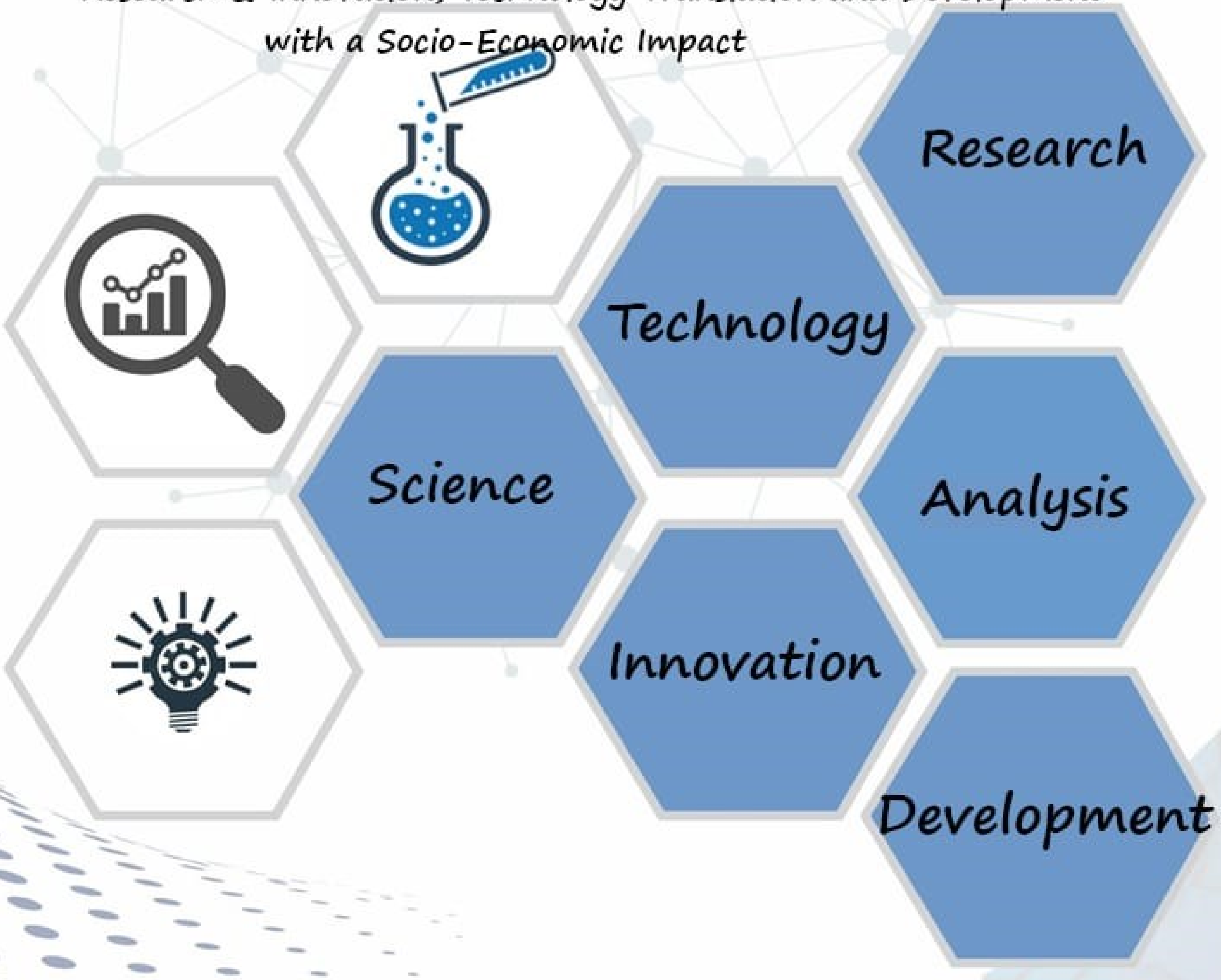
Pakistan Council for Science and Technology
Ministry of Science and Technology
Government of Pakistan

SURVEY ON NEED ASSESSMENT OF S&T HUMAN RESOURCE FOR DRIVING INNOVATION

Strengthen National STI Ecosystem Through an Effective and Planned Demand Driven Technical Workforce Development to Support Culture of Research & Innovation, Technology Translation and Development with a Socio-Economic Impact



Survey On Need Assessment Of S&T Human Resource for Driving Innovation

2024

Survey On Need Assessment Of S&T Human Resource for Driving Innovation

How to cite this report
Bakhtiar, F. (2024). Survey on Need Assessment of S&T Human Resource for Driving Innovation. Pakistan Council for Science and Technology, Ministry of Science and Technology, Government of Pakistan.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATION

CC&I	Chamber of Commerce and Industries
CPEC	China-Pak Economic Corridor
CPD	Continuous Professional Development
GAP	Good Agricultural Practices
GoP	Government of Pakistan
HEC	Higher Education Commission
HEIs	Higher Education Institutions
HSE	Health, Safety, and Environment
ICT	Information and Communication Technology
ISO	International Organization for Standardization
KP	Khyber Pakhtunkhwa
MoST	Ministry of Science and Technology
MPhil	Master of Philosophy
NCST	National Commission of Science and Technology
NASTHR	Need Assessment of Science and Technology Human Resources
OECD	Organization for Economic Cooperation and Development
NRA	National Research Agenda
OHSAS	Occupational Health and Safety Assessment Series
OECD	Organization for Economic Cooperation and Development
PAP	PhD Association of Pakistan
PBS	Pakistan Bureau of Statistics
PCST	Pakistan Council for Science and Technology
PhD	Doctor of Philosophy
R&D	Research and Development
SAT	State-of-the-Art Technology
SDGs	Sustainable Development Goals
S&T	Science and Technology
STEM	Science, Technology, Engineering, and Mathematics
UK	United Kingdom

UKAS	United Kingdom Accreditation Service
UNDP	United Nations Development Programme
USA	United States of America
ToRs	Terms of References

PREFACE

Scientific and Technological human resource are one of the crucial drivers in the development and adoption of technological innovations across the key sectors of any vibrant economy. Given the potential for massive disruptions in socio-economic ecosystem, government needs to ascertain the existing state and future S&T human resource requirement in the country. In the context realizing the importance of the subject, Pakistan Council for Science and Technology (PCST) under the aegis of the Ministry of Science and Technology undertook the study on future need assessment of S&T Human Resources for driving innovation during the period 2020-22. The study covered three key sectors of economy i.e. Higher Education Intuitions, R&D Organizations and industry.

The objective of the study is closely related to the objectives of our national vision. Government of Pakistan's commitment to switch over its traditional resource-intensive economy to knowledge-based economy has put great emphasis on education and knowledge creation in its future development agendas. The study helps in evidence-based informed policy-formulation for planned production of highly qualified human resource in various fields of S&T to align with the socio-economic development priorities of the country.

Based on its nature and scope this study is a pioneer attempt at the national level to assess both the current state of highly qualified S&T human resources (HR) as well as the demand-supply gap of highly qualified S&T HR between academia and the industry. Further, the study has been conducted at a point in time when the fourth industrial revolution is rapidly advancing with technology and highly trained HR being at its very core.

This benchmarking S&T HR survey has been conducted using a comprehensive questionnaire designed to analyze the current state and future need of country's S&T HR workforce in HEI, S&T/R&D Organizations and the Industry on the factors like demographics, type, nature and level of education and employment nature.

The study enables the policy-makers to draw lessons on the impact of these factors on the national economy and development, essentially looking at the human capital available within a nation and how effectively it is being utilized.

It is expected that results from this survey on need assessment of S&T Human Resources for driving innovation will give insights not only into the S&T HR working in HEI, S&T/R&D organization and the industry. It is also envisaged that this exercise would form the basis to formulate appropriate policies, which would give a renewed strength to our different sector of economy suffering from declining growth and productivity due to lack of appropriate S&T workforce

Engr. Farid Bakhtiar Khan
Project Director
Survey on Need Assessment of S&T Human Resources for Driving Innovation
Pakistan Council for Science and Technology
Islamabad

ACKNOWLEDGMENTS

Pakistan Council for Science and Technology (PCST) expresses its gratitude to all the Higher Education Institutes (HEIs), Research and Development Organizations, Industries and individuals for their invaluable support, assistance, and cooperation during the data collection phase of this survey.

We sincerely acknowledge the dedicated efforts of the Project Committee, Project Team, Data Collecting Firm, and all other individuals involved in the data collection, analysis, and compilation of this report. Without their tireless and persistent efforts, this challenging and massive task could not have been completed successfully.

Rizwan Ahmed Shaikh
Senior Joint Secretary (MoST) / Chairman, PCST (Look after)
Pakistan Council for Science and Technology
Islamabad

EXECUTIVE SUMMARY

Scientific and Technological human resource are crucial component in the development and adoption of technological innovations across the key sectors of any vibrant economy. Given the potential for massive disruptions in socio-economic ecosystem, the government needs to ascertain the current state and future S&T human resource requirement in the country.

To date, no comprehensive survey has been conducted in Pakistan either to assess the current state of highly qualified S&T human resources (HR) or the demand-supply gap of S&T HR between academia and the industry. It is in this context that Pakistan Council for Science and Technology initiated a comprehensive survey study under the project titled "*Need Assessment of Science and Technology Human Resources (NASTHR) for Driving Innovation and Achieving Vision 2030*". The key objective of the study was to take stock of S&T human resources in the country and to help the Government in evidence-driven and informed policy-making.

The scope of the survey encompasses higher education institutions, S&T/R&D organizations and industrial units working in the four provinces and the federal capital territory using a well-structured and close-ended questionnaire. The findings, however, exclude the data of strategic organizations and their affiliated academic institutions owing to their privacy and confidentiality.

The report presents research objectives, methodology, survey results and key findings of the study. The current state of human capital and innovations in science and technology (S&T) is in state of dismal in Pakistan and calls for urgent actions to invest in human resources. Pakistan is the fifth most populous country in the world, yet in terms of the number of research and development (R&D) researchers per million population, it has only 383 researchers, while Finland, which has less than 6 million population has 7,228 researchers per million population. Scientific publications are considered as an important and internationally recognized benchmark of progress in the field of S&T of any country. According to World Bank report of 2018, the number of scientific publications per million populations is: Pakistan (59), India (99), China (373), Russia (560), Germany (1259), the USA (1273), Canada (1,619), Australia (2,146), Norway (2,222), and Switzerland (2,511). The number of Patent applied also signifies as an important element related to progress in S&T. In case of Pakistan, patent applications per million people for the year 2021 were only 1.84, whereas South Korea had the highest number of patent applications per million people i.e., 3599.63. Following is some of the key findings received on the basis of the survey carried out in HEIs, R&D organizations and selected Industry:

Higher Education Institutions

The survey questionnaire was sent to 224 Higher Education Institutions (HEIs) both in the public and private sector in the four provinces; Punjab, Sindh, Khyber Pakhtunkhwa, Baluchistan, and the Federal Capital Territory. The report is a reflection of Human Resource needs assessment of HEIs as of 2020 and does not necessarily represent data of all the HEIs working in the country. The public universities constitute 58% of the total universities surveyed. About 26% universities were multi-campus in nature and 37% of the universities have enrollments from the international students.

More than two third of staff working in the universities are regular employees (around 72%), and relatively lesser number are hired on a contractual basis. Gender-wise, around 70% of staff in the universities is male. Almost 90% of men are working as regular staff, whereas, 60% of women are contractual staff. Only 36% of the universities have a continuous professional development (CPD) plan for their teaching faculty.

Senior faculty staff that is, professors and associate professors working in the surveyed universities constitute 12% and 9% of the teaching faculty, respectively, while majority of them are assistant professors and lecturers. About 75% of staff with a PhD degree and 60% with MPhil/MS are male. Women occupy around one-third of the positions of assistant professors, one-quarter of the positions of associate professors, and only 23% of the positions of professors.

The data of HEIs shows that surveyed public and private universities have produced 1778[1] PhDs during the last five years and the highest number of PhDs (69%) were produced by universities in Punjab. An encouraging finding is that the ratio of female students who completed their PhD degrees during the last five years is slightly than their male counterparts (~ 51% to 49%). Similarly, among the 2103 currently enrolled PhD students, female constitute 52% of the total enrollments.

Industries

The study surveyed 243 industrial units of which 21, 32, and 48% were large, medium, and small industries, respectively. Around half of the industrial units have some form of quality standards certification in place, 115 industries have no quality certification, and 6 industries did not provide any data related to quality standards. ISO-9001 standard is about quality management. It also assesses customer focus and motivation of top management for improvement. ISO-14000 standard is about environmental management. Health, Safety, and Environment (HSE) system (OHSAS-18000) is about occupational health and safety management systems. Global GAP is related to good agricultural practices, whereas UKAS provides certification on testing, inspection, and calibration. The data shows that 95% of the industries do not have any international environmental quality standards, and only 44% of them have organizational quality management standards, whereas, 39% of industries have no quality standard certification.

About 98% of the employees in the industries are working as regular staff and women constitute only 11% of the total staff. In sharp contrast to the fact that a considerable number of women are enrolled in MPhil and PhD programs in various universities, there are not many job opportunities for them in the industrial sector. The data shows a huge gap between the demand and supply of highly qualified HR in the country. It's cause of concern given the fact that currently more women than men are enrolled in PhD programs at universities, and after finishing their degrees, a majority of them would not be able to find opportunities in various industries and play due role in the productivity of the country.

[1]*(based on the information provided by survey responding institutions- this does not reflect the data of all the HEIs working in the country)*

Analysis of 243 industrial units shows that there were less than one percent of employed staff is with a PhD and/or a master's degree and only 18% of the staff possessed bachelor or equivalent degree, whereas, the rest possessed qualifications of intermediate level or below.

Research and Development (R&D) Organizations

The study surveyed 218 R&D organizations, of which 97% are public entities, 2% are privately owned and only one percent are autonomous entities. Most of the employees (90%) in R&Ds are working as regular staff. Men constitute 80% of the total workforce which is a cause for concern given the trend as 50% of the female students who are currently enrolled in PhD programs would not be able to find jobs in such organizations.

A majority of the staff with tertiary education in R&D organizations possessed bachelor's degrees, whereas, 6% had a PhD and 16% had MS/MPhil degrees.

Conclusion and Recommendations

The analysis reflects a huge gap in the demand and supply of highly qualified human resources. It is recommended that the Government can initiate policy interventions to proactively engage academia, industry and other key stakeholders to bridge the gap by creating demand for trained human resources and also encourage academia to initiate more demand-oriented programs in collaboration with industry to address the demands of the market. Government can also arrange collaborator workshops with academia, S&T/R&D organizations and the Chambers of Industries to engage in a positive dialogue to pave the way for creating employment opportunities. The data also shows gender disparity in the workforce in academia and industry. Government may also share these findings with the stakeholders to make them realize such a wide disparity and hire more female human resources. At present, more than half of the students enrolled in PhD programs are women, it is necessary for the government to initiate policy measure that help encourage S&T/R&D organization and the industry to promote conducive working environment and employment opportunities for them in the future.

KEY HIGHLIGHTS OF THE SURVEY

The survey was conducted in four provinces and the federal capital territory among the institutions of higher education, industrial units and Science and Technology Research and Development Organizations using a structured and close-ended questionnaire. The findings, however, exclude the data of Strategic Organizations and their affiliated academic institutions due to confidentiality and classified nature.

- The surveyed public and private universities have produced 1778 PhDs during the last five years and the highest number of PhDs (69%) were produced by universities in Punjab.
- An encouraging finding is that during the last five years, the percentage of students who completed a PhD is slightly more among women (51%).
- Currently, 2103 students are enrolled in any PhD program, and the highest number of such students is enrolled in the universities of Punjab; and women constitute 52% of the students enrolled in these programs
- The majority of staff working in the universities are regular employees (72%), and only a quarter of them are hired on a contractual basis.
- Women constitute only 11% of the total staff in the industries. A considerable number of women are enrolled in MPhil and PhD programs in various universities, but there are not many job opportunities for them in the market. The data shows a huge gap between the demand and supply of highly qualified human resources in the country. It is a worrying situation because currently, more women than men are enrolled in PhD programs in universities, and after finishing their degrees, a majority of them would not be able to find opportunities in various industries
- From 224 public and private universities surveyed in Pakistan, the public universities constitute the majority (58%) of the higher education institutions surveyed.
- About 37% of universities have international students.
- Around 30% of universities have more than one campus.
- Around 70% of staff in the universities is male. Almost 90% of men are working as regular staff, whereas 60% of women are contractual staff.
- Only 36% of the universities have a continuous professional development plan for their teaching faculty.
- The survey showed that universities are 20% short of the required number of staff with PhD and MPhil/MS degrees.
- About 75% of staff with a PhD are male, whereas around 60% of staff with an MPhil/MS are male.
- In 224 universities surveyed, professors and associate professors constitute 12% and 9% of the teaching faculty respectively, whereas assistant professors and lecturers are 40% and 43%.
- Women occupy around one-third of the positions of Assistant Professors, one-quarter of the positions of Associate Professors, and only 23% of the positions of Professors.
- The study surveyed 243 industrial units of which 21% were large, 32% were medium and 48% were small industries.
- Slightly more than half of the heads of the industries possessed Masters degree.
- Around 70% of the surveyed industrial units have some kind of quality standards certification. ISO 9001 standard is about quality management and also assess customer focus and motivation of top

management for improvement; whereas ISO 14000 standard is about environmental management. The data shows that 95% of the industries do not have any international environmental quality standards, and only half of them have organizational quality management standards, whereas one-third industries have no quality standard certification.

- About 98% of the employees in the surveyed industries are working as regular staff.
- Analysis of 243 industrial units shows that there were negligible PhD level staff, less than 1% of workers have completed Masters and 18% of the staff possessed a bachelor's degree.
- The study surveyed 218 Research and Development Organizations, of which 90% are public entities, 6% are privately owned and 4% are autonomous entities.
- Most of the employees (90%) are working as regular staff, and 80% of the total workforce are men. This is a matter of great concern as currently, women constitute half of the students who completed PhDs during the last five years, and almost 50% of the students currently enrolled in PhD programs are also women. As in the case of industries where very few women were employed, the situation is not different in R&D organizations.
- A majority of the staff with tertiary education in R&D organizations possessed bachelor's Degrees, whereas 6% had a PhD and 16% had MS/MPhil degrees.
- The analysis shows a huge a gap in the demand and supply of highly qualified human resources and it is recommended that relevant stakeholders may actively engage with academia and industry to bridge the gap by creating demand for human resources and also introducing new subjects in academia to meet the demands of the market. Stakeholders may also take measures such as arranging collaborator workshops with academia and industry to engage in a positive dialogue to pave the way for creating employment opportunities.
- The data also shows gender disparity in workforce in academia and industry. The findings provides an opportunity to the stakeholders to realize such a wide disparity and hire more female human resources. As currently, more than half of the students enrolled in PhD programs are women, it is necessary to create opportunities for them in future.

There is a huge gap in the demand and supply of highly qualified human resources. During the last five years, universities have produced around 1800 PhDs, but no industrial unit has hired a PhD in any province, whereas in Research and Development Organizations, only 6% of the staff with a tertiary qualification had PhDs. An overwhelming majority of the workers in the industrial units and R&D organizations have only 12 years of education (i.e. intermediate). In this context, stakeholders may engage with industries and R&D organizations to negotiate for creating employment opportunities for the highly qualified human resources regularly produced by our academia

1. INTRODUCTION AND BACKGROUND OF THE PROJECT

1.1 Introduction

Knowledge-economy has become a dominant factor in this 21st century. Global economy with knowledge-based industries and activities is playing a pivotal role in the economic development of many countries particularly the global leaders. Knowledge economy is characterized by high levels of investment in scientific and technological research and development, the widespread adaption of technology in every sphere of socio-economic activities in the society, and the growing importance of highly skilled work-force. Many countries worldwide including our neighboring countries are promoting the development of a knowledge economy, recognizing the vital role that knowledge and innovation drive economic growth and competitiveness. Realizing the importance of the knowledge economy, Pakistan Council for Science and Technology (PCST) has initiated this study to take stock of the current state and future needs of highly qualified S&T human resources in key sectors of economy i.e. Higher Education Institutions, Research and Development Organizations, and the industry.

1.2 Background

Government of Pakistan (GoP) while recognizing the importance of knowledge-based economy has put great emphasis on education and knowledge creation in its development agendas for the next decade as reflected in Pakistan Vision 2025 and Vision 2030, which aims to increase higher education coverage from 7% to 12%, and the total number of PhDs from 7,000 to 15,000 by 2025 (GoP). Steps are being taken for the production of highly qualified manpower so that they can play their multiple academic and research roles with the ultimate objective of socio-economic development of Pakistan.

The national agenda aims to make Pakistan among the top 25 economies of the world by utilizing untapped potential by investing in knowledge, innovation, and entrepreneurship as key drivers of growth and future progress. The Vision consists of five enablers and seven pillars[1], of which the first and the sixth pillars are directly related to the present study. The first pillar is “People First” which aims to develop human and social capital, and the sixth pillar is “knowledge economy” which aims to develop a competitive knowledge economy through value addition.

National Research Agenda (NRA) has been drafted to align with the national vision to provide direction to the national research and development activities that could help the government to achieve the goals mentioned in the Vision. National Research Agenda contains 15 priority areas[2], but all of them have a cross-cutting theme that is based on research, technology, and innovation.

---

[1] *The key five enablers include 1) shared vision, 2) political stability & continuity of policies, 3) peace and security, 4) rule of law and 5) social justice. The seven pillars are: 1) people first, 2) Growth, 3) Governance, 4) Security, 5) Entrepreneurship, 6) Knowledge Economy, and 7) Connectivity.*

[2] *The priority areas are Agriculture & Food Security, Water, Energy & Fuel Cell Technology, Health & Pharmaceuticals, Climate Change & Environment, Biotechnology, Information & Communication Technology, Mineral Resources, Nanotechnology, Housing, Electronics, Space Technology, Marine Resources, Automobiles and Robotics.*

Vision 2030 and National Research Agenda 2020 are directly aligned with two Sustainable Development Goals (SDGs) i.e. SDG-4 and SDG-8. SDG-4 calls for ensuring inclusive and quality education and promoting lifelong learning opportunities for all, whereas, SDG-8 is about the promotion of sustained, inclusive, and sustainable economic growth, full & productive employment, and decent work for all (UNDP, 2023).

Pakistan's literacy, enrollment, and various educational indicators have demonstrated notable improvements over the past few years. The government has shown a strong commitment to enhancing both the quality and accessibility of education through targeted policy interventions and increased resource allocation. This determination is evident in the Pakistan Economic Survey 2021-22, which underscores the nation's resolve to uplift the education sector. However, realizing the necessary reforms and advancements in the education sector requires the active involvement of the private sector according to Pakistan Economic Survey 2021-22.

Among various initiatives taken by the Government, China-Pak Economic Corridor (CPEC) is a promising initiative that will support our National Vision. After achievement of the vision's objectives; Pakistan will be a middle-income country with per-capita income of over 3000 US dollars in the near future. The incidence of poverty will be around 10% and income, gender and regional disparities will be lowered by at least one half of the current levels.

1.3 About Pakistan Council for Science and Technology

Pakistan Council for Science and Technology (PCST) is mandated to advise the Government on the development of science and technology at the national level. The Council is involved in S&T policymaking, planning, implementation, and carrying out policy studies. PCST is also the secretariat of the National Commission of Science and Technology (NCST), headed by the Prime Minister (which takes the major decisions for the development of S&T in the country).

PCST performs various functions, but the current study is mainly related to the following two functions:

- To collect, update statistics and maintain a database on the science and technology potentials of the country
- To take measures for effective collaboration among academia, research and development organizations, and industry for the development of indigenous products or technologies

1.4 Human Capital in an International Context

Though the latest data regarding the number of PhDs in Pakistan is not available, comparing past reports by the Organization for Economic Cooperation and Development (World Economic Forum, 2017) and the Higher Education Commission of Pakistan (HEC, 2023), the following figure 1 shows that in just a single year of 2014, the US produced 67,499 PhDs, India produced 24,300 PhDs, whereas Pakistan produced only 1,351.

