trends and research transformation from previous opinion-based biased studies -to evidence-based quantitative and molecular research lay some ground for a bright future of scientific research in Nepal.

5. Future perspective for scientific research and development in Nepal

Considering the overall funding opportunities and research capabilities in Nepal, we should focus on low-cost applied research which can generate cost-effective research outputs and technologies to solve practical issues (ranging from local to global). For example, we can contribute to the multi-disciplinary research on climate change by carrying out, at very low cost, epidemiological studies of possible links between urban air quality and associated pulmonary disease, cancer, and cardiovascular diseases. National scientific and technological capacities should be enhanced for the effective utilization of science for the benefit of the Nepalese people. Universities should be developed as centers of excellence by establishing R & D centers and innovation labs. Government should be proactive and maintain a strong political will, conducive policy environment, and enabling institutional framework to promote science, research and technology generation for the betterment of society and country. Government should have a policy to utilize the many Nepalese scientists working in international forums for collaborative research to develop the scientific expertise of the nation.

6. Conclusions

The government of Nepal should prioritize research and development as a national need with a proper budgetary allocation for the intellectual and economic development. Government also needs to endow its research organizations with long-term uninterrupted financial, structural and human resources to promote scientific innovations. Similarly, the research organizations should also explore the opportunities provided by other national and international funding agencies. Scientific professionals, experts and professional societies/associations involvement in policy making should also be enhanced which would not only benefit the government's strategies by giving an expert opinion but also boost the morale of Nepalese scientists spending life in the science and technology domains (S & T). Each scientist holding a research position should be given a strong motivation (i.e. security/prizes/rewards) to rise above their personal interests and work for the collective benefit of the country. For a nation like Nepal, devastated by natural calamities, and hit hard by the ongoing pandemic, the future lies in the four pillars of centeredness on research, collaboration, critical engagement and self-criticising for overall growth. Recognizing areas of strength and playing to it should be the strategy.

Declarations

Author contribution statement

Acharya KP, Phuyal S: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Chand R, Kaphle K: Analyzed and interpreted the data; Wrote the paper.

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No data was used for the research described in the article.

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The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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