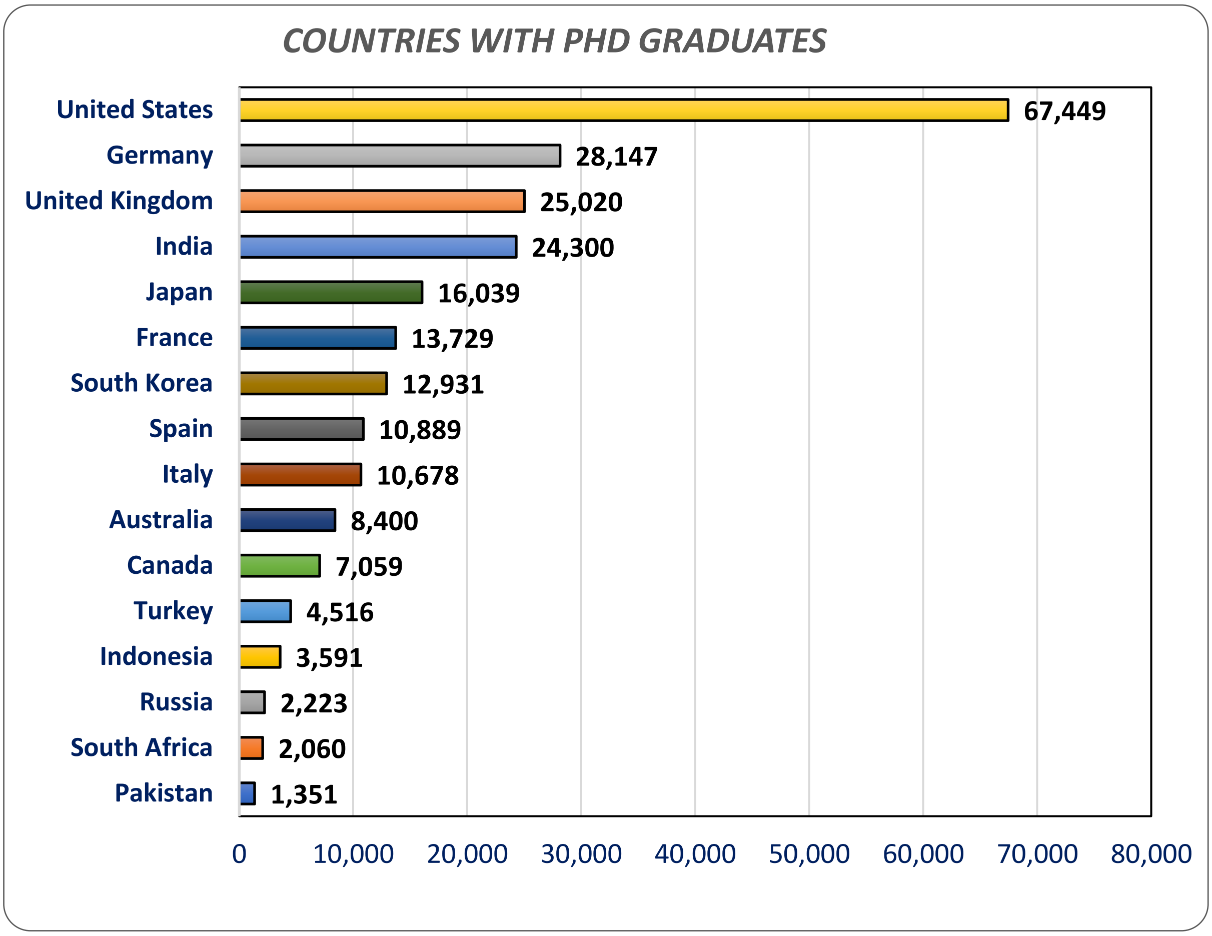


Figure 1: Countries with PhD graduates

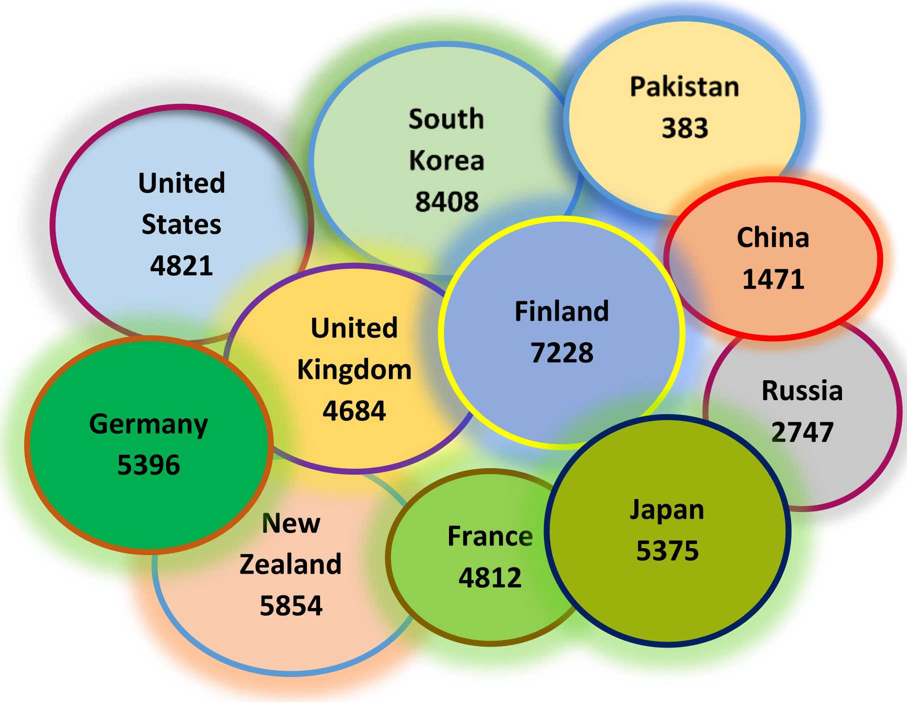


Figure 2: R&D Researchers per million population – Source: UNESCO via World Bank

Another dimension to analyze the progress of a nation is to compare R&D researchers per million population. The Figure 2 shows the comparative size of R&D researchers in some selected countries to provide a relative view of R&D work carried out in a country. Though China and Pakistan are among the most populated countries in the world, in terms of R&D researchers per million populations, they have very low figures when compared to South Korea, Finland, New Zealand, Germany, and Japan.

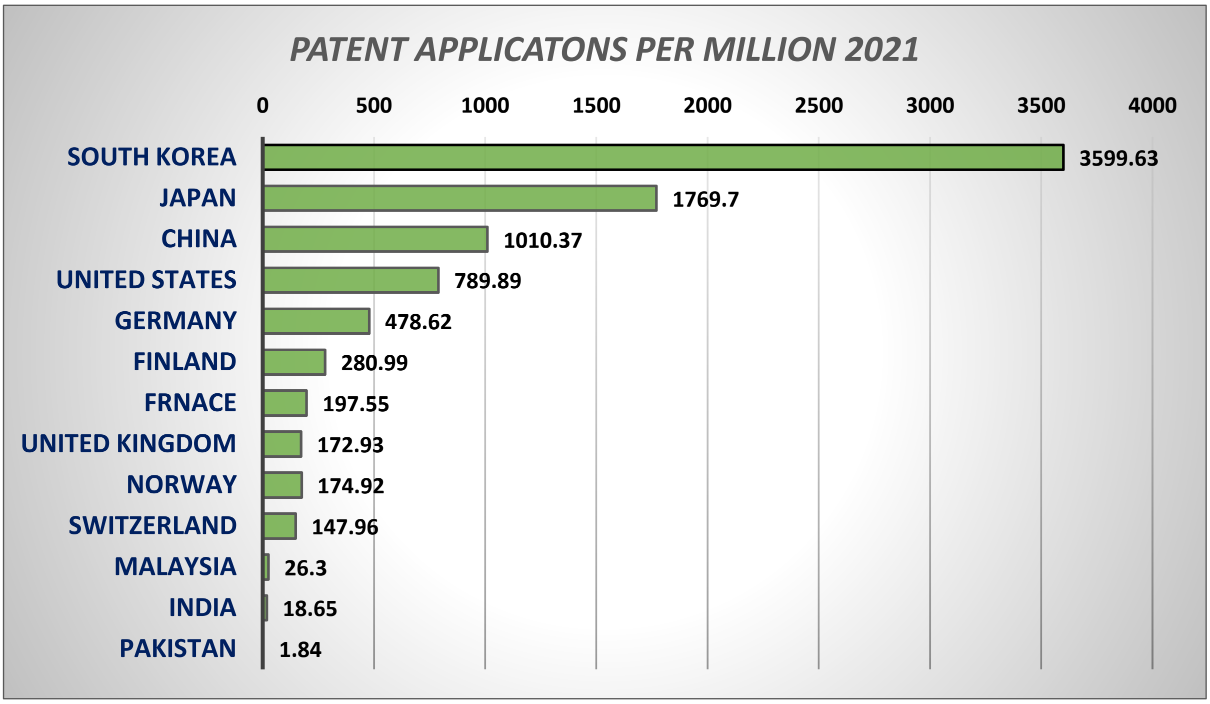


Figure 3: Patent applications per million- Source: World Bank

The number of patent applications also signifies progress in science and technology. The figure 3 displays data for only selected countries (World Bank dataset, 2021). It shows that in Pakistan, patent applications per million people for the year 2021 were less than 2, whereas South Korea had the highest number of patent applications per million people, i.e., 3599.

Scientific publications are considered an important mark of progress in science and technology. World Bank data for the year 2018 indicates that Pakistan falls among the countries with the lowest number of scientific publications per million populations. The number of scientific publications per million populations for the year 2018 is: Pakistan (59), India (99), China (373), Russia (560), Germany (1259), the USA (1273), Canada (1,619), Australia (2,146), Norway (2,222), and Switzerland (2,511) (World Bank, 2018).

1.5 Justification for the Study

There has not been a single detailed study to assess the future needs of highly qualified S&T human resources development at the national level. This study focusses on reviewing the current status of human resources working in public and private sector universities, S&T / R&D organizations and the industry to determine their human resource needs in different fields within the next decade through quantitative and qualitative research methods. It is expected that the findings of the project would provide a firm basis for policymakers and relevant stakeholders for the formulation of evidence-based strategies for human resource development and utilization.

The project would help in the achievement of relevant goals set in the national vision as they can only be actualized in a true sense; subject to harmonizing and optimizing the demand and supply gaps of highly qualified manpower produced that is relevant to the socio-economic development of the country. In the given context, there is a pressing need for the current study, which has evaluated the current status of highly qualified manpower in the country and projected future human resource requirements. This assessment is crucial, aligning with the national development agenda and mega projects like the China-Pakistan Economic Corridor (CPEC), which hold substantial socio-economic potential.

1.6 The Gap in Demand and Supply of Highly Qualified Human Resources

Pakistan has the 9th highest work/labour force in the world (Planning Commission, 2022), but employment trends in Pakistan during the last three decades indicate a widening gap between increasing population and labour participation (World Bank, 2022) as reflected in the following graph.

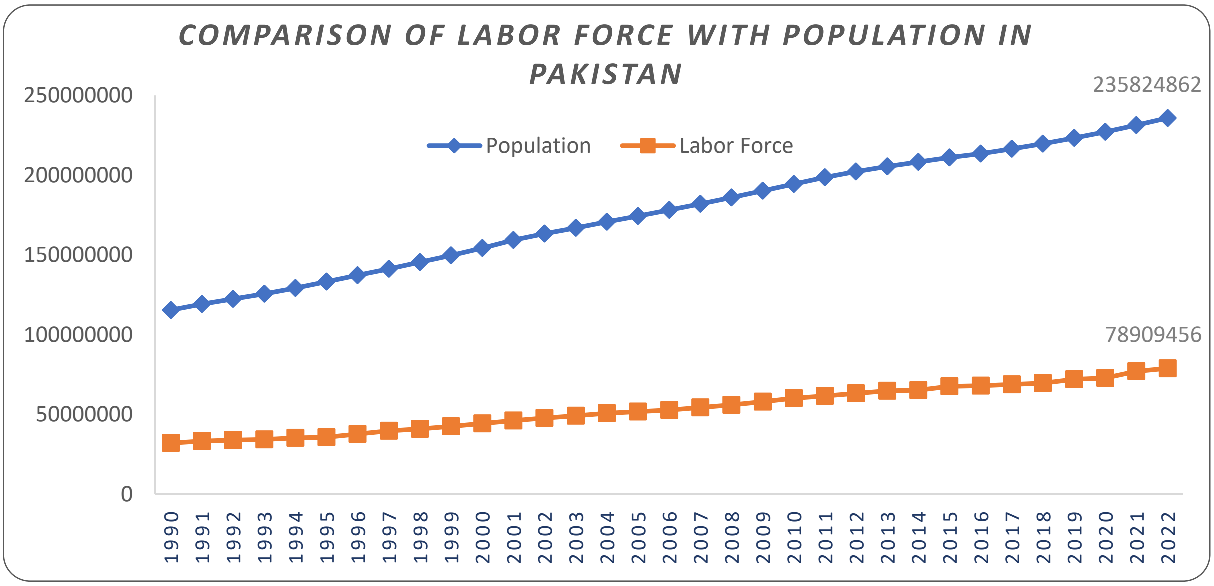


Figure 4: Comparison of Labor Force with Population in Pakistan

The latest available data from Pakistan Labour Force Survey 2020-21 indicate a 6.3% unemployment rate (5.5% for men and 8.9% for women) in the country (PBS, 2022). Ironically, the unemployment rate among the youth aged 15-24 years was the highest at 11.1%.

Though the government has made efforts in line with national vision and the number of PhDs is increasing, however there have not been enough jobs for them. According to the PhD Association of Pakistan (PAP), more than 3000 PhDs in Pakistan are jobless (News, 2020). Findings of a recent survey by Pakistan Institute of Development Economics show that 62% of our youth want to leave the country if given an opportunity (Nayab, 2022).

During the last three years, more than a million educated youth have already left the country to seek employment abroad (Tribune, 2022). Hence, the current study intends to know where the gaps lie in demand and supply, what the demands of the industry are, and what the higher institutions of education are producing/supplying. In 2022, more than 700,000 educated youth have left Pakistan in search of employment (Aiman, 2022). Hence, the current study aims to identify the discrepancies between the demand and supply in the job market, assess the industry's requirements, and analyze the output of higher education institutions in meeting these demands.

1.7 Objectives of the Study

The key objectives of the study are to review and update the current status of highly qualified science and technology (S&T) human resources i.e. PhDs and MPhil/MS (minimum 18 years of education), working in all public/private sector universities, all S&T / research and development organizations and selected industrial units, track PhDs produced in different disciplines during last 5 years to gauge their gainful employment/unemployment status; and carry out future need assessment of human resources to pace with Vision 2030.

2. STUDY APPROACH AND IMPLEMENTATION METHODOLOGY

This section covers the assessment of project implementation, using the followings approaches.

2.1 Key Phases in the Project Implementation

The assessment was conducted using the following approach.

i. Conduct Review of Secondary Data.
ii. Prepare Data Collection Tools (Quantitative).
iii. Conduct a Survey of 224 Public and Private Universities for Human Resources and their Needs.
iv. Conduct a Survey of 218 Research & Development and Science & Technology Organizations Human Resource and their Needs.
v. Conduct a Sample Survey of 200 Industrial Units in 4 Provincial and one Federal Territory (ICT) headquarters for Human Resource and their Needs.
vi. Conduct 4 provincial-level and 1 federal-Level Introductory Workshops.
vii. Entry of data through a software application.
viii. Analysis and reporting.

3. STUDY PROCESS

3.1 Study Implementation Methodology

Project implementation methodology consists of the following steps:

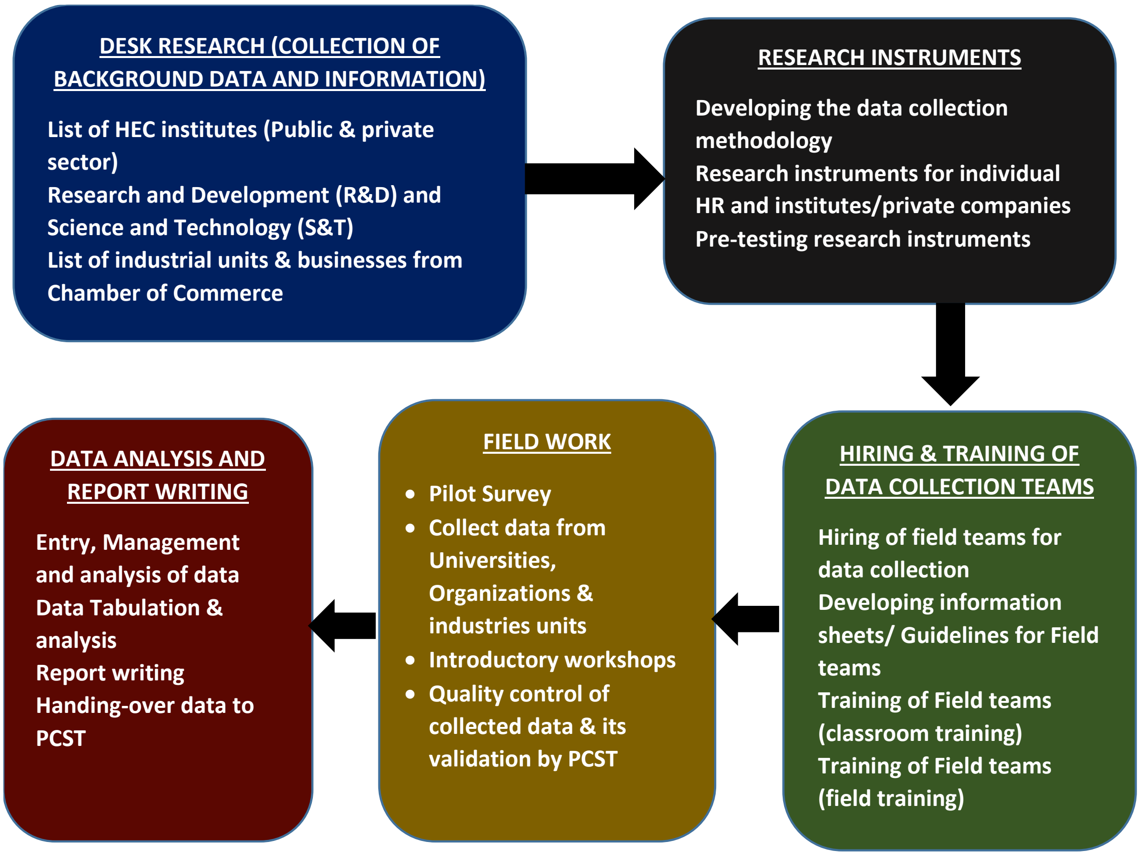


Figure 5: Implementation Methodology

3.2 Project Inception

3.2.1 Kick off Meeting /Coordination with PCST

Prior to the commencement of work, methodology, work plan, and field plan were share with PCST and other stakeholders. The objective of the engagement was to:

- Finalize communication protocols necessary to communicate with the client and other stakeholders;
- Establish a point of contact.

3.2.2 Review of Secondary Data, Documents, and Reports

The research team has sourced the data available with PCST, the HEC, the Pakistan Bureau of Statistics (PBS), and the Chamber of Commerce and Industries (CC&I) as a prelude to the commencement of the exercise. In addition, the following documents have also been reviewed:

1. Project Document
2. List of Universities
3. List of R&D/S&T Organizations
4. List of Industries
5. Vision 2025 & 2030
6. National Research Agenda
7. United Nations Sustainable Development Goals (UN SDGs)

3.2.3 Project Inception Report

After conducting the extensive review of the secondary data and information, and visiting study sites, the research team developed and finalised proper protocols/tools on specific items, work plan, and methodology. An inception report was formulated and shared with the client.

3.2.4 Development of Data Collection Tools

Quantitative tools were developed to collect data from universities, research and development organizations, industries, and PhD graduates. The key consideration during the development of quantitative tools was to decide on the information required; define the target respondents, select the method(s) of reaching the respondents; determine question content; word the questions; sequence the questions; check questionnaire length; pre-test the questionnaire and develop the final questionnaire. The tools contained questions related to the current situation of human resources in the universities/organizations/industries, and their future needs. Before actually collecting the data, the tools were pre-tested to ensure validity of tools and consistency in data collection.

The tools were designed around the following key objectives (Table 1) to give rich information surrounding the study:

Table 1: Key Objectives, Types of Tools and their description.

Objective	Type of Tool	Description of Tool
1. Review and update the current status of highly qualified science and technology (S&T) human resources i.e., Ph. Ds and MPhil / MS (minimum 18 years of education), working in all public / private sector universities, all S&T / research and development organizations and selected industrial units;	• Proformas (Quantitative) • Secondary Data	• Interviews with Authorized Representatives of 224 Universities • Interviews with Authorized Representatives of 218 research & development and science and technology organizations • Interviews with Authorized Representatives of 200 industries (sample size)
2. Track Ph.Ds produced in different disciplines during last 5 years to gauge their gainful employment / un-employment status		• Interviews with Authorized Representatives of 224 Universities to get the status of employment of their PhD students passed during last five years
3. Carryout future need assessment of human resources to pace with National Development Vision		• Interviews with Authorized Representatives of 224 Universities • Interviews with Authorized Representatives of 218 research & development and science and technology organizations and relevant departments and ministries • Interviews with Authorized Representatives of 200 industries (sample size)

3.2.5 The Sample for the Study

The following sample size for the survey has been determined to collect the relevant data (Table 2).

Table 2: Region, Universities, R&D and S&T organization, Industrial Units and their Sample Size.

S.#	Region	Universities	R&D and S&T Organization	Industrial Units
1.	**Islamabad**	24	59	3
2.	**Baluchistan**	12	17	6
3.	**Khyber Pakhtunkhwa**	41	26	17
4.	**Punjab**	80	67	131
5.	**Sindh**	67	49	43
	Total	**224**	**218**	**200**

3.2.6 Development of Data Entry and Analysis Software Application

The firm's research team developed a database application for entry, management and analysis of the survey data.

3.3 Survey Instruments Testing and Validation

The section deals with survey and its validation process.

3.3.1 Planning Pilot Survey

Just after successful training, the research team planned a pilot activity to test the survey instrument/ questionnaire. The pilot survey was based on 5% sample as per following:

- 12 Universities
- 08 R&D/S&T organizations
- 10 Industries

3.3.2 Survey Instrument Validation

The research team conducted a pilot activity where all the data collectors collected data and sent to the head office for entry into the software application, and then the questionnaires along with entered data were validated. To ensure the reliability and effectiveness of the survey before the actual survey, the response received from the sample survey was validated to verify that the survey questions are clear, unbiased, and capable of capturing the intended data accurately. The received information was analyzed and the questionnaire was refined for consistency.

3.4 Project (Field) Implementation

Following diagram illustrated the field implementation plan:

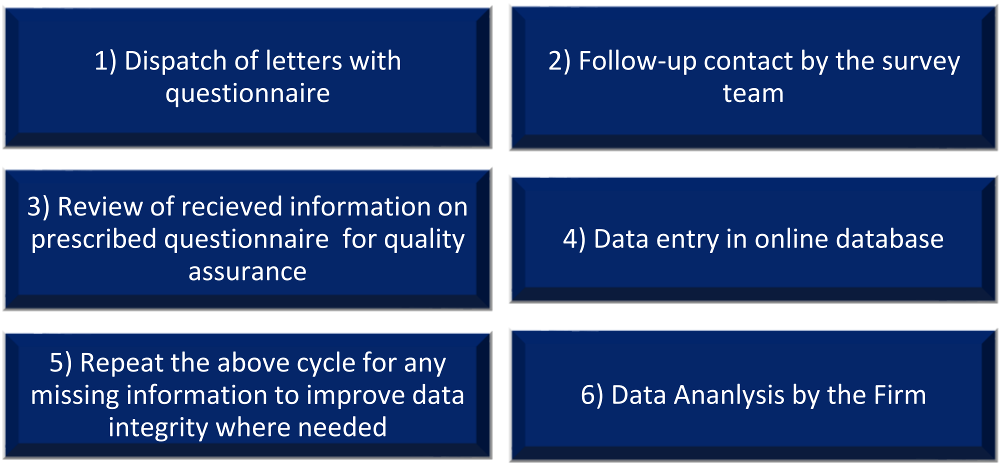


Figure 6: Field Implementation Plan

3.4.1 Training of Data Collection Teams

The training of data collection teams took place over three days in Islamabad, including one day of fieldwork (pre-testing) in nearby areas to pre-test the data collection tools. The field teams were introduced to the research tools, by explaining every question in detail. A 'run-through' of all questions was conducted, allowing each member of the team to comment on the logic and wording of questions. The training contents comprised of:

- Basic concepts and importance of project
- Collection of accurate and complete information from the respondents
- Effective communication skills to get questionnaires/checklists filled in and/or improving these according to circumstantial evidence found in the field
- Completing and checking the questionnaires/checklists of data collection to ensure legibility and accuracy
- Time management during data collection
- Techniques for data documentation/recording, initial analysis, and reporting
- Ethical considerations during data collection
- Field logistics

3.4.2 Introductory Workshops

To seek facilitation in data collection, the research team also organized project introductory workshop; one each in provincial headquarter and Islamabad with participation from the following stakeholders:

- Higher Education Commission
- Higher Education Institutions
- R&D/ S&T Organizations
- Industrial Units
- Bureau of Statistics
- Chambers of Commerce
- Relevant public sector organisations

3.4.3 Quality Assurance during Data Collection

The data quality was ensured throughout the data collection and compilation/tabulation processes with respect to completeness, accuracy, and timeliness, through continuous feedback and close monitoring by the firm’s core team. This made it possible for the team to virtually keep track, provide feedback, correct mistakes and if necessary, request re-visits to collect data from specific data points again. Thus, this mechanism allowed for correction during data collection process, without requiring waiting for the time when entire data would be collected and digitized. The provision of detailed guidelines, tight timelines, consistency in definitions/terminologies were used, and structured procedures of each activity helped to ensure adherence to most optimum quality of data collection.

3.4.4 Monitoring during Survey Administration

Throughout the fieldwork, the key team members monitored the progress as well as the quality of the collected data by visiting the field. The key experts along with other team members visited the field and provided feedback to the data collection teams.

4. FINDINGS

4.1 Higher Education Institutions

The emergence of Higher Education Institutions (HEIs) in the region which constitute Pakistan began with the establishment of King Edward Medical University (previously named as Lahore Medical School) in 1860. According to the data provided by the surveyed HEIs, by 1946, just before the partition of the subcontinent, there were 24 HEIs in various regions which currently constitute Pakistan. The charts below show the growth and distribution of HEIs in Pakistan. After independence, Pakistan witnessed slow but steady growth of HEIs. However, as reflected in Figure-7 below, in terms of decade-wise growth of HEIs in Pakistan a large number of HEIs were established in the last two decades beginning with the year 2000.

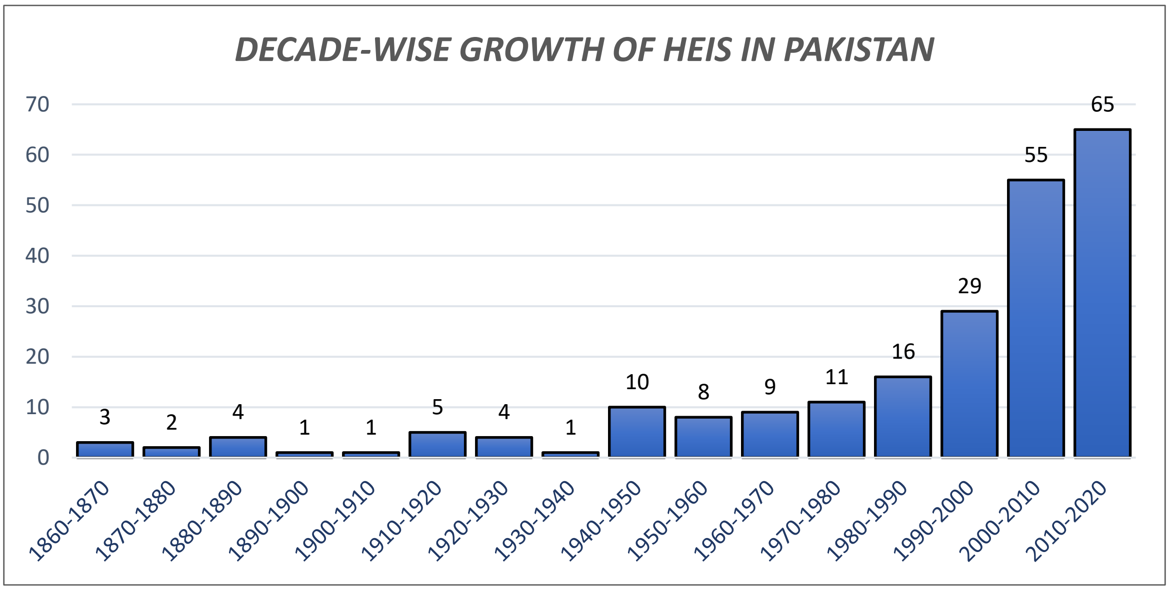


Figure 7: Decade-wise growth of HEIs in Pakistan

If the data is analyzed in-depth, year on year basis, w.r.t. year of establishment, the following figure (figure 8) shows that the higher number of HEIs established in a single year, were 15 and 20 HEIs in the 2002, and 2012, respectively.

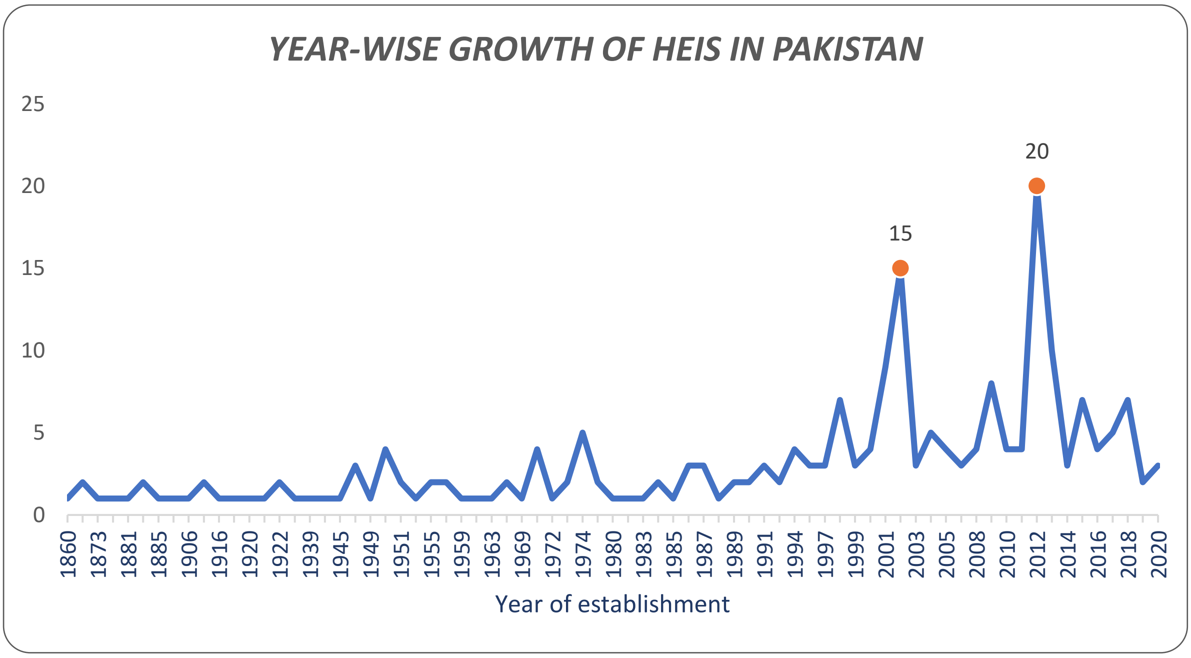


Figure 8: Year-Wise Growth of HEIS in Pakistan

A further analysis indicates that during the last two decades, the highest number institutions (i.e. 43) were established in Punjab, followed by Khyber Pakhtunkhwa (31) and Sindh (30). In the Federal Capital Territory and Balochistan, the number of HEIs established during the two decades is 12 and 8 respectively. The figure below (Fig: 9) shows that a large number of HEIs in Punjab were established i.e. 6 & 10 HEIs in the years 2002 and 2012 respectively; whereas a 7 HEIs were established in Sindh in 2013 alone.

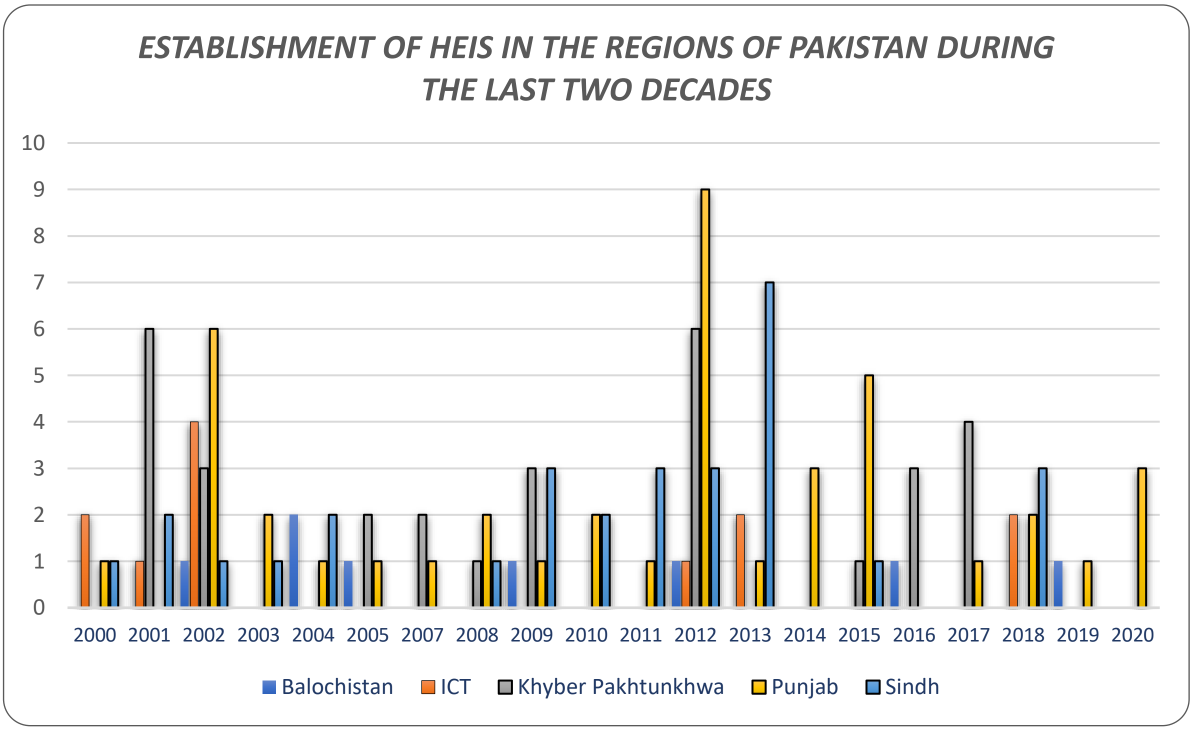


Figure 9: Establishment of HEIs in the regions of Pakistan during the last two decades

The map below displays distribution of HEIs by specialization in the country. It shows that HEIs are mainly concentrated in the provincial capitals, i.e. Karachi, Lahore and Peshawar.

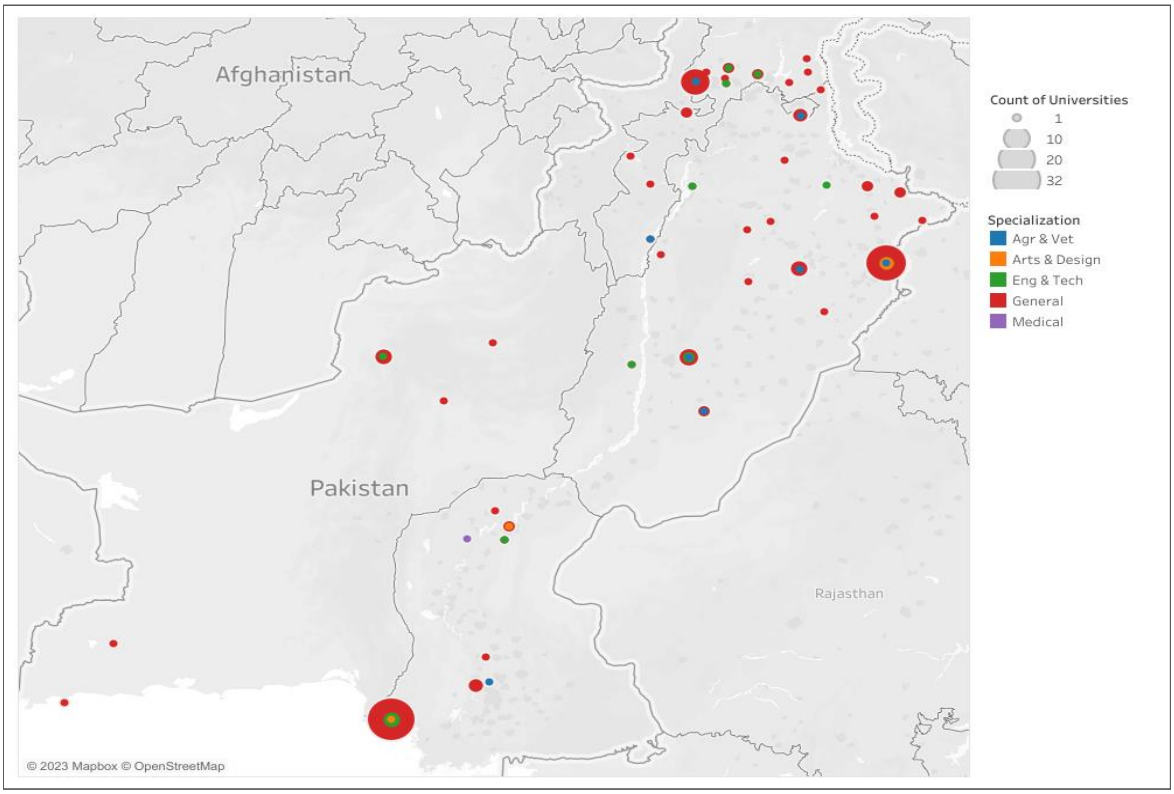


Figure 10: Distribution of HEIs in Pakistan

For the current study, a total of 224 public and private universities were surveyed, and the following figure shows the number of these universities by region. Overall, public sector universities constitute 58% of the total universities in the country. However, the number of private universities is higher in Punjab province.

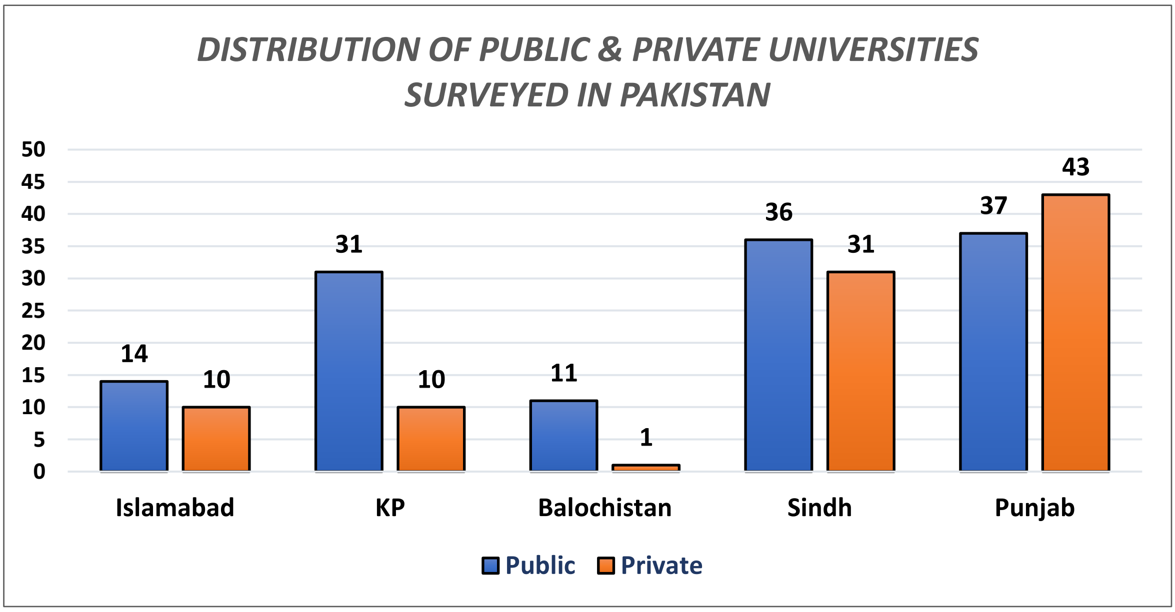


Figure 11: Distribution of public and private universities surveyed in Pakistan.

Among the universities surveyed, 81 (37%) HEIs have international students. This is an encouraging finding as Times Higher Education (University of Liverpool, 2023) ranking lists only 30 HEIs of Pakistan that fall in the best 1500 universities in the world. Enrollment of international students is one of the worlds recognized benchmark, as employed by various university ranking systems. International students are enrolled in more than 80 universities in the country is very encouraging and speaks for the quality of our institutions in the global education landscape. This is also an important source of bringing foreign exchange to the country as already exploited by the developed west.

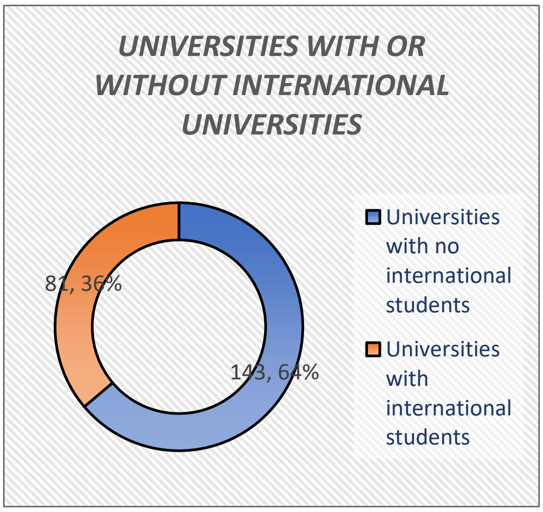


Figure 12: Universities with/without international students

Though, the number of universities with international students is higher in Punjab and Sindh, the proportion of the universities with international students is relatively higher in Islamabad, where out of 24 surveyed universities, 9 (38%) have international students.

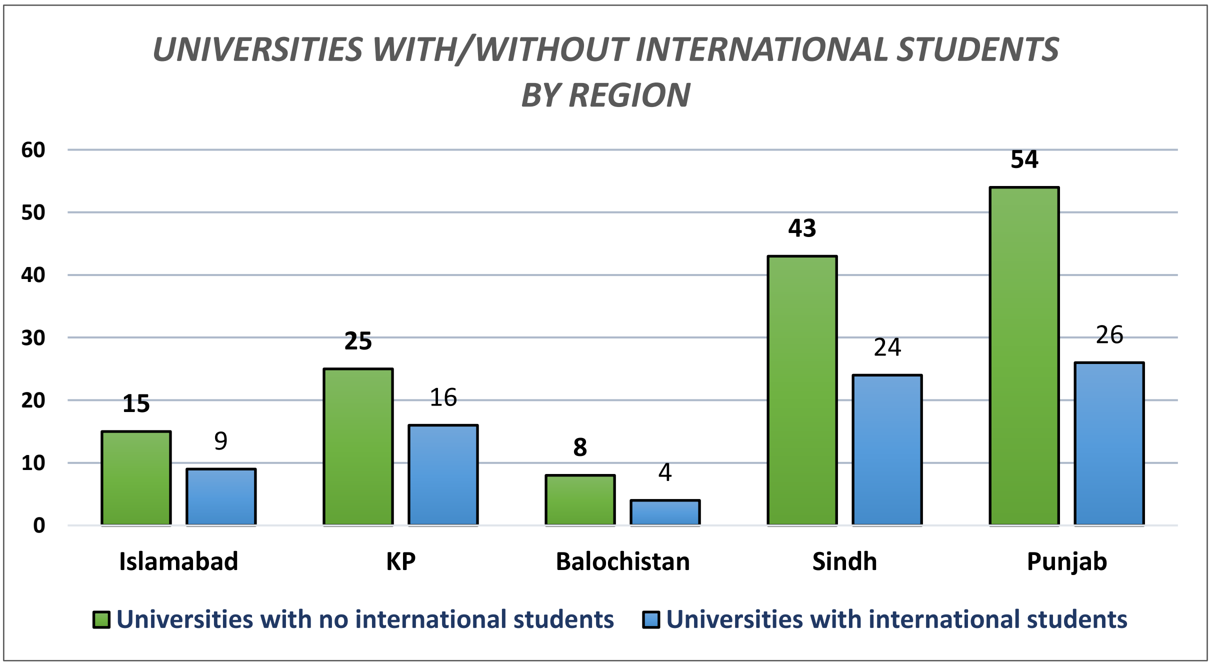


Figure 13: Universities with/without international students by region

A majority of the universities surveyed have only one campus, whereas only 59 (26%) of universities have sub-campuses. In absolute numbers, Punjab has a greater number of universities with more than one campus. However, if the figures are analyzed proportionate to total number of HEIs within a province, the universities with more than one campus constitute only 23% of total universities in Punjab province, whereas 42% of the HEIs in Islamabad have more than one campus. The lower percentage of HEIs with more than one campus in Punjab and Sindh may be due to a higher number of HEIs in these provinces. One of the factors possibly could be the fact that Punjab has the highest number of private sector universities. The composition of private sector universities, which are mostly specialized in nature and are uni-campuses unlike the traditional public sector universities.

A single-campus university often fosters a cohesive and close-knit community, facilitating stronger interpersonal relationships among students and faculty. This environment can enhance collaboration and a sense of belonging. On the other hand, multi-campus universities can make higher education more accessible to a broader population by strategically placing campuses in different regions, reducing travel and other financial burdens for students (Cruz & Michael Del Bono, 2019). Also, multiple campuses which specialize in certain disciplines can attract students who are particularly interested in those areas of study. Also, multi campus university having remote campuses in the country side have the potential to give opportunity to the neglected rural class reducing disparity and helping achieving the UN SDGs and national development vision. Furthermore, a multi-campus structure can promote cultural diversity and regional engagement, exposing students to different perspectives and enriching their overall educational experience.

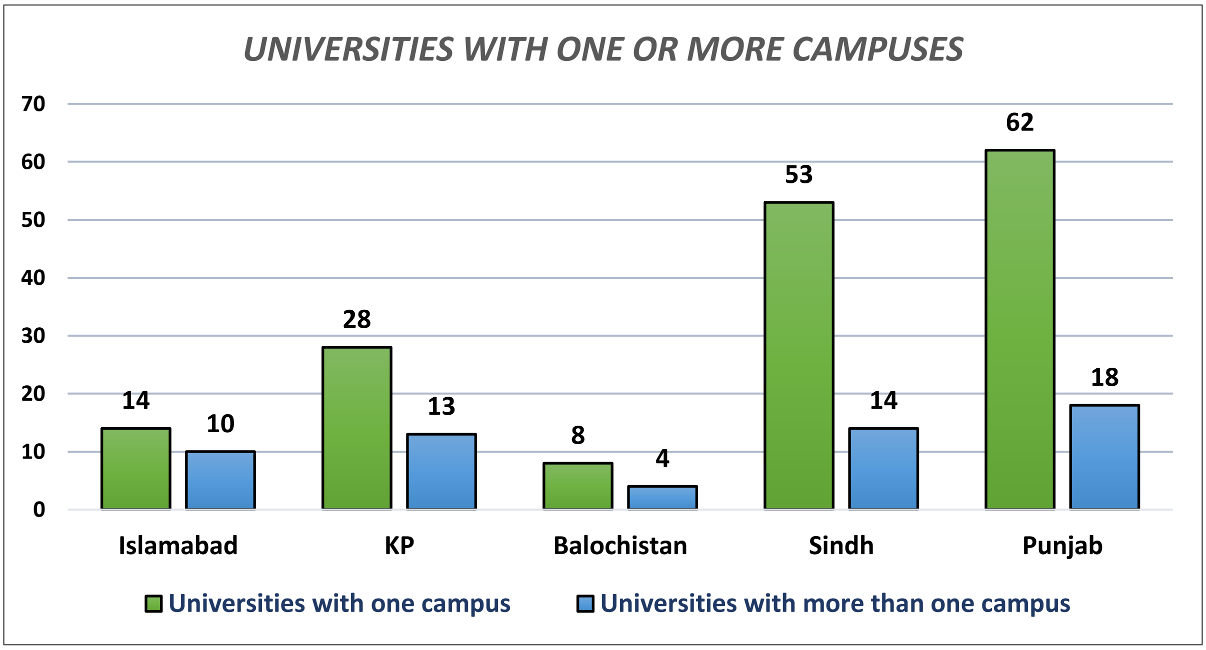


Figure 14: Universities with one or more campuses

The majority of staff working in the universities are employed on regular basis, and only a quarter of them are hired on a contractual basis. The composition of people hired as visiting faculty is significantly very low. Further, there is a gender disparity observed in the staff of universities as more than two-thirds of staff working is male, and only less than one-third are female. These indicators provide insight and true reflection of gender parity at the universities to the policy makers enabling them to better policy formulation towards women empowerment in the given sector as envisioned in the national development agenda including vision 2025 and visions 2030.

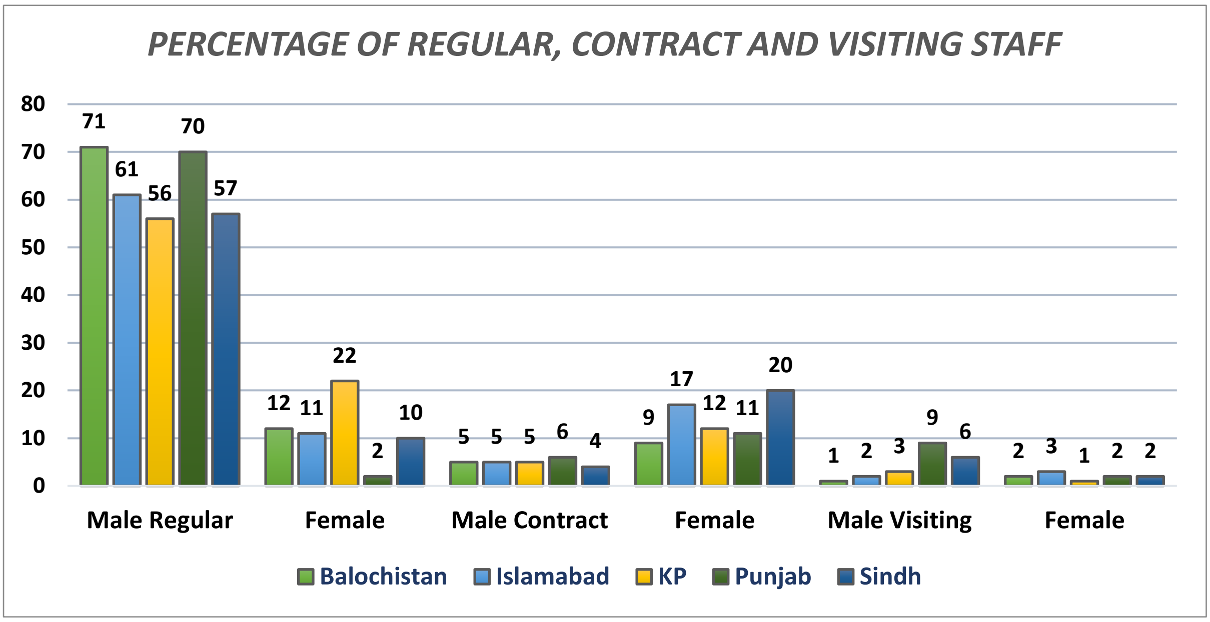


Figure 15: Percentage of regular, contractual, and visiting staff

The gender disparity is more visible when one looks at the percentage of male and female staff on regular, contractual, and visiting posts. An overwhelming number of regular staff are men, while most of the women are hired on a contractual basis. In Khyber Pakhtunkhwa, the percentage of regular female staff is higher than the other regions, whereas it is the lowest in Punjab. Though the percentage of visiting staff is very low in all the universities, the gender disparity is also visible at that level of positions.

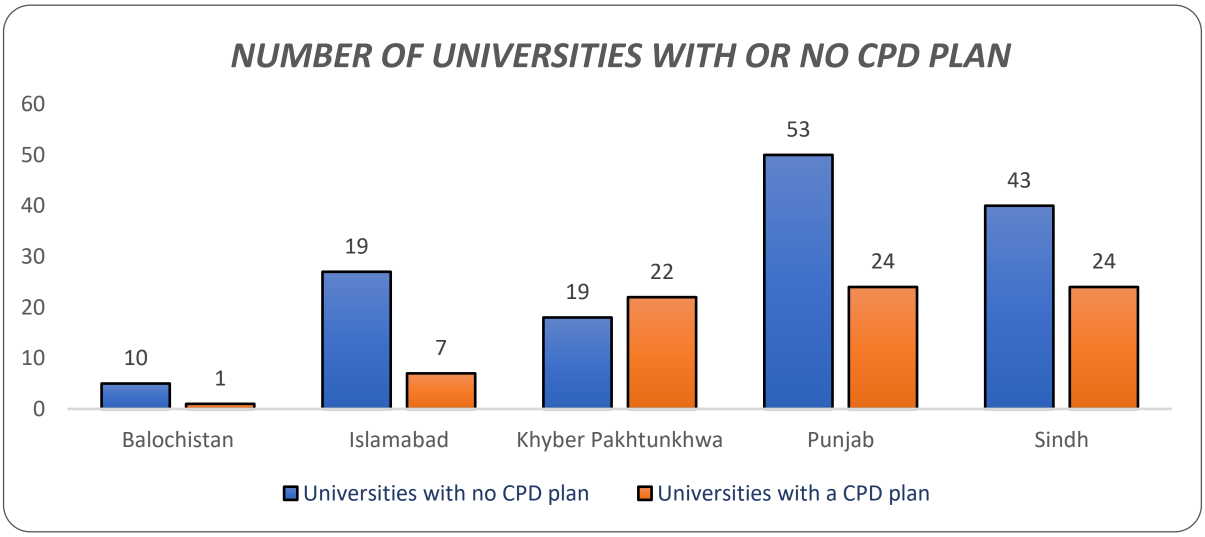


Figure 16: Number of universities with or no CPD Plan

A majority of the universities do not have a Continuous Professional Development (CPD) Plan, a CPD plan serves as a systematic framework guiding individuals in augmenting their professional expertise, knowledge, and capabilities over the course of their careers. It provides a structured approach for ongoing learning, ensuring that individuals not only stay relevant but also elevate their competence to meet evolving demands within their professional domain. Whereas only 36% of them have such a plan. In Khyber Pakhtunkhwa, Sindh and Punjab, a significant number of universities have a CPD plan in place, but in Balochistan and Federal capital proportionately lesser number of universities have CPD plan in place.

Out of the total HEIs surveyed, 165 HEIs (74%) addressed the questions about the faculty/ highly qualified technical human resources (HR) of these institutions. This included information both about existing human resource and the future requirements. Based on the information received it is observed that there is huge shortage of the highly qualified HR in the HEIs of Pakistan. The data show that the number of PhDs currently working in the mentioned HEIs is 7,363, whereas they require additional 8,794. This implies that the HEIs require about 120% more PhD staff in addition to the existing. Similarly, the number of staff with MS/MPhil currently working in the survey respondent institutions is 8,321, whereas they require 9,478 more staff. Overall, 18,272 staff with MPhil and PhD are still required in the given HEIs. This is contrary to the fact that even though a large number of highly qualified position are lying vacant in the HEIs as reported trough this survey; almost 4,000 PhDs are still jobless in the county as cited in various reports.

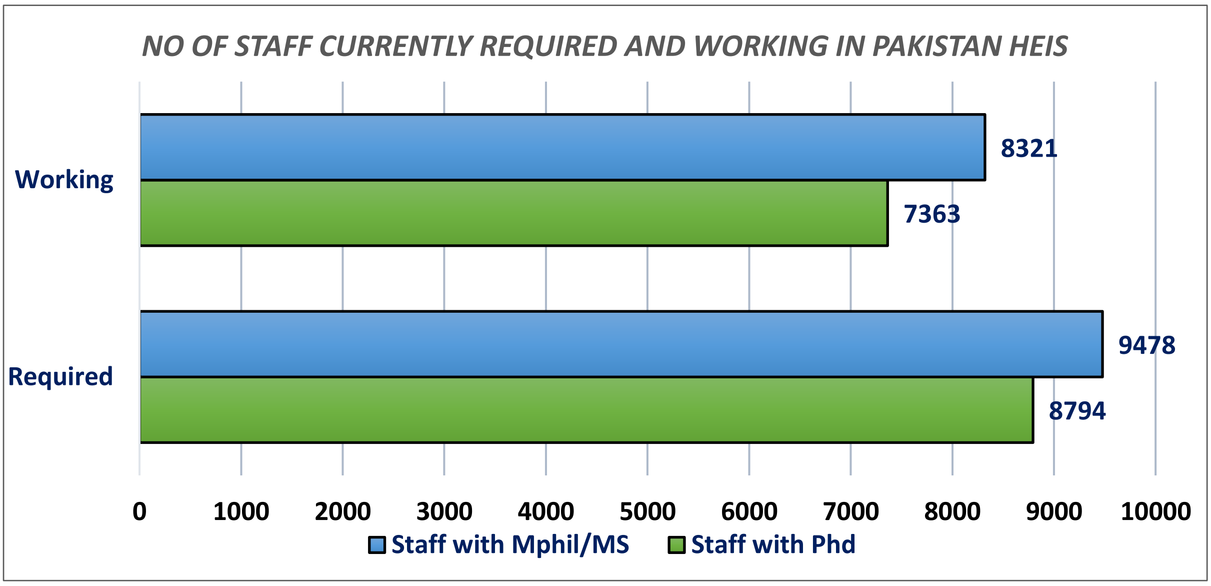


Figure 17: Number of staff currently required and working in Pakistani HEIs

This phenomenon may indicate a deficiency in the implementation of the triple-helix model, emphasizing collaboration between government, industry, and academia for effective economic development. A failure in industry-academia collaboration and the absence of opportunities for applied research result in a surplus of PhDs with theoretical expertise but lacking applicability in real-world contexts. Skill mismatch, insufficient support for entrepreneurship, and a lack of policies promoting industry engagement in curriculum development contribute to the unemployment of highly qualified individuals. To address these challenges, policymakers need to reevaluate existing education and employment policies, ensuring they are aligned with the demands of various sectors. Promoting ongoing dialogue between academia and industries, incentivizing research-driven economic growth, and establishing innovation hubs or clusters are essential steps. Regular monitoring and evaluation mechanisms need to be implemented to assess policy impacts and identify areas for improvement. In embracing the triple-helix approach, which underscores collaboration and innovation, policymakers can bridge the gap between academic achievements and the practical needs of the job market, fostering a more dynamic and responsive educational ecosystem.

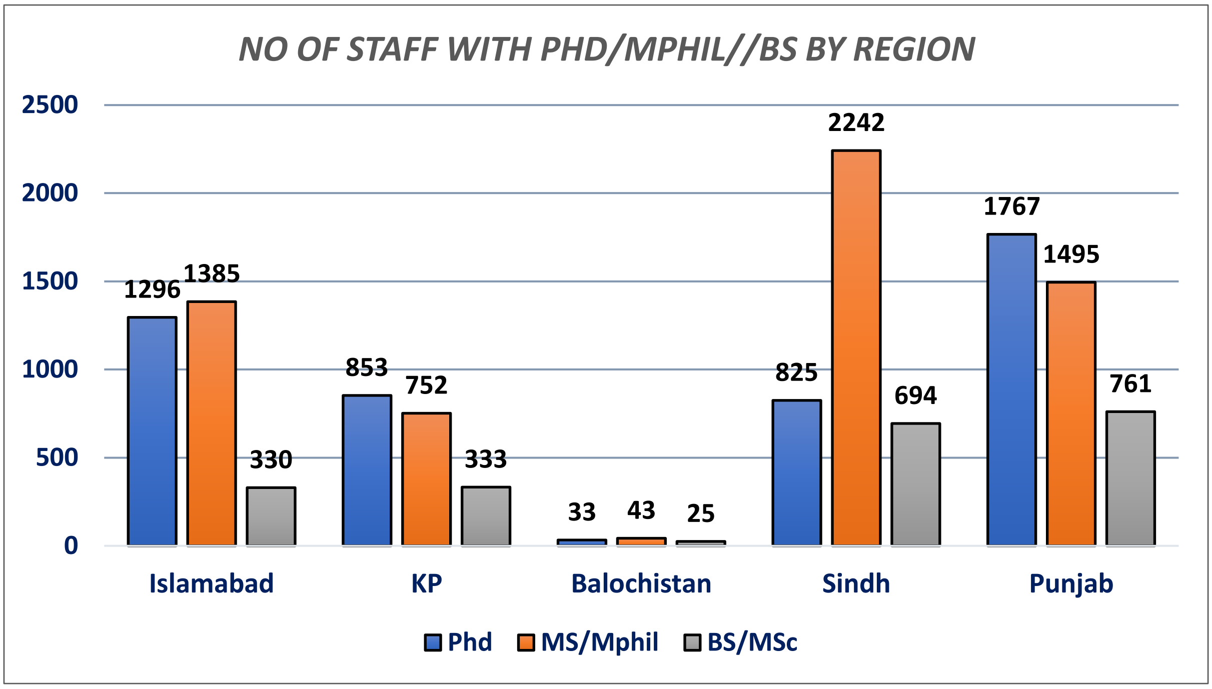


Figure 18: Number of staff with PhD/MPhil/BS by region

Universities in Sindh and Islamabad have a greater number of staff with an MPhil/MS than a PhD, whereas, the universities in Punjab and KP have a higher number of PhDs. However, comparing the number of staff with the number of HEIs, the analysis shows that HEIs in Islamabad have a higher average number of staff (i.e., 125 staff per HEI) than in other regions. This might be due the socio-economic facilities and environmental attraction of the capital city.

The discipline wise analysis of the HR data *(based on the information provided by survey responding institutions – this does not reflect the data of all the HEIs working in the country)* shows that the highest number of staff with a PhD Degree are in Engineering and Technology disciplines (2406), followed by social science (1369) and physical sciences (938), respectively. In term of HR with a terminal degree as MS/MPhil the highest number of staff are working in engineering and technology (2579) disciplines followed by biological/medical sciences (1803), and social sciences (1401), respectively.

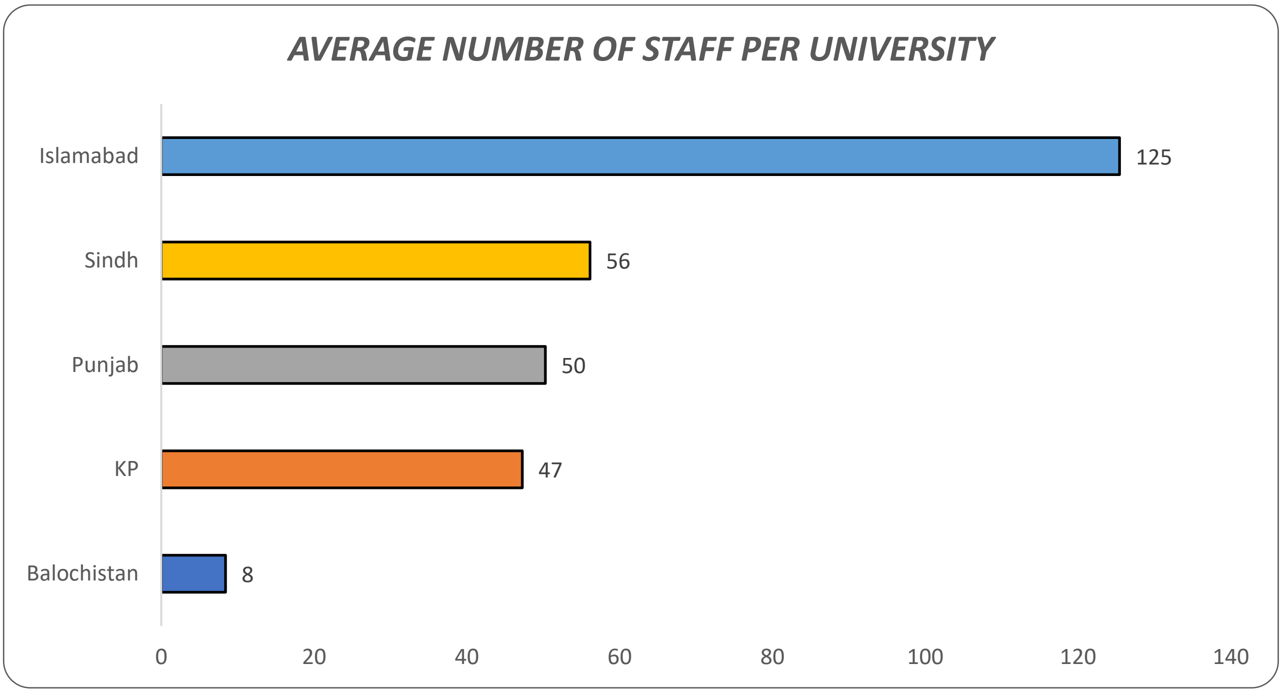


Figure 20: Average number of staff per university

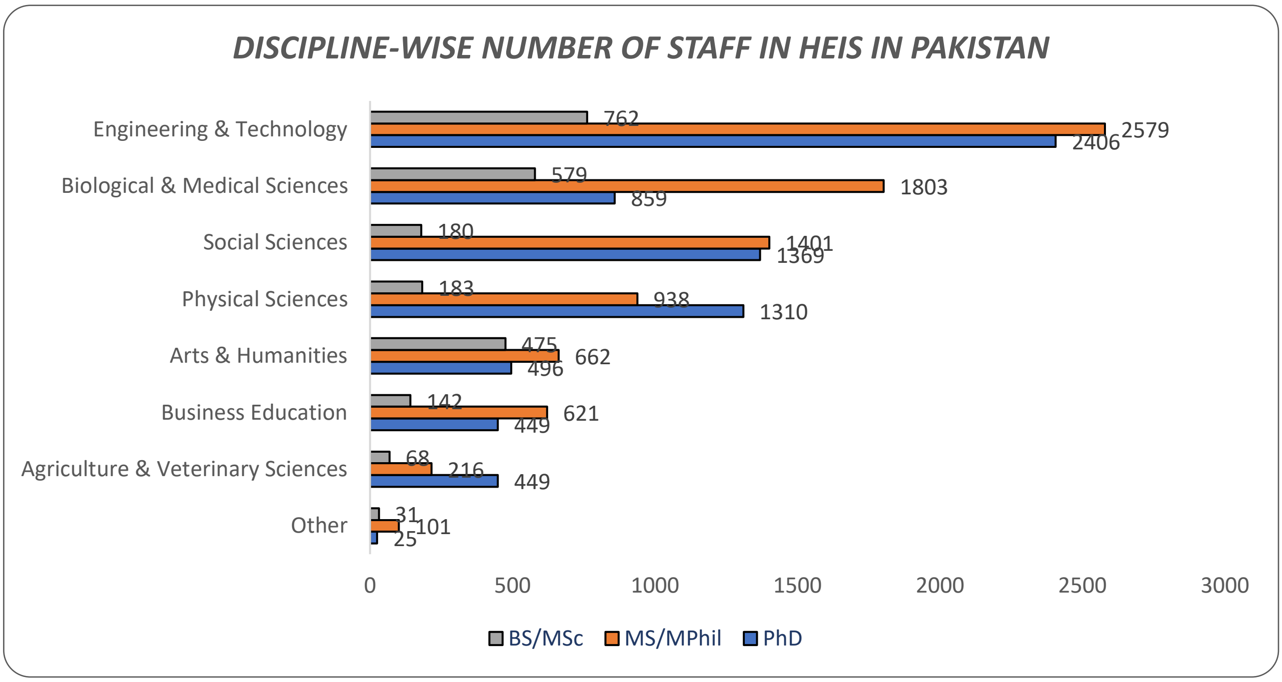


Figure 19: Discipline-wise number of staff in HEIs in Pakistan

In terms of gender, the data reflect disparity between the male and the female staff with a tertiary degree; which is significantly higher for staff having PhD degrees. Three quarters of the faculty with a PhD degree are males and a quarter of them are females. However, the gap between male and female staff having terminal degree as MS /MPhil is relatively less than the PhD; having a ratio of 41% and 59% for female and male staff, respectively.

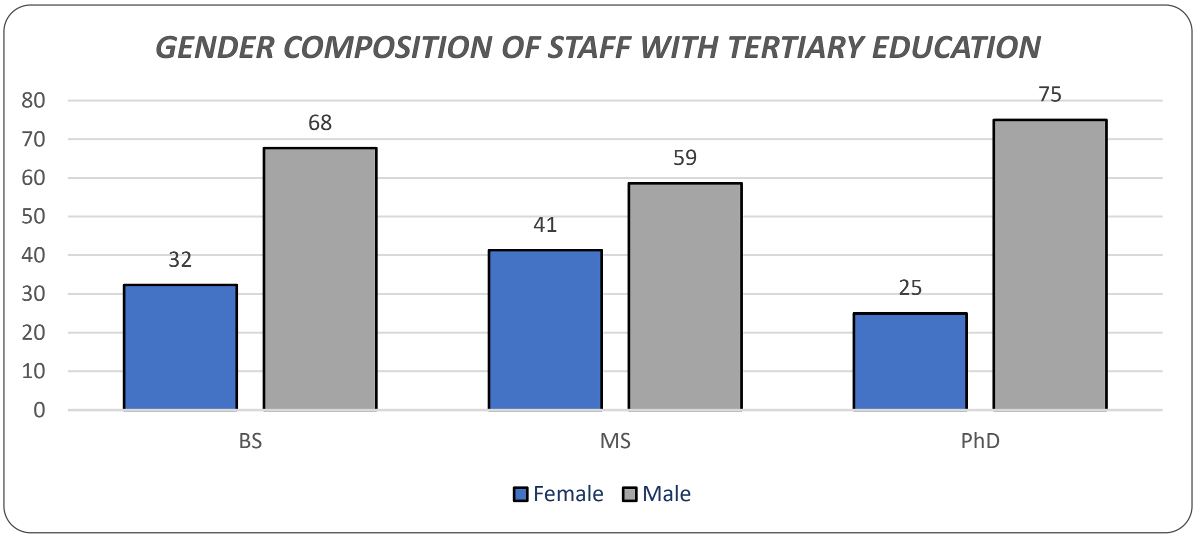


Figure 21: Gender Composition of Staff with Tertiary Education

The teaching faculty mainly consists of lecturers and assistant professors which comprises around 80% of the total teaching staff in the surveyed universities. Professors and Associate Professors constitute only around 20% of the teaching staff.

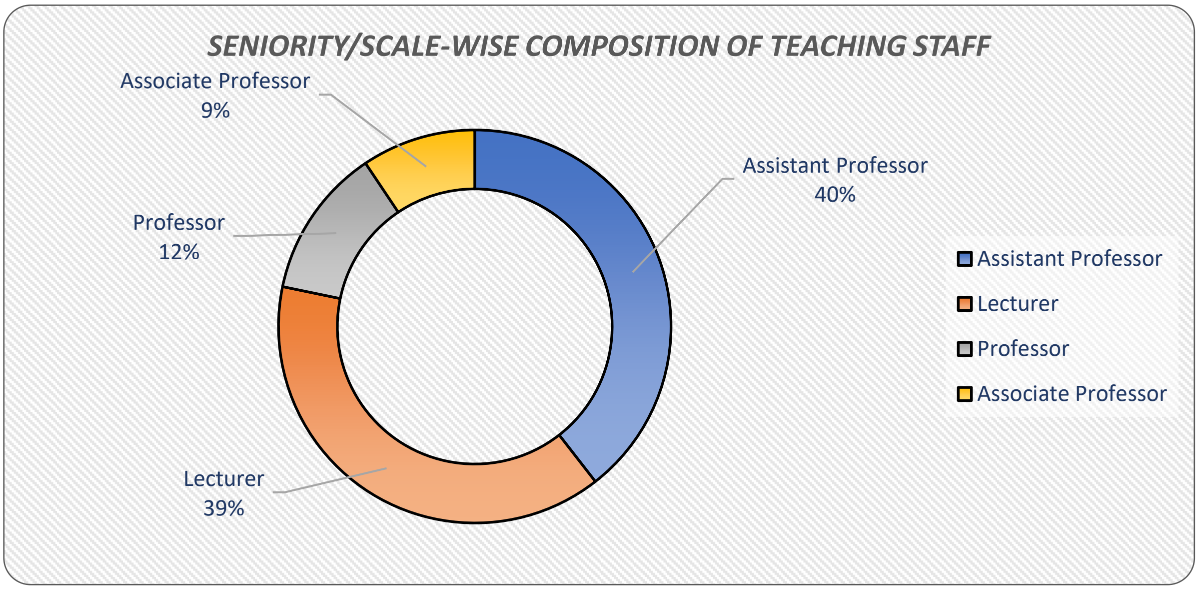


Figure 22: Seniority/Scale-wise Composition of Teaching Staff

At lowest positions i.e. lecturers, the gender disparity is significantly lower; however, the gender disparity increases as the positions moves higher. Women occupy around one-third of positions of Assistant Professors, and around one-quarter of positions of Associate Professors and Professors.

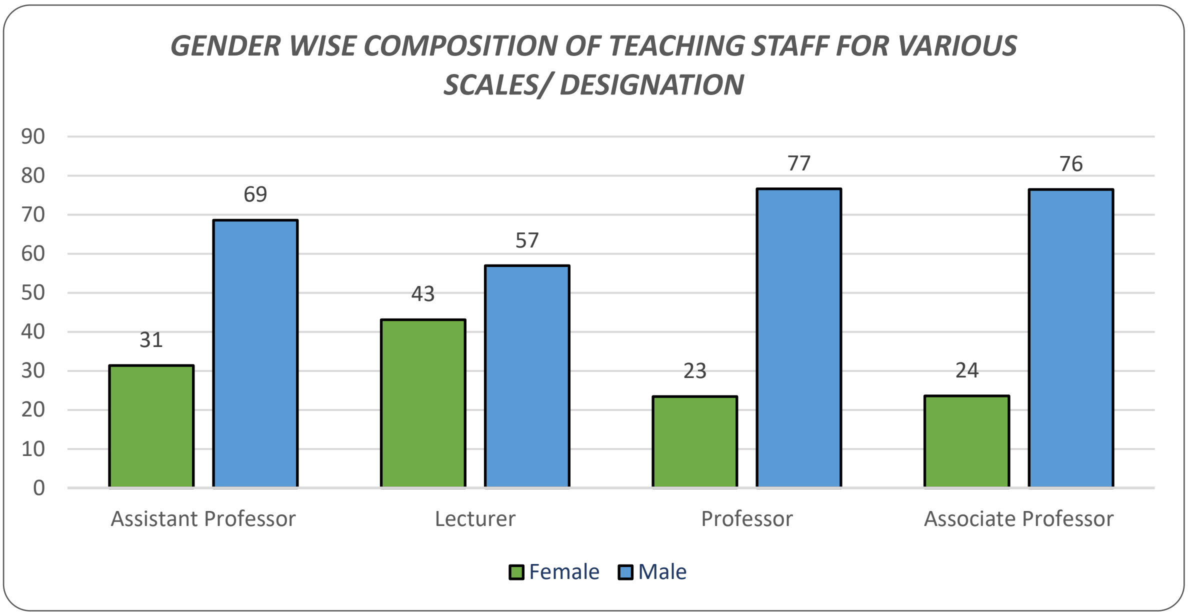


Figure 23 Gender-wise Composition of Teaching Staff for various scales/designation

From discipline-wise analysis of the data received from HEIs, it has been observed that the cumulative figures of PhD staff, currently working and those required in future, shows a degree of variation, among the different discipline. The gap between existing staff and additional future requirements of PhD level staff in the Engineering and Technology, Biological & Medical Sciences and Physical Sciences is 1:1.13, 1:0.98 and 1:1.23 respectively. In other words, in the discipline of Engineering and Technology requires an additional 113% more PhD level staff in future where as 98% and 123% additional PhD level staff is required in Biological & Medical Sciences and Physical Sciences. However, the gap is significantly higher in case of art & humanities, and the social science having ratio 1:6.32 and 1:1.42 respectively.

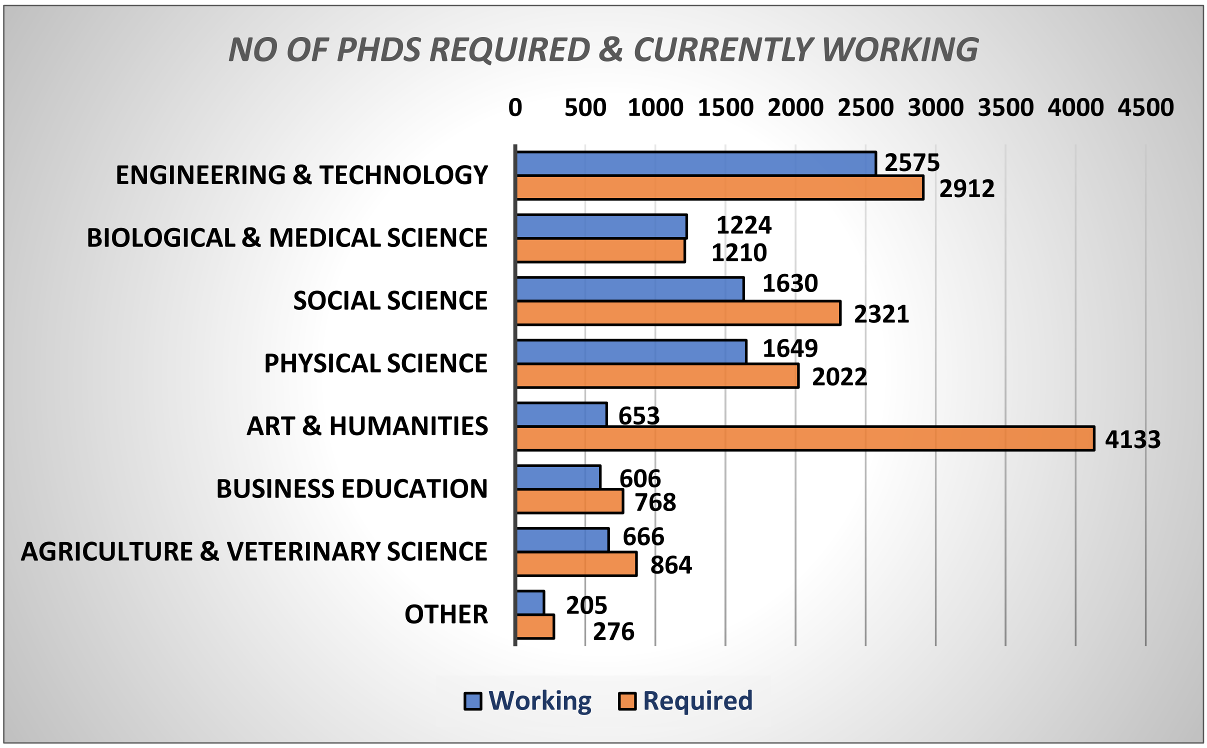


Figure 24: No of Phds required & currently working

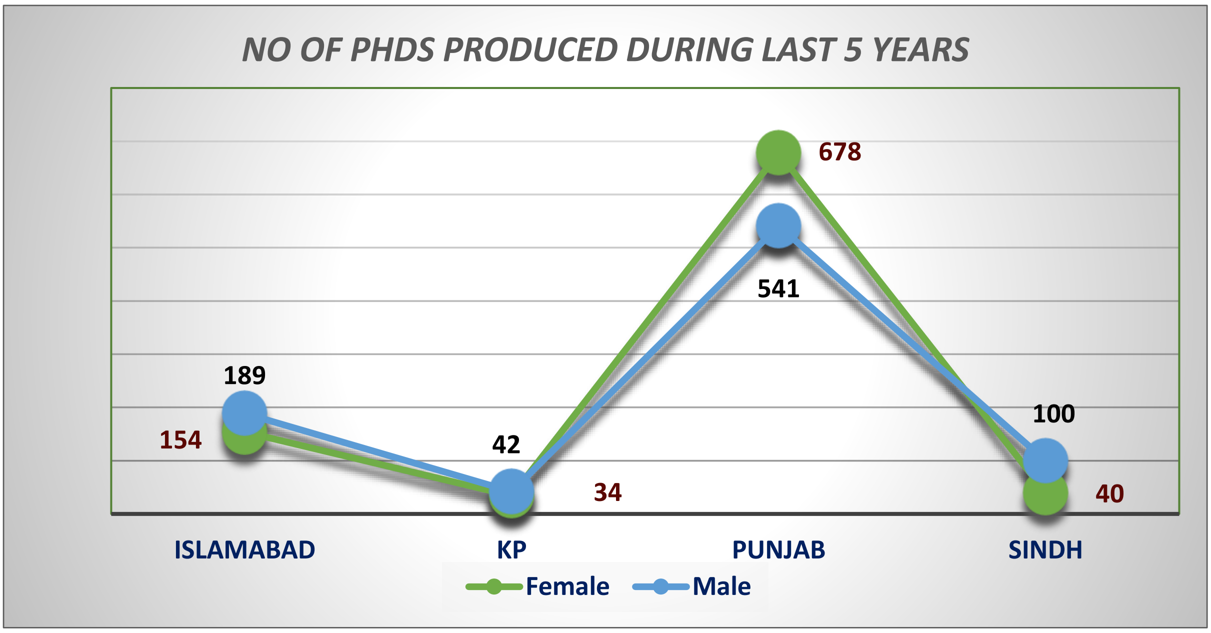


Figure 25: Number of PhDs produced during last 5 years

HEIs including both Public and private universities, have produced 1778* PhDs during the last five years, with the exception of HEIs based in Balochistan who did not share data with respect to the PhD produced by them during the given period. The highest number of PhDs (69%) were produced by HEIs based in Punjab, followed by the federal capital territory and Sindh respectively.

One of the important findings of the study is the fact that during the last five years, the number of female students who completed their PhD degree during the given period is higher than their male counterparts. This is an encouraging indicator and is in line with the national commitment under the sustainable development goals and our national visions towards advancement of gender equality and bringing about women empowerment which represent around 50% of the population.

*(*based on the information provided by survey responding institutions- this does not reflect the data of all the HEIs working in the country)*

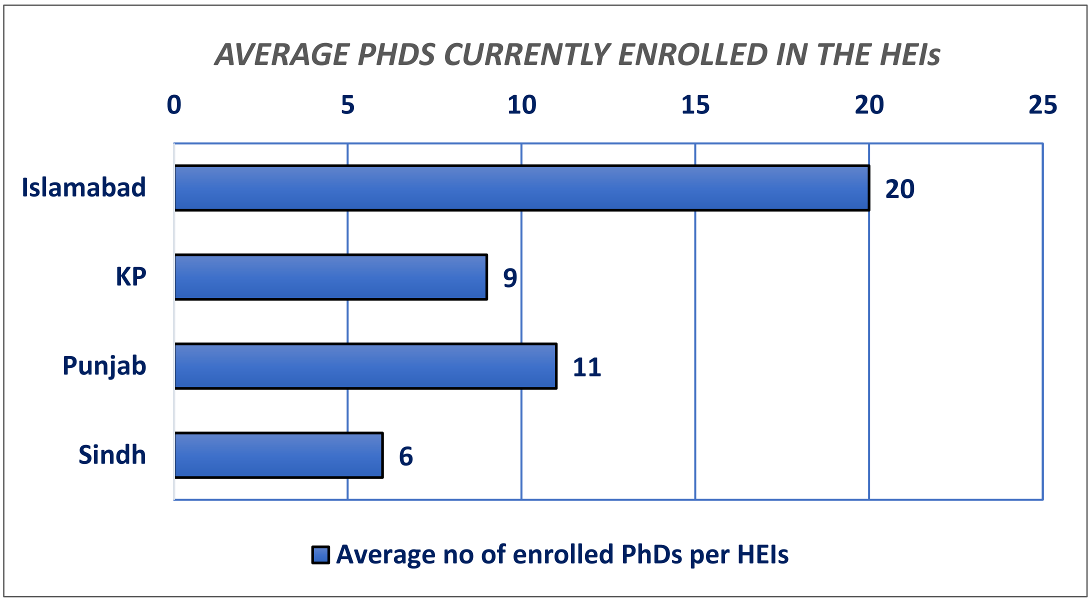


Figure 26: Average No. of PhDs currently enrolled in the HEIs

During the survey period a total of 2,103 students enrolled in the PhD program of the responding HEIs. Although there is highest number of PhD enrollments in the HEIs based in the Punjab province in in absolute numbers; however~~,~~ the average number of students enrolled in a PhD program per university is higher in Islamabad region (20), followed by Punjab (11), Khyber Pakhtunkhwa (9) and Sindh (6), respectively.

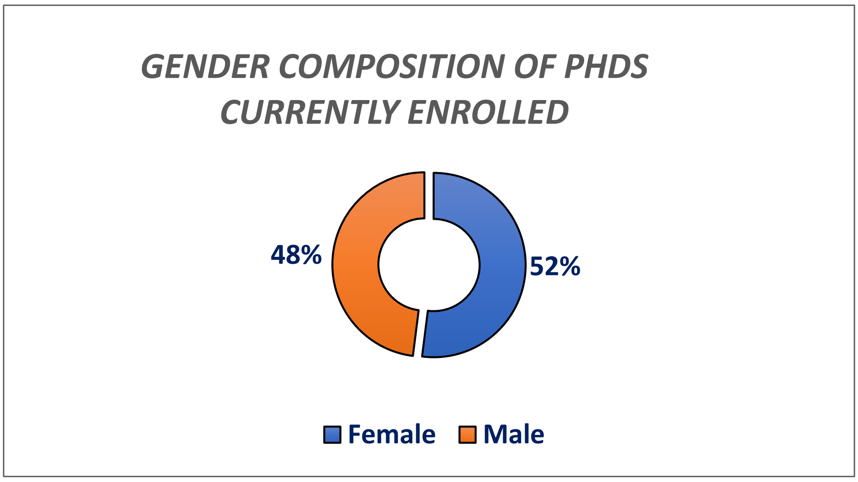


Figure 27: Gender composition of PhDs currently enrolled

Among the students currently enrolled in a PhD program, the percentage of women is slightly more than men, and again the highest percentage of male and female PhD students are enrolled in the universities of Punjab. However, this is normal considering the fact that Punjab represents more than half of the country's population.

4.2 Research and Development Organizations

A total number of 218 Research and Development (R&D) organizations were surveyed; which includes 67 from Punjab, 59 from Islamabad, 49 from Sindh, 26 from Khyber Pakhtunkhwa (KP), and 17 from Balochistan. Most of the R&D organizations surveyed in the country are public sector entities, only 2% are private.

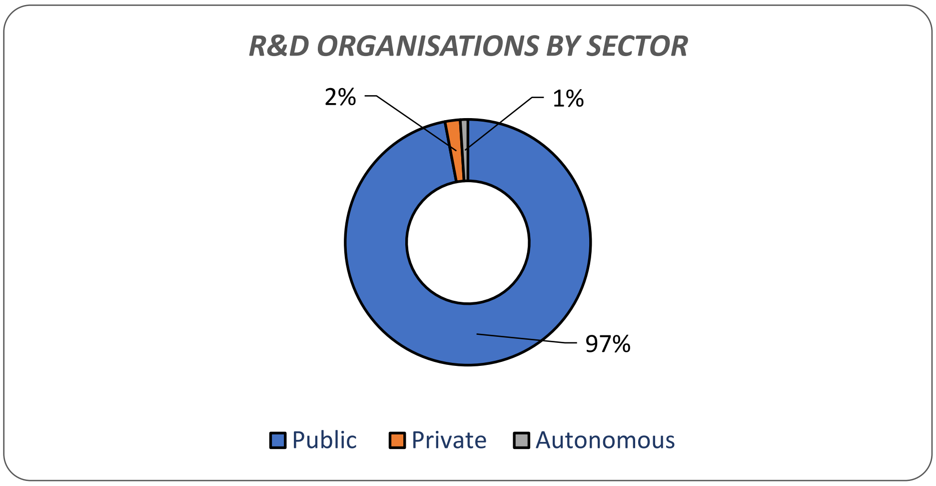


Figure 29: R&D Organizations by Sector

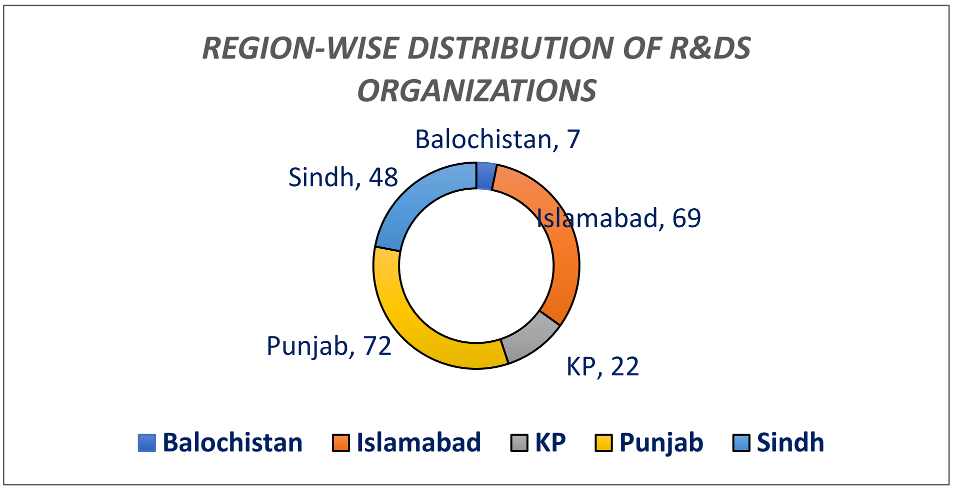


Figure 28: Region-wise distribution of R&Ds

The region-wise break-down shows that Khyber Pakhtunkhwa (KP) and Punjab have 5% and 3% private and no autonomous R&Ds, whereas Sindh has 2% private and autonomous R&Ds each.

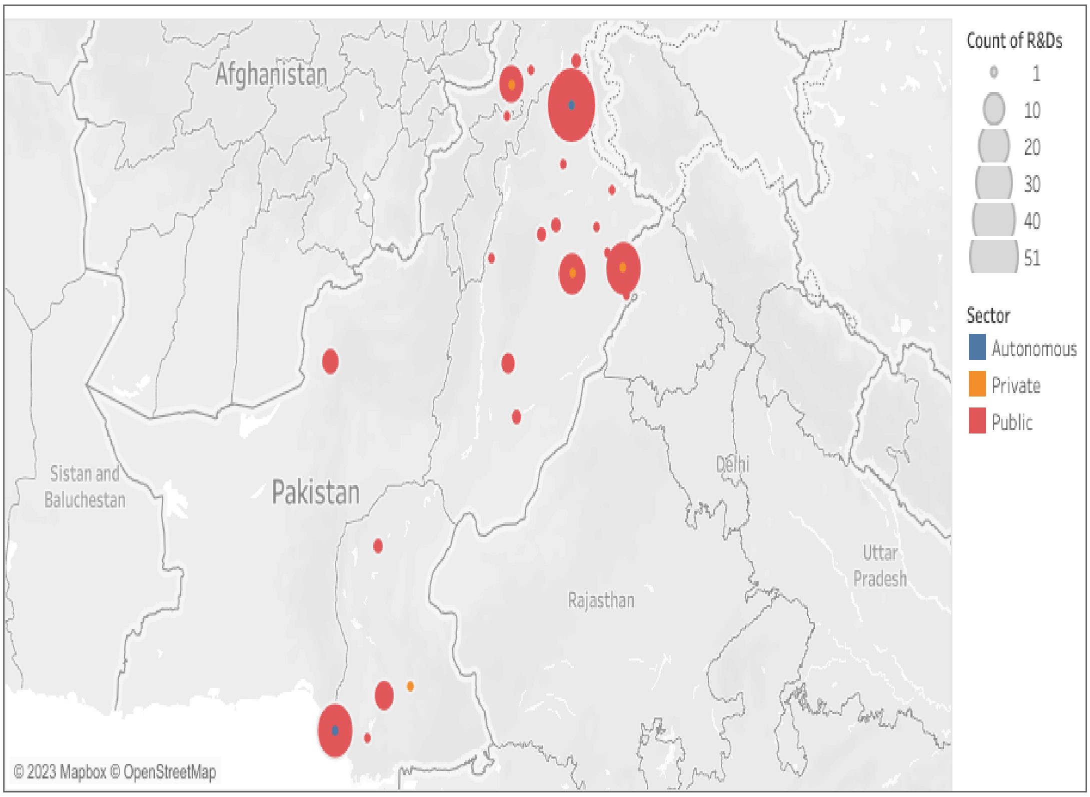


Figure 31: Region-wise distribution of R&Ds

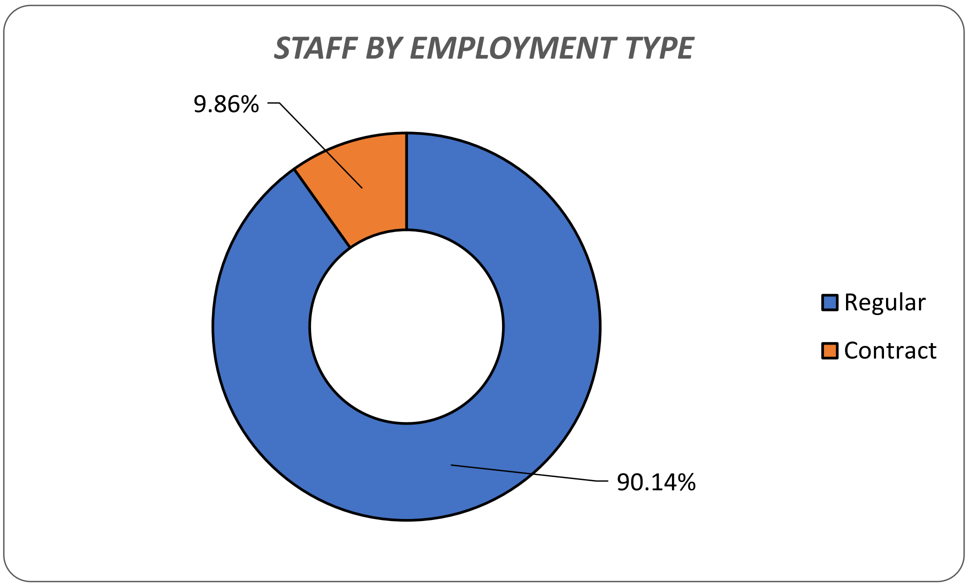


Figure 30: Proportion of Staff by Employment Type

The majority of the staff currently working in the R&D organizations are regular staff which constitute approximately 90% of the total staff; reason being majority of them being employed in the public sector.

The gender-segregated analysis of data related to employment type shows that the proportion of the regular male staff working in R&D organizations is considerably more than their female counterparts in most of the country except for the Sindh province where the proportion of female staff is comparatively better.

Overall, women constitute only 20% of regular and contractual workforce in the R&Ds. This is a matter of policy consideration by the relevant stakeholders, considering the fact that women constitutes both half of the students who completed PhDs during the last five years, as well as students currently enrolled in PhD programs.

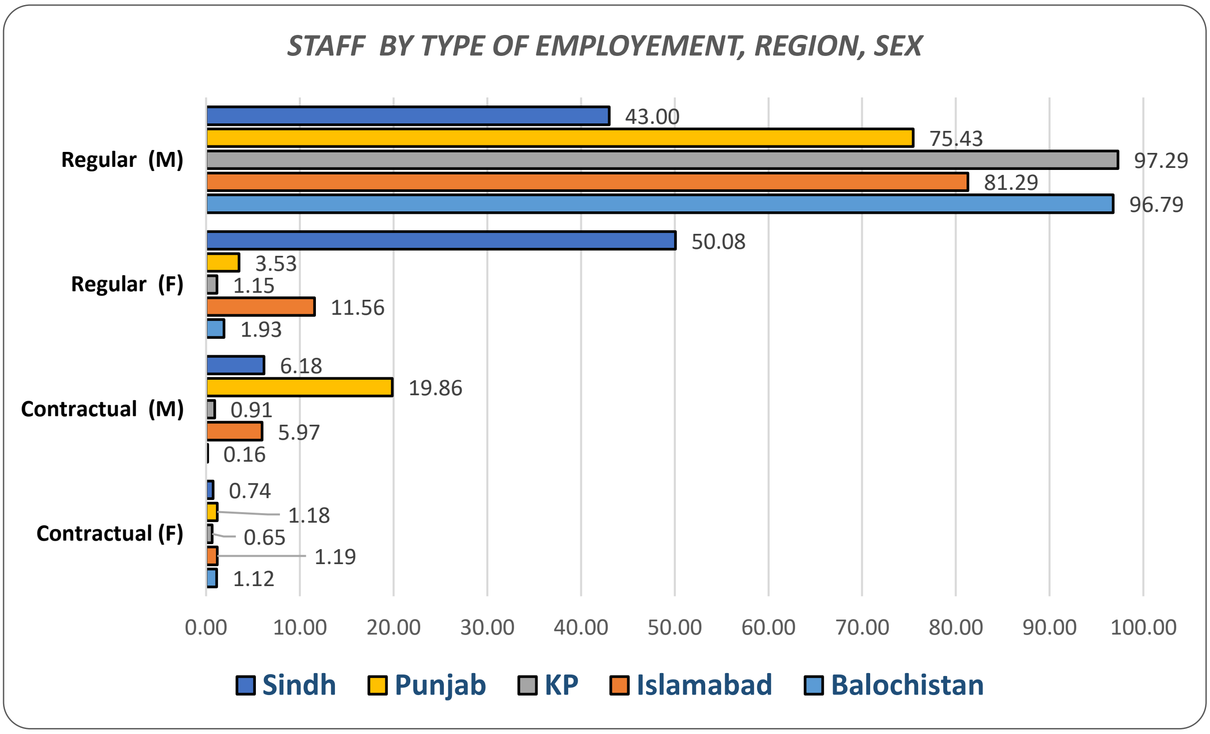


Figure 32: Staff by Type of Employment, Region, Sex

Employees with PhD degrees working in R&D organizations constitute only 6% of the total highly qualified HR. Technical Workers having master's equivalent to 18 years of qualification constitute only 16 %; whereas the remaining technical workforce holds the degree of BS/BSc (equivalent to 16 years). However, considering a surge in enrollment in PhD programs in various universities of the country and assessing demand for PhD holders in the industries as well as R&D organizations, it is fair to conclude that majority of the PhDs would not be able to find jobs in these sectors.

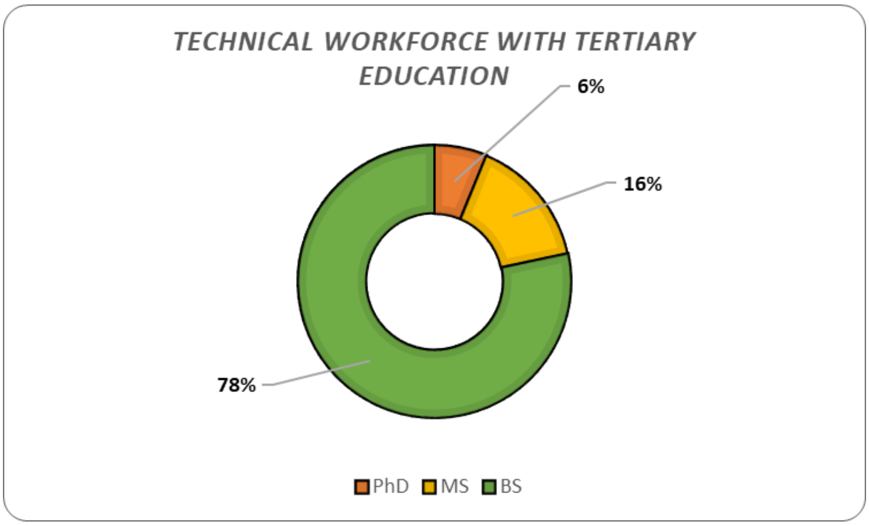


Figure 33: Technical Workforce with Tertiary Education

The highest number of workers with tertiary education (i.e., BS, MS, and PhD) employed in R&D organizations have academic background in Physical Sciences, Agriculture & Veterinary Sciences, and Social Sciences. Those having degrees in Engineering & Technology, Biological & Medical Science, Business Education, and Arts & Humanities constitute 22% of the highly qualified work force. The regional comparative analysis shows that the highest number of staff with tertiary education is working in the R&Ds in Islamabad, and the majority of them have an academic background in physical and social sciences.

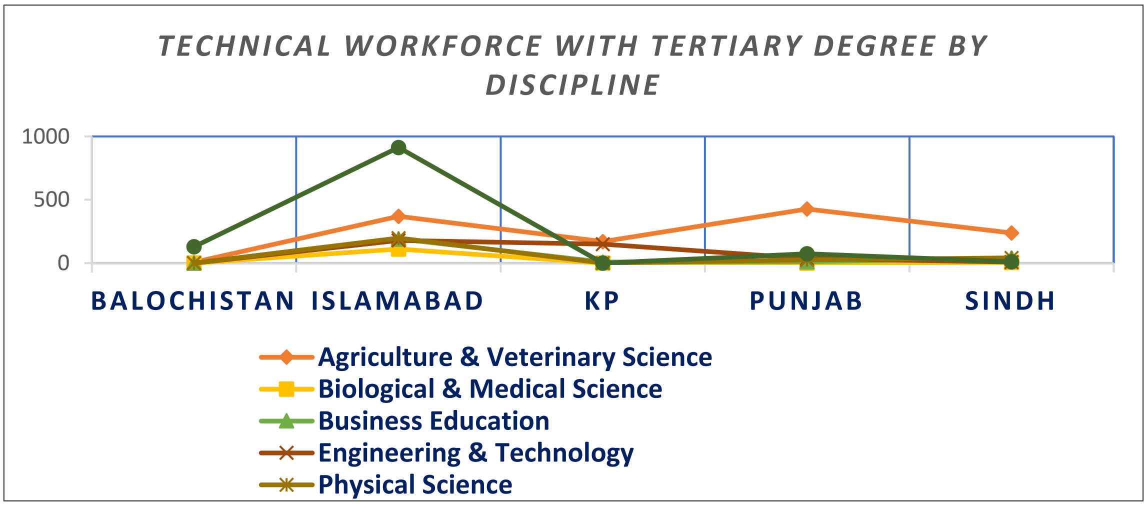


Figure 34: Technical workforce with tertiary degrees by discipline

The chart based on the information provided by the responding R&D organizations the distribution of staff based on their education levels and disciplines in Research and Development (R&D). The majority of R&D staff (55%) have obtained bachelor's degrees, primarily in social sciences, physical sciences, agriculture, and veterinary sciences. Additionally, 27% of the staff hold master's degrees, predominantly in agriculture and veterinary sciences, as well as physical sciences. Only 18% of the staff have achieved a Ph.D., with a focus on physical sciences and agriculture & veterinary sciences. Conversely, the representation of staff with degrees in engineering and technology, business education, biological and medical sciences, as well as arts and humanities, remains notably low.
The number of highly skilled technical workforce required and currently working shows that R&D organizations are understaffed. Currently, 790 PhDs are working in R&Ds, but they still require additional 854, which is more than 100% of the current number of staff.

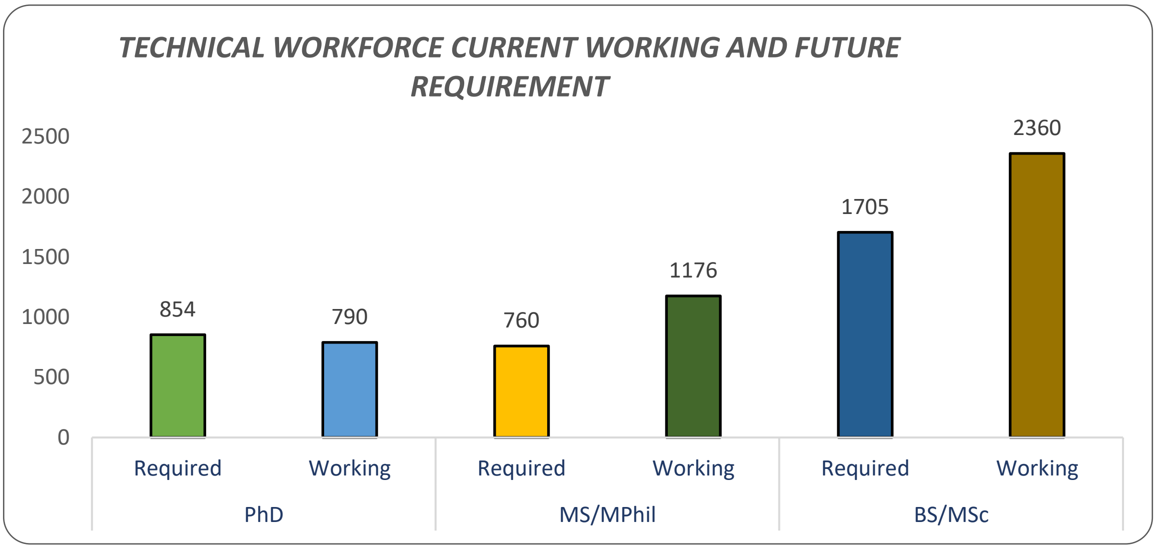


Figure 36: Technical workforce currently working and future requirement

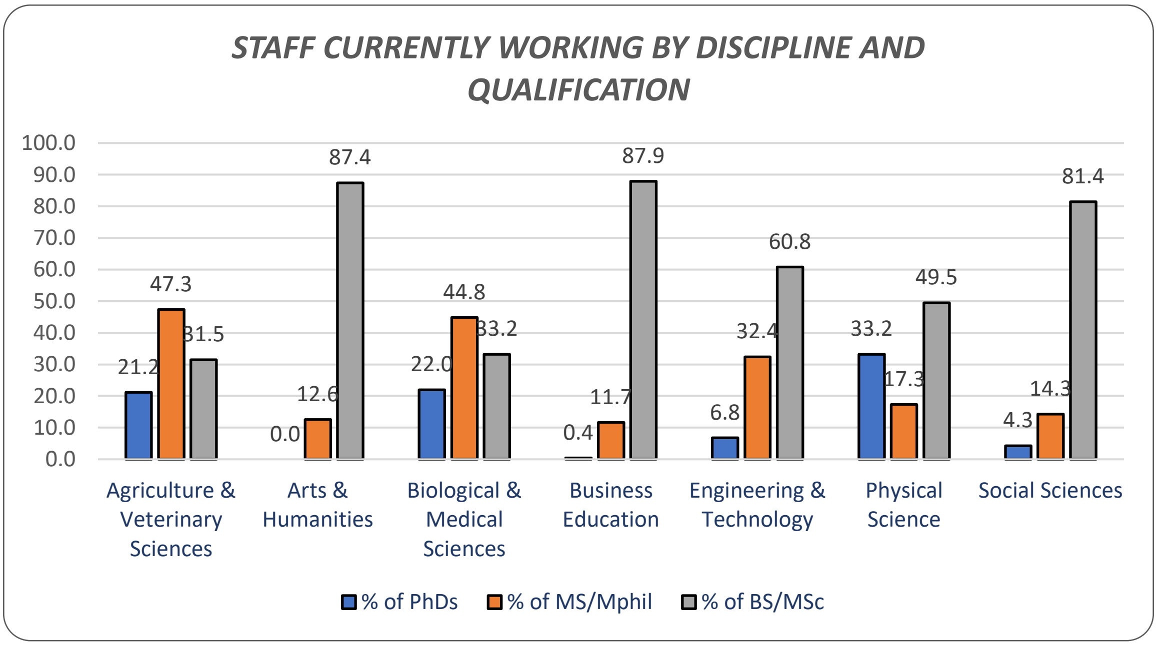


Figure 35: Percentage staff currently working by discipline and qualification

Table 3: Discipline wise staff enrolled in a PhD program

Discipline	Staff enrolled in a PhD program
Agriculture & Veterinary Sciences	52
Arts & Humanities	0
Biological & Medical Science	12
Business Education	7
Engineering & Technology	57
Physical sciences	42
Social Sciences	8
Total	**178**

As per information provided by the responding organizations, there are 178 employees who are currently enrolled in a PhD program, and the higher number of them are enrolled in the disciplines of Engineering & Technology (32%), followed by Agriculture and Veterinary Sciences (29%), and Physical Sciences (24%) respectively. However, when these figures are analyzed with respect to the number of PhDs required and currently working in the R&D organizations discipline-wise, there appears some contradictions between the requirement and preference of staff in terms of scaling up their skills to the PhD level. For instance, based on the consolidated figure, R&D organizations require 28 PhDs in Engineering & Technology, while 57 staff members are enrolled in PhD programs in the same discipline. Although the data does not involve conclusive information of all the R&D organizations; however, it provides some reflective. Similarly, on the contrary, side, the number of PhDs required in Agriculture & Veterinary Sciences is 391, but only 52 employees have enrolled in a PhD program. The same is the case with Physical Science in which the required number of PhDs is 376, but only 42 employees are enrolled in a PhD program.

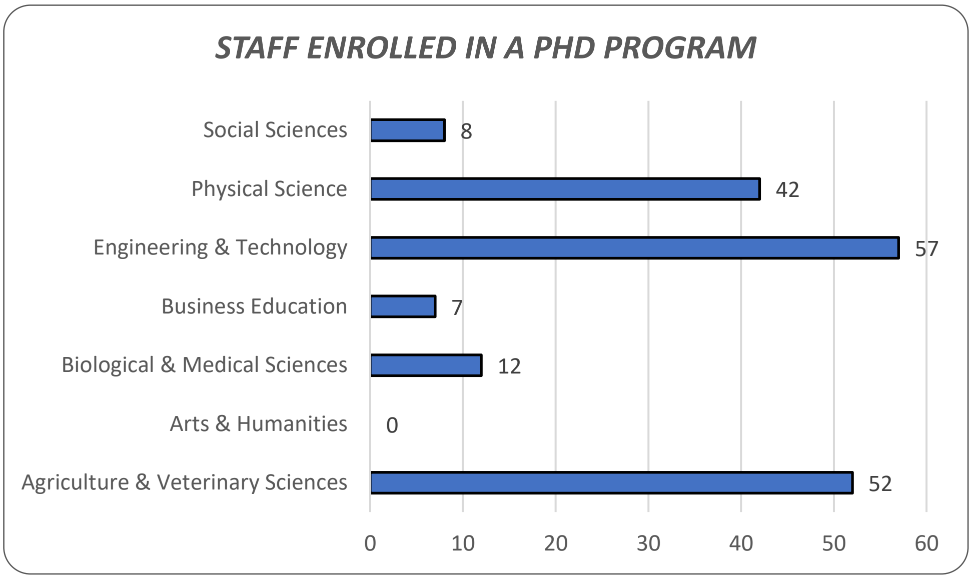


Figure 37: Staff Enrolled in a PhD Program

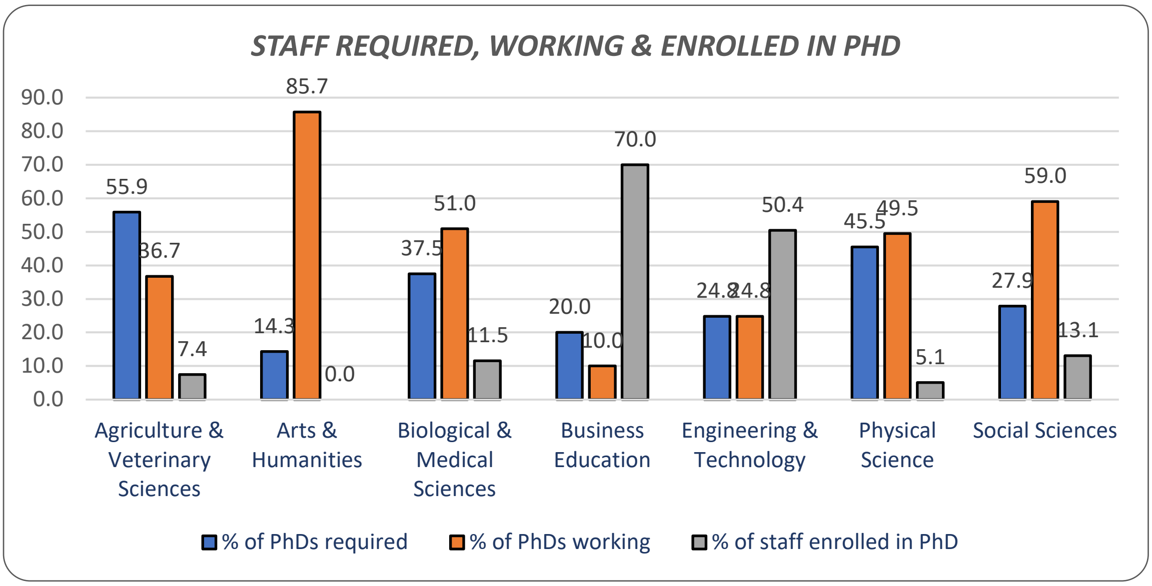


Figure 38: Percentage of staff required, working, and enrolled in PhD

The majority of the employees working in the survey responding R&D organizations who are currently enrolled in a PhD program are males; which constitute 84% of the total staff, and the most preferred disciplines are Engineering & Technology, followed by Agriculture & Veterinary Sciences, and Physical Sciences respectively. Though a few male staff members are also enrolled in Business Education and Social Sciences, no female staff has chosen these disciplines for their PhD.

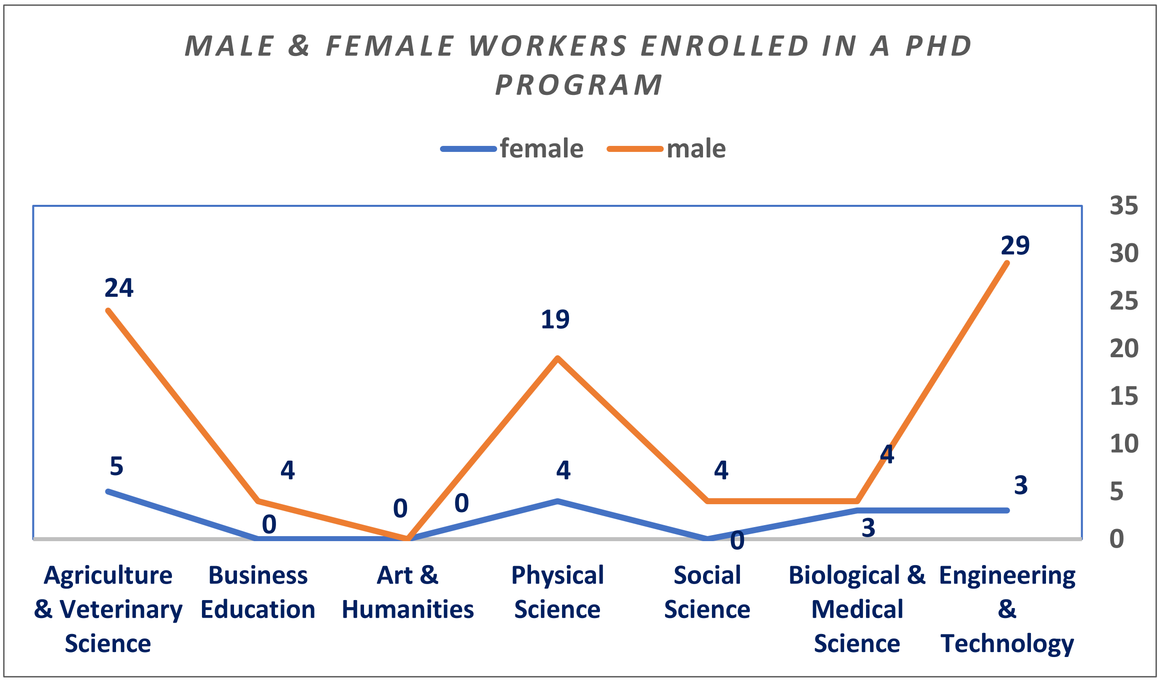


Figure 39: Percentage of male and female workers enrolled in a PhD program

The following chart provides a detailed insight regarding staff currently enrolled in a PhD program. It shows gender-segregated and region-wise analysis of data along with information about whether their enrollment in a PhD program is self-financed or sponsored by their organization. The analysis shows that among 178 employees pursuing a PhD, only 47 are sponsored by their organizations, whereas the rest bear themselves the cost of their higher education. Furthermore, region-wise analysis indicates that the highest number of employees enrolled in a PhD program are from Islamabad-based R&Ds (i.e., 112 out of total 178). No female employee from Sindh, Khyber Pakhtunkhwa, and Balochistan is enrolled in a PhD program.

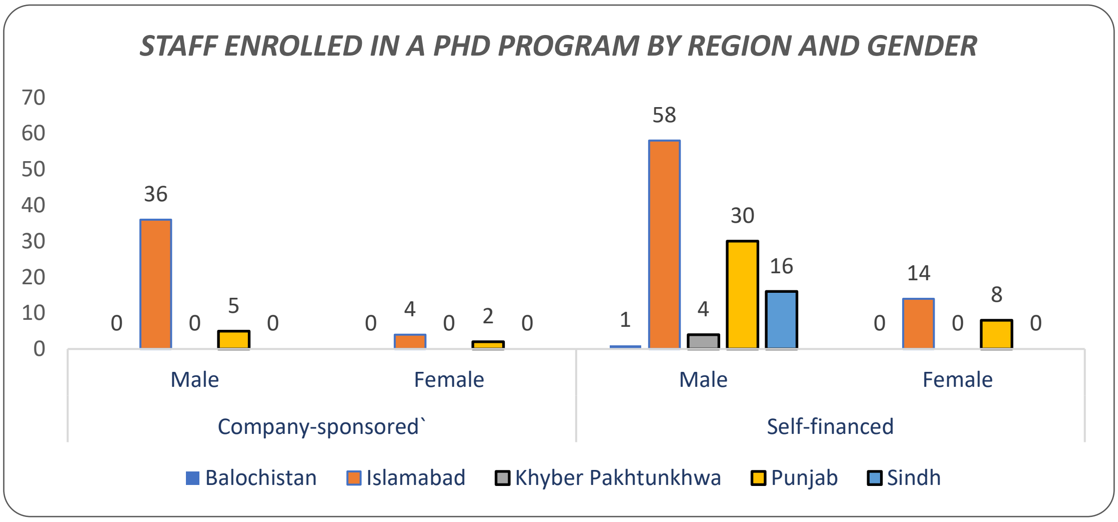


Figure 40: Number of staff enrolled in a PhD program by region and gender

Compared to 178 employees enrolled in a PhD program, the number of those enrolled in MS/MPhil program is 146. Around half of the staff is enrolled in Engineering and Technology discipline, and 16% are pursuing MS in Agriculture & Veterinary Sciences.

Discipline	Staff enrolled in MS/MPhil program
Agriculture & Veterinary Sciences	23
Biological & Medical Science	15
Physical Science	16
Engineering & Technology	71
Business Education	15
Social Sciences	2
Arts & Humanities	4
Total	146

However, considering the required number of employees with a Master's degree and the number of employees currently enrolled in that program, the data indicates some mismatch between the requirement and the enrollment of employees in an education program at this level discipline-wise. The number of employees enrolled in the MS program in engineering & technology is close to the number of employees required, but there is a huge gap in the number of employees with background in agriculture & veterinary sciences and the number of staff enrolled in that discipline.

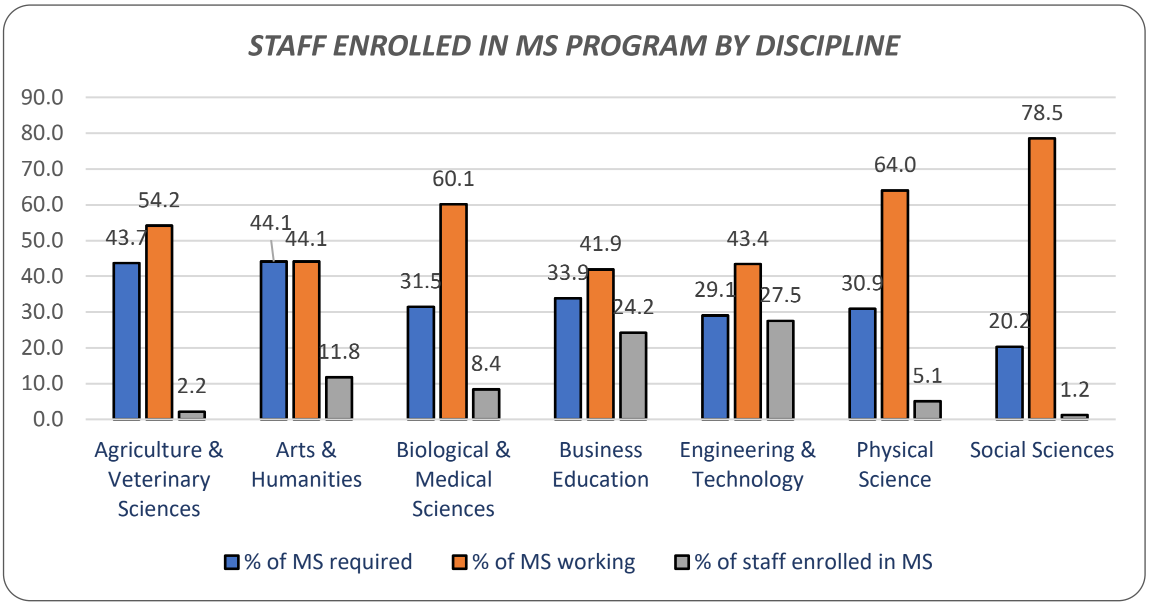


Figure 41: Percentage of staff enrolled in MS program by discipline

Compared to the percentage of women enrolled in a PhD program (which is 16%), those enrolled in an MS program are more in number (i.e., 39%). However, the percentage of women is still much lower than their male counterparts in both the programs.

A good majority (79%) of the staff currently enrolled in an MS program are working in the R&Ds of Islamabad, and 16% work in the R&Ds in Punjab. Those from Khyber Pakhtunkhwa, Sindh and Balochistan constitute 1%, 4% and 0%, respectively.

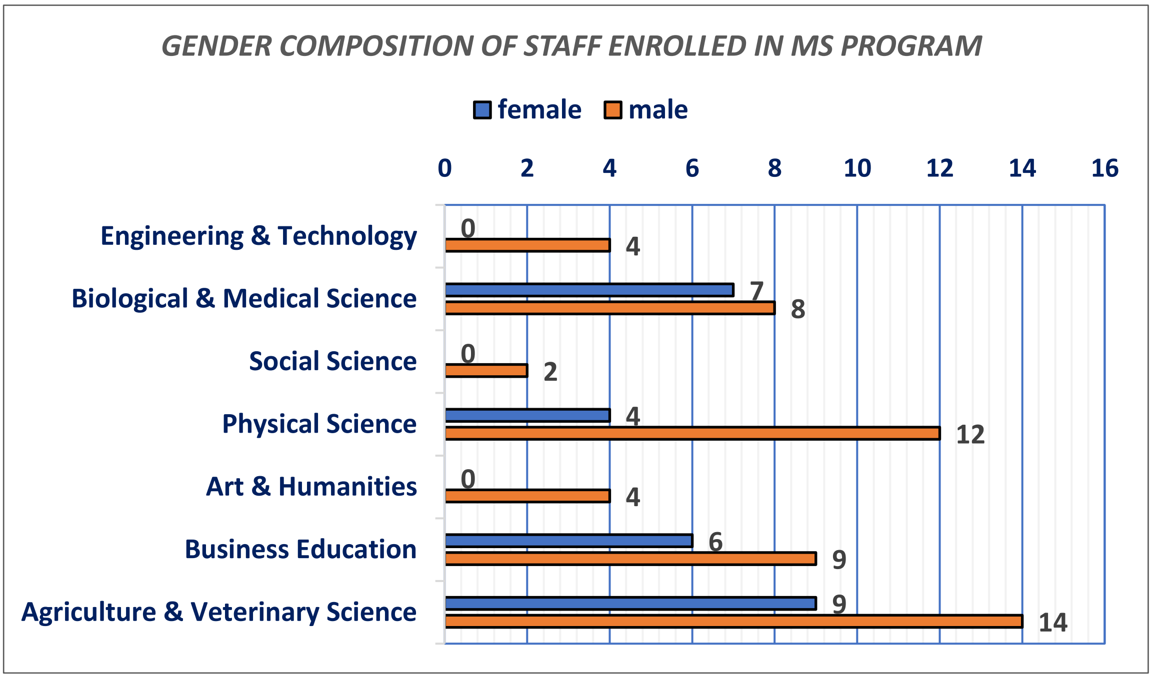


Figure 42: Gender composition of staff enrolled in MS Program

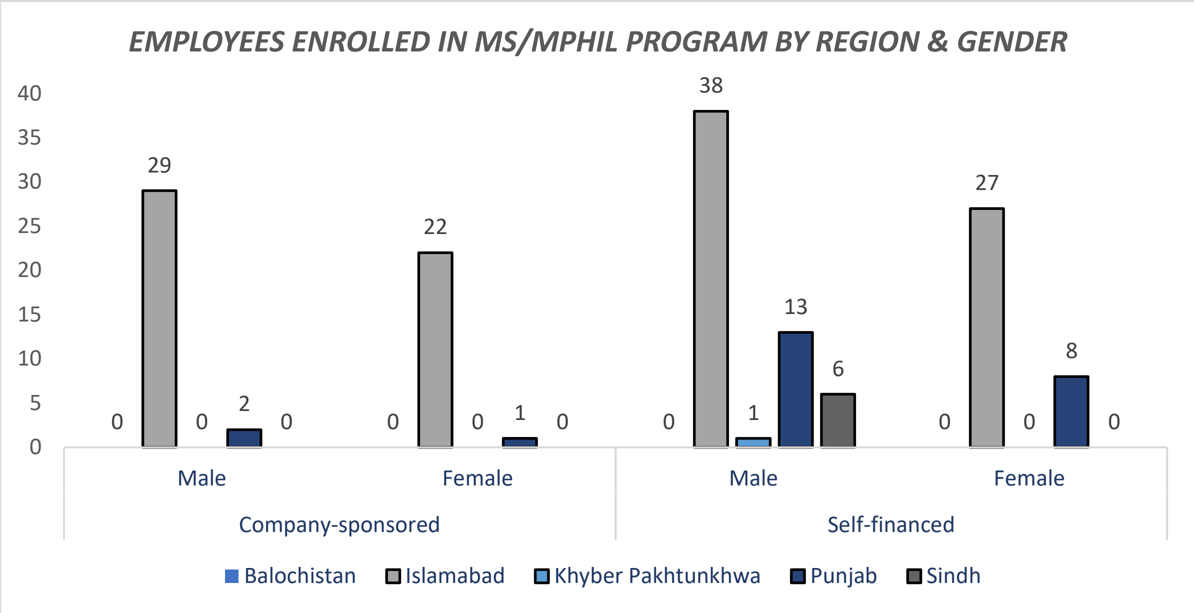


Figure 43: Number of employees enrolled in MS/MPhil Program by region & gender

Only 37% of the workers who are enrolled in the MS/MPhil program are sponsored by their respective organization. This reflects that those R&D organizations have either administrative, financial or any other constraints hindering to support organizational and individual’s pursuit towards scaling up of technical skill/qualifications. It is also worth to highlight that in case of both organization and self-sponsored, the number of staff enrolled in MS/MPhil program is higher among male than their female counter part.

4.3 Industries

The number of total industrial units surveyed in the four provinces is 250. The majority of them consisted of small and medium enterprises (SMEs) based on their higher proportion compared to large/total number of industrial units operating in the country. It is worth to mention that these industrial units constitute only a sub of the total SME/Large Scale industrial units functioning in the country and this survey is a sample representation of the industrial sector. Further the reflection in form of graphs and charts is based on the information provided by the industrial unit in respect to survey.

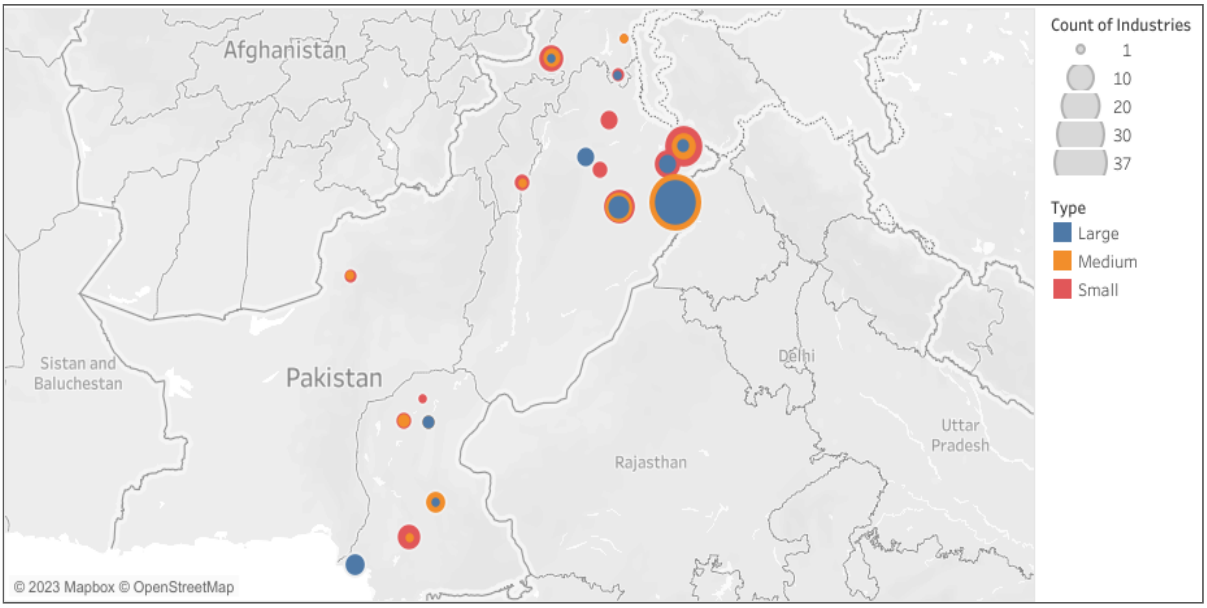


Figure 45: Industrial Units surveyed

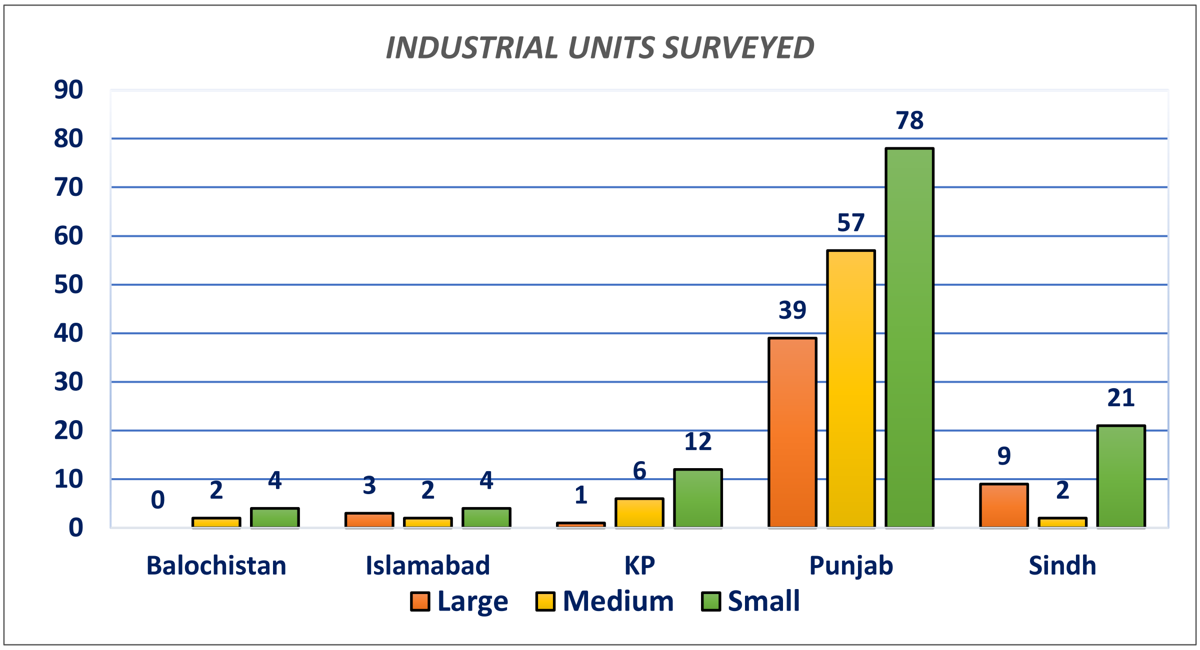


Figure 44: Region-wise distribution of industries surveyed

The following chart shows qualification level of Heads/Chief Executives of surveyed industrial units. It shows that only two industries (one each in Sindh and Islamabad) are headed by a PhD degree holder. In Punjab, most of the industries are headed by individuals having a Master degree, whereas in Sindh, comparatively higher number of industries are headed by persons possessing a Bachelor's degree. In Balochistan and Khyber Pakhtunkhwa, a majority of industries are led by persons with qualifications equal to intermediate or below in the surveyed industrial units.

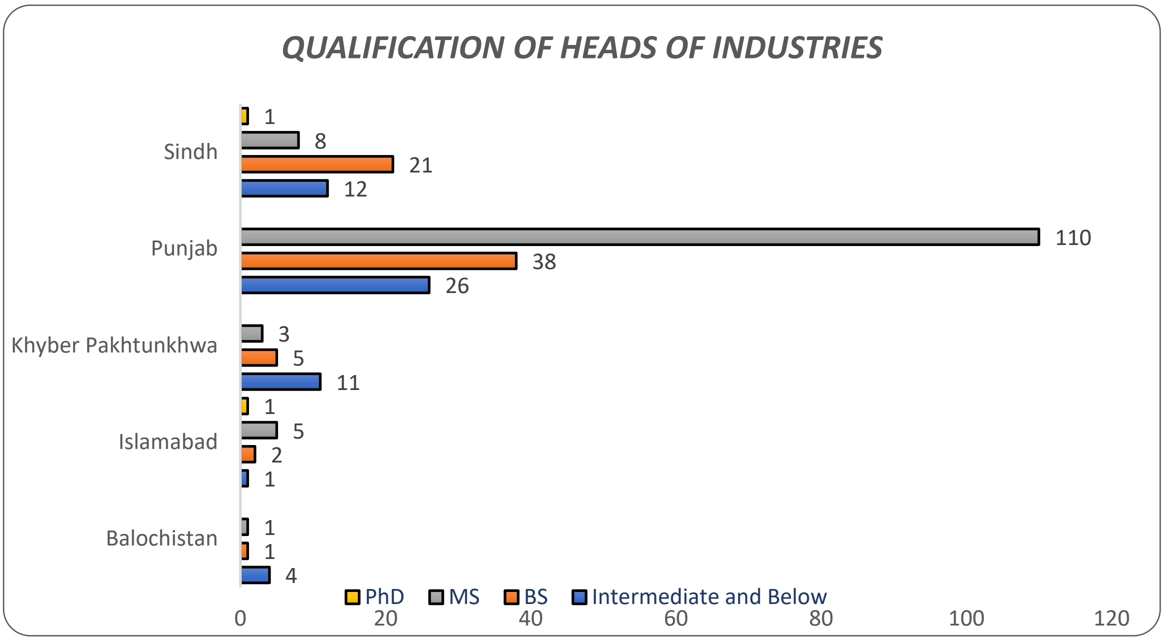


Figure 46: Qualification of heads of industries

Around half of the industrial units have some kind of quality standards certification, 115 industries have no quality certification, and 6 industries did not provide any data related to quality standards. ISO-9001 standard is about quality management and also assesses customer focus and motivation of top management for improvement, ISO-14000 standard is about environmental management, HSE system (OHSAS-18000) is about occupational health and safety management systems, Global GAP is related to good agricultural practices, whereas UKAS provides certification on testing, inspection, and calibration. The data shows that 95% of the industries do not have any international environmental quality standards, and only 44% of them have organizational quality management standards, whereas 39% of industries have no quality standard certification.

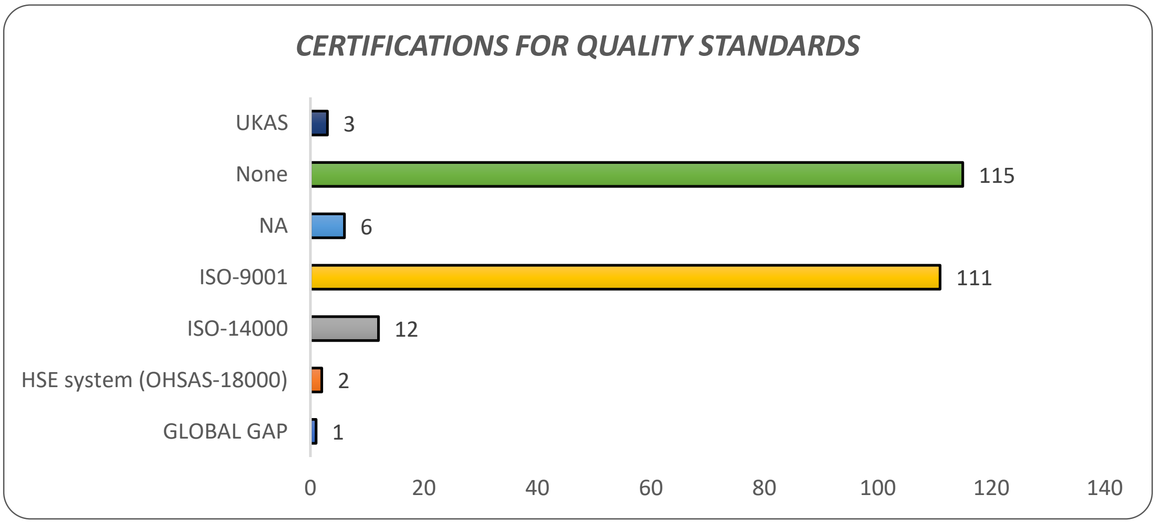


Figure 47: Certifications for quality standards

The majority of the industries in Punjab have only ISO-9001 certification, and 55 have no certification. A relatively fewer industries in Sindh, Khyber Pakhtunkhwa, and Balochistan have quality standard certification.

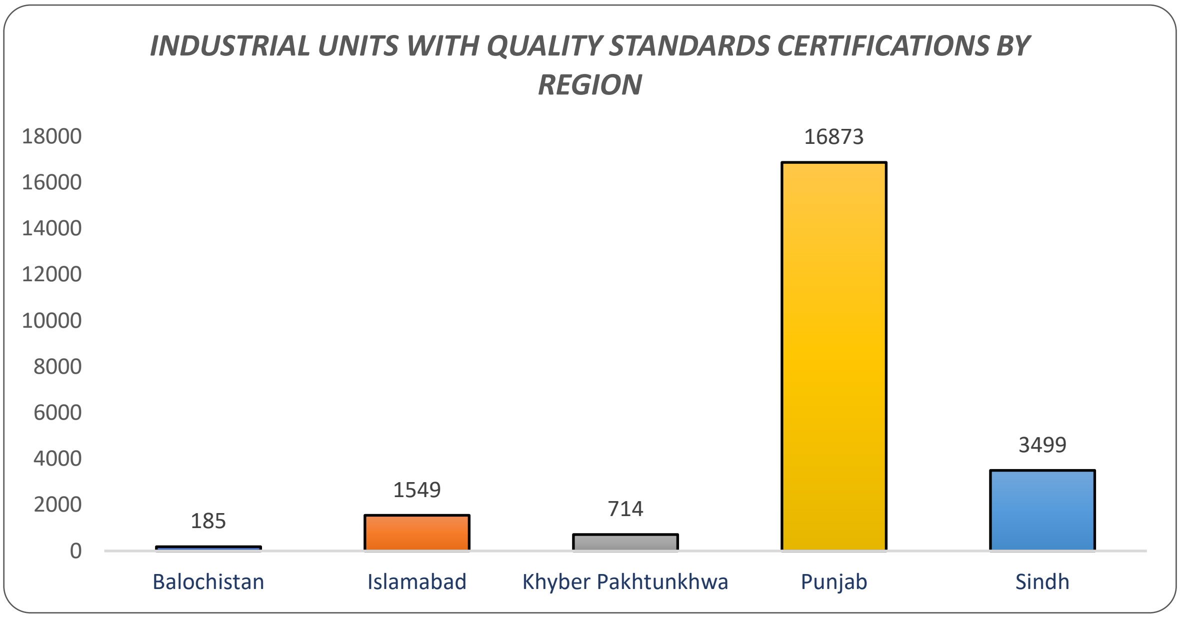


Figure 48: Number of industrial units with quality standards certifications by region

The total number of employees working in the surveyed industrial units is 22,820. The chart below shows that the highest number of employees from the Punjab province. This is due to the fact that the majority of the industry based either in Punjab and the Sindh Province and so highest number of industrial units surveyed are from Punjab.

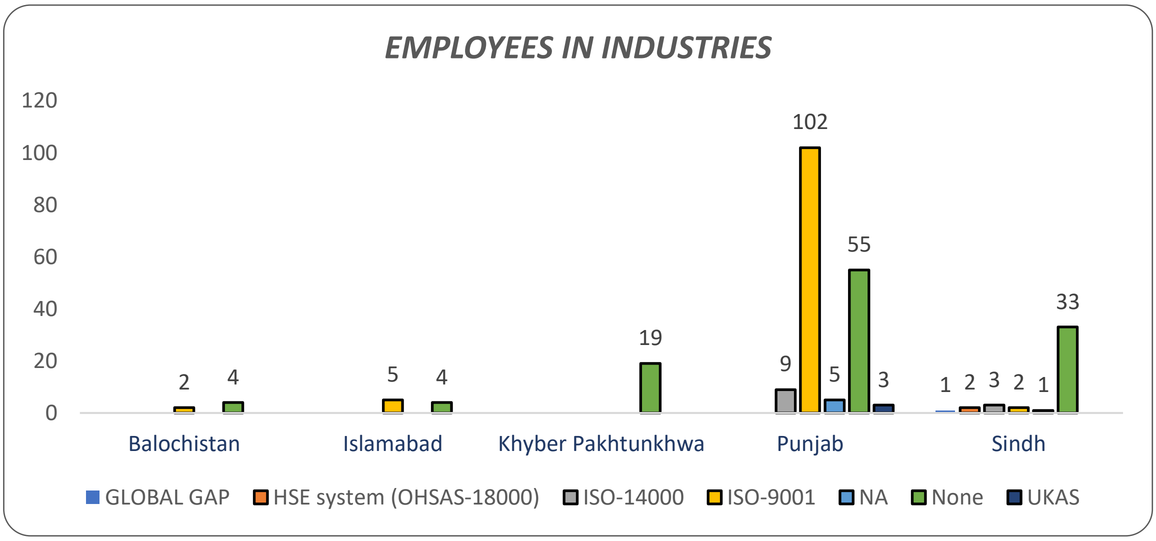


Figure 49: Number of employees in industries

Though the component of industrial units surveyed from Punjab Province is highest, the average number of employees per industry is higher in Islamabad than in any other region. Islamabad is followed by the Punjab and Sindh provinces in terms of average number of employees per industrial unit surveyed. One of the primary reasons for this difference could possibly be due to higher number of larger scale industrial unit in these regions compared to Khyber Pakhtunkhwa and Balochistan Provinces.

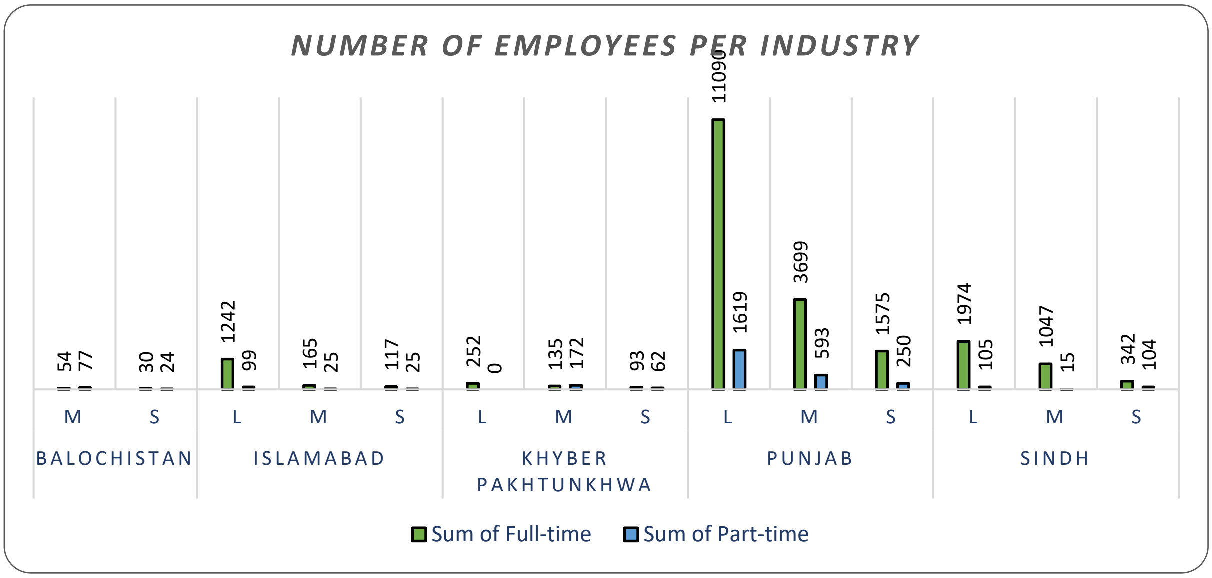


Figure 50: Average number of employees per industry

Almost all the workers in the surveyed industries in Islamabad, Punjab and Sindh are hired as full-time employees, whereas more than half of employees in industries in Balochistan and one-third in Khyber Pakhtunkhwa are part-time workers. It is inferred that the larger the size of the industry, the higher the number of full-time employees.

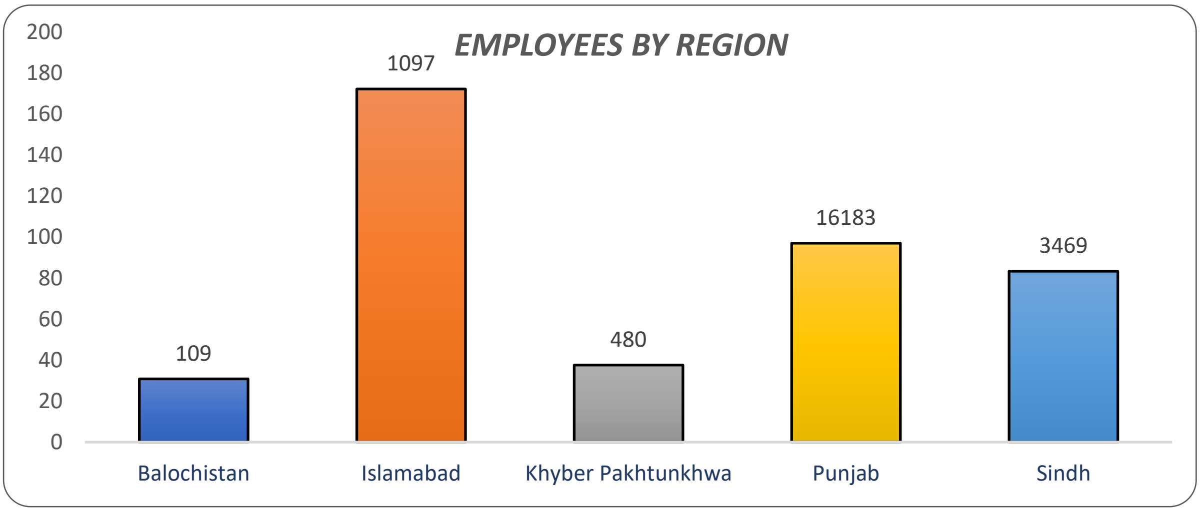


Figure 51: Number of Employees by region

Women constitute only 11% of the total industrial workforce. However, no industry from Balochistan and KP reported women workers as their employees. As mentioned in the previous section, a considerable number of women are enrolled in MPhil and PhD programs in various universities, but there are not many job opportunities for them in the market. The data shows a huge gap between the demand and supply of highly qualified human resources in the country. It is an alarming situation because currently, more women than men are enrolled in PhD programs in the universities, and after finishing their degrees, a majority of them might not be able to find opportunities in the industries.

The majority of the workforce in the industrial units have qualifications of intermediate or below. Employees with a PhD and MS are only 0.1% and 0.2% respectively, which is negligible, whereas those with a bachelor's degree constitute only 18% of the total work force. The data depict a very bleak future for our highly qualified human resources. If industries do not employ workers with PhDs, there is risk of potential brain drain of highly skilled technical manpower. As reflected in the chart the industrial sector is not able to employ PhD holders. This has caused a general imbalance in the supply and demand of highly qualified human resources. This will result in underemployment and less job satisfaction, which, in turn, will result in low productivity and creativity. To be globally competitive and adopt a culture of innovation in the industrial sector, the industry needs to create opportunities for the highly skilled technical manpower.

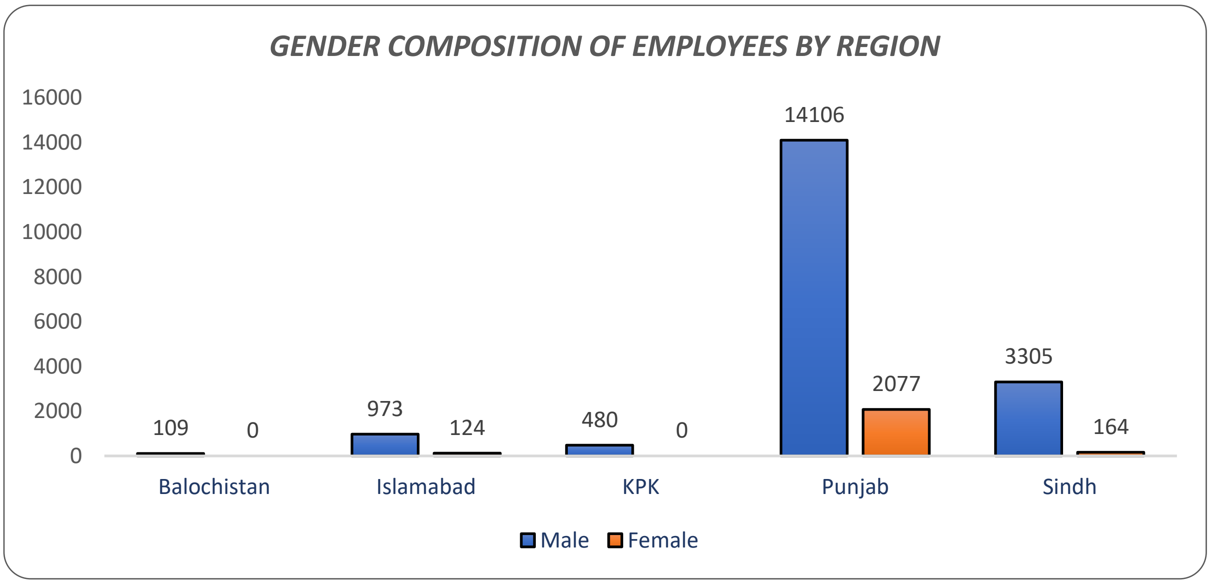


Figure 52: Gender composition of employees by region

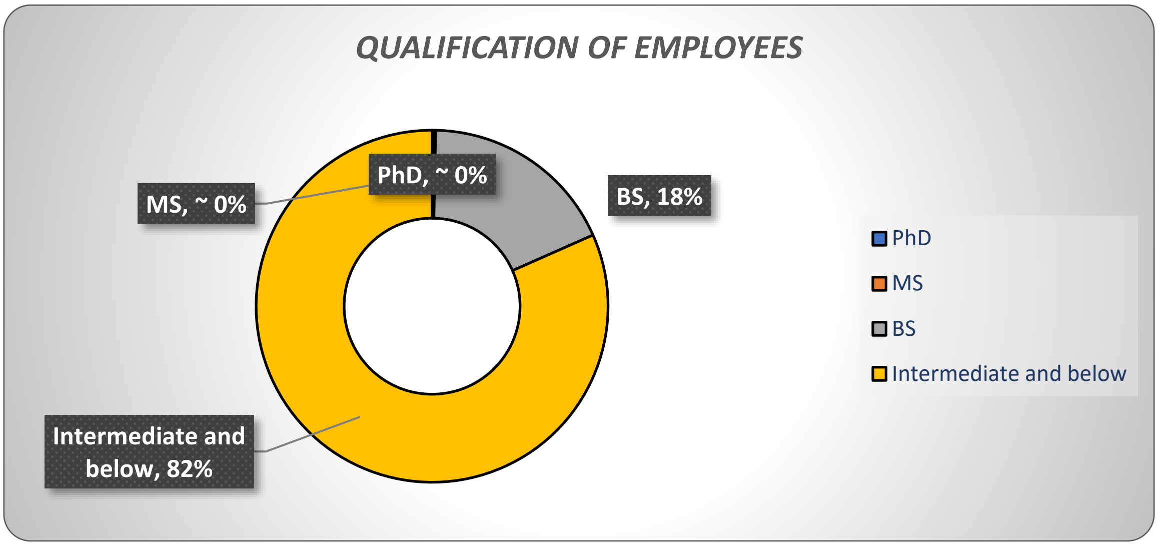


Figure 53: Qualification of employees

1% of employees of the industrial units operating in Islamabad have PhD and MS degrees, whereas the majority of the employees in industrial units in throughout the country possess lower qualification such as intermediate or below. Only in industries in Balochistan had the majority of the workers with bachelor's degrees as reported by the industrial units.

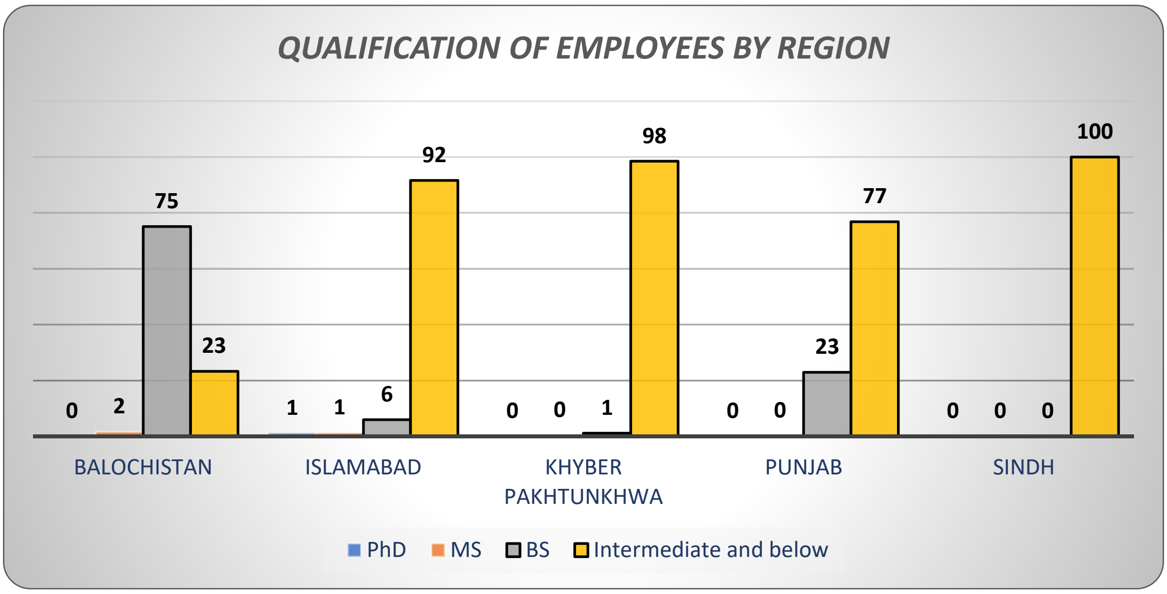


Figure 54: Qualification of employees by region

The core areas in which the employees are having a Master's or Bachelor's degrees are product development, processing, marketing, management, and machine operation.

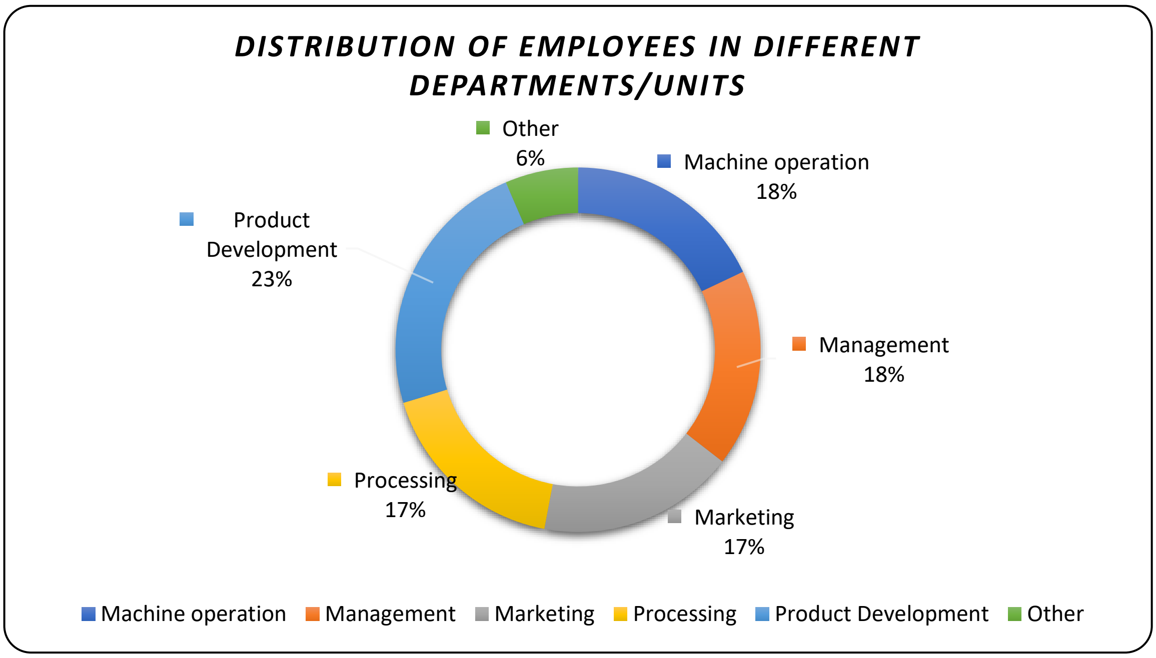


Figure 55: Distribution of employees in different departments/units

In response to future requirement of highly qualified S&T HR, the industries did not express much interest in staff with a higher qualification. As reported by the survey responding industrial units, only 23 positions with a PhDs will be required by the industries in the next decade amongst the surveyed 243 industrial units; with 20 of them required in Islamabad alone, and 3 in Khyber Pakhtunkhwa. The data presents a worrisome picture for the future of our thousands of students who will graduate from universities during the next decade, but they will not find any opportunities in the country's industries. There is dire need to strength the linkage between the industries, R&D organizations and the academia. Government may initiate and fund applied research/PhDs and MS level programs driven by our national industrial needs for the HR of the industry on the pattern of HEC programs for the academia.

5. KEY LESSONS

During meetings and workshops with representatives of institutions of higher education, industries and research and development organizations, it was learnt that most of the industrial units in Pakistan are not involved in basic research, and they are mainly involved in manufacturing and production. For instance, Pakistan do not have a very strong base for the initial stages of pharmaceutical research, including discovery and development of drugs, pre-clinical research, clinical research for various drugs; rather raw material is mostly imported and only drug manufacturing/production is carried out. Further, the Industry do not hire scientists/researchers, to conduct experiments, formulate and test medicine which is mostly done by foreign institutions/R&D organizations; as reported by a manger of a leading pharmaceutical company in the country during the study.

A similar response was also provided by representative of auto industry, the auto industry in Pakistan is more of an assembler and do not design and develop the core components of the vehicles. The manufacturing is restricted to fewer peripheral components. The industry receives pre-manufactured key components designed and developed in the advanced countries and assemble them into products for the local market. To reduce the burden on national exchequer, the relevant government agencies including Ministry of Trade and Commerce, Ministry of Industries and Production, Government of Pakistan and Engineering Development Board, etc. may encourage the auto industry to focus on local design and development of vehicle as per both domestic and global requirements. Government may consider policy reforms to incentivize local innovation and value addition, drawing inspiration from regional countries like India and Thailand. Encouraging technology transfer, fostering regional collaboration, investing in skills development, and promoting export-oriented policies are key strategies that could help Pakistan's auto industry transition towards more self-reliant and competitive manufacturing practices. These are some of main gaps identified in the study that why the industries in Pakistan do not hire highly qualified scientists in Pakistan because they do not feel the need for them. They mostly rely on technicians and machine operators with diplomas who can manage operations. In terms of not hiring highly qualified scientists by the industry was due to high salaries expectation by PhDs as reported by a manager of auto industry with limited or no value to the industry given lack of industries' motivation towards indigenous design and development.

To address the key reason behind the lack of R&D motivation by the industry including the auto sector industries, one of the representatives of the academia was of the view that universities lack state-of-the-art laboratories and latest equipment to train and develop international level research skills among the students to be globally competitive and hired by the international research facilities. Similarly, the reasons for these students not being hired by local industry are two-fold; the first reason is the same as mentioned already that our local industry is not engaged in basic research. The second reason is lengthy official and legal procedures to get regulatory, review, approval for domestically designed and developed products and its commercialization.

A manager from a seed factory reported during the survey that although they intend to introduce new hybrid seeds for agriculture which are climate resistant, but the procedure to get approval from the relevant government regulatory bodies was very cumbersome.

There is a gender disparity observed in the staff of universities as more than two-thirds of staff working is male, and only less than one-third are female. The gap is far wider in case of the industry. Females constitute a very minor portion of workforce in industries, which is mainly dominated by their male counterparts. During the survey the participants from the industry shared two main reasons for not employing females. The first in their opinion was industrial jobs being too challenging and requires a lot of time and efforts compared to other profession. Socio-cultural dynamic specific to our country is also one of the key reasons for this gap. For instance, in large proportion of the society women have to take care of their households and don't have the necessary leverage to work extra hours at the industrial workplace. Given this scenario, it is imperative for the Women's Ministry to take proactive initiatives to address the gender gap in scientific research and development within Pakistan. Encouraging and supporting women's participation in STEM (Science, Technology, Engineering, and Mathematics) fields can contribute significantly to boosting indigenous research and innovation. By providing targeted funding, scholarships, mentorship programs, and promoting a conducive environment for women in research and development, the Women Ministry and other relevant agencies can play a pivotal role in fostering a culture of innovation and scientific inquiry within the country. This not only empowers women but also enhances Pakistan's capacity for homegrown research and development, reducing dependence on foreign expertise.

To harness national objective for development, the key stakeholders including national and provincial governments, educational institutions, industry, and professional associations must collaborate to address the given challenges. Policy actions are required to incentivize industry-academia collaboration, offer tax incentives for research and development investment, adapt curricula to industrial needs, and provide specialized training programs. It is essential for stakeholders to recognize the long-term benefits of hiring high qualified S&T human resource to develop a culture of research and innovation supporting integrated academia-R&D organizations and an industry ecosystem.

6. RECOMMENDATIONS

There is a notable discrepancy in the supply and demand of highly qualified human resources in Pakistan. Despite universities producing higher number of PhDs in the last five years, none of the surveyed industrial units in any of the province has employed a PhD degree holder. Similarly, only 6% of staff with tertiary qualifications in R&D / S&T Organizations possesses PhDs, while the majority of workers in industrial units have only attained a 12-year education (vocational/intermediate level). Insufficient employment opportunities for highly qualified S&T HR, forces many to seek jobs abroad where their skills are in higher demand. The exodus of highly trained S&T professionals can obstruct economic development and technological advancement and innovation.

Federal and Provincial Ministries/Departments of S&T, Industries and Production, Trade and Commerce, PCST, HEC, and other relevant stakeholders need to coordinate and play a pivotal role in bridging this gap. These institutions require to proactively engage with industries and R&D organizations to negotiate the creation of employment opportunities for the surplus of highly qualified individuals. By facilitating dialogue and collaboration between these sectors, they can work towards utilizing the talent pool of PhD holders and addressing the demand and supply gap between academia, R&D/S&T organizations and the industry.

The growing trend with respect to joblessness of highly trained S&T HR including M.Phil. & PhDs, coupled with the influx of students currently enrolled in PhD programs, poses a significant challenge. Failure to provide adequate job opportunities for highly trained PhDs may discourage students from pursuing advanced degrees, potentially hindering the strategic and economic development of the country and intensifying brain drain. To address this issue, federal and provincial institutions may spearhead efforts to introduce demand-driven curricula and innovative research activities in collaboration with academia and industry. PCST can serve as a platform for academia, S&T/R&D Organizations, industry and other key provincial and federal stakeholders to bridge the gaps between the current market demands and the requisite skills for available jobs. This collaboration can enable HEC and other academic institutions about the evolving market needs, both domestic and international.

Furthermore, the academia/HEC may strengthen their offices of Research, Innovation and Commercialization (ORICs) and business incubation centers (BICs) to foster stronger partnerships between academia and industry to ensure research aligned with market needs. In this regard these institutions may provide better training programs both for the faculty and students to strengthen their research and commercialization skills; fostering international collaboration and resulting in innovative approaches and expertise. These efforts will provide students with valuable knowledge and innovative skills, necessary to be competitive internationally. Such initiatives can help students better understand industry dynamics and prepare them for successful careers in their respective fields and play their due role in the socio-economic development of the county.

Last but not least the findings of the study may be disseminated to all the relevant stakeholders to highlight gender disparity within their workforce. Currently, women which represent half of the country's population, are underrepresented in industrial settings, despite outnumbering male students in PhD programs. Failing to create more job opportunities for women could result in educated and highly qualified women remaining unemployed, with their valuable knowledge and skills left untapped.

7. CONCLUSION

The data provided by Institutions of higher education, industrial units, and R&D organizations show a huge gap in the demand and supply of highly qualified human resources. Analysis of data suggests the following conclusions, which, however, require further qualitative research to explore the reasons for such a gap:

- Our industry is not advanced enough to accommodate highly qualified human resources produced by our universities. An overwhelming majority of the staff working in industrial units and R&Ds have qualifications below Bachelor's degrees, it is inferred that knowledge and skills of PhDs are not required or of no use to the employers.
- The gap between the supply and demand of highly qualified human resources could also mean that PhDs produced by our universities do not meet the required criteria of employers and are unable to satisfy the demands of the market.
- This gap also implies a lack of close coordination and collaboration between academia and the industry.The former have not been able to design curricula to meet the demands of the later.
- Lack or, to be realistic, the absence of opportunities for PhDs in the industry means that hundreds of students who are currently enrolled in PhD programs in various universities of the country will not be able to seek adequate employment in the future after they complete their doctorates. As a result, many PhDs would either seek employments which are below their caliber or would leave the country depriving the nation of young talent.

The survey data also huge gender disparity in the workforce of academia, industry and R&Ds. Women constitute a minority in all the entities. Even in academia, percentage of women as regular employees is considerably low, and they are hired as either contractual employees or visiting faculty. Moreover, percentage of women among the higher positions at universities (like professors, associate professors, and assistant professors) is also lower than their male counter parts.

Low-end industry dominance, education-industry gap and resultant brain drain is the key challenge in the socio-economic development of the country. Addressing these challenges requires a concerted effort amongst the government, academia, S&T/R&D organizations, the industry and the private sector. This includes overhauling and aligning policies to support the growth of high-end industries where can then create more job opportunities for highly trained S&T/R&D professionals, increasing funding for research and development to create more high-skilled job opportunities, offering competitive salaries, benefits, and incentives to retain talent within the country.

8. REFERENCES

Aditya, A. (2024, January 3). Technology Transfer Plans in Thailand - Ande Aditya. Https://Andeaditya.com/. https://andeaditya.com/technology-transfer-plans-in-thailand/

Aiman. (2022, December 14). Over 765,000 Educated Youth Leave Pakistan for Employment Overseas. Sapphire Builders and Associates. https://sapphireassociate.com/educated-youth Leave-Pakistan-for-employment.

Cruz, S., & Michael Del Bono. (2019, January 9). Why the Multi-Campus Model Works. OUSA. https://www.ousa.ca/blog_multicampus

GUL, A., & AHMAD , A. (2012, June). Perspectives of Academia-Industrial Linkage in Pakistan: An Insight Story. https://www.researchgate.net/publication/271524404_Perspectives_of_Academia-Industrial_Linkage_in_Pakistan_An_Insight_Story

HEC. (2023). PhDs produced by Pakistani Universities. Retrieved 2023 July, from Higher Education Commission: https://www.hec.gov.pk/Urdu/universities/Pages/AJK/PhD-Produced-by-Pakistani-Universities.aspx

Hollows, S., Rab, M., & Schulze, C. (2016). Understanding Female Participation In Stem Subjects In Pakistan "Women And Science Series" Think Piece. HYPERLINK "https://www.britishcouncil.pk/sites/default/files/stem_final_with_foreword_1_1.pdf" *https://www.britishcouncil.pk/sites/default/files/stem_final_with_foreword_1_1.pdf*

Nayab, D.-e. (2022). Desire to Live in Pakistan: Stay or Leave? The Pakistan Development Review, 61(4). News, T. (2020, July 24). Jobless PhD holders to cross 3,000 mark by end of this year. Islamabad.

Pakistan Economic Survey 2021-22. https://www.finance.gov.pk/survey/chapter_22/PES10-EDUCATION.pdf

PBS. (2022). Pakistan Labour Force Survey 2020-21. Islamabad: Pakistan Bureau of Statistics.

Planning Commission. (2022). Annual Plan 2020-21. Islamabad: Ministry of Planning, Development, and Special Initiatives.

The Nation. (2022, November 25). 4000 Pakistanis unemployed despite having PhDs. Retrieved July 27, 2023, from https://www.nation.com.pk/25-Nov-2022/4000-pakistanis-unemployed-despite-having-phds

The World Bank. (2022). Population - Pakistan.

Tribune. (2022, December 12). Country's brain drain situation accelerated in 2022. Islamabad.

UNDP. (2023). Sustainable Development Goals. Retrieved from UNDP: https://www.undp.org/sustainable-development-goals

University of Liverpoor. (2023, July 27). World University Rankings 2023. Retrieved from https://www.timeshighereducation.com/world-university-rankings/2023/world-ranking#!/length/-1/locations/PAK/sort_by/rank/sort_order/asc/cols/stats

World Economic Forum. (2017). These countries have the most doctoral graduates. Retrieved 2023 July, from WEF: https://www.weforum.org/agenda/2017/02/countries-with-most-doctoral-graduates/

9. PROJECT COMMITTEE & PROJECT TEAM

PROJECT COMMITTEE

Shakeel Ahmed, Secretary, PCST

Engr. Farid Bakhtiar, Project Director

Dr. S. Zaheer Hussain Shah, DSA (P&C), MoST

Mr. Khuda Bukhsh, GM, EDB

Mr. Attiq-ur-Rehman, Director, PBS

Dr. Mumtaz Ali Memon, Assoc. Prof, NUST

Mr. Faisal Baig PC/SRO, PCST

Mr. Muhammad Noman Nazir, AEA (P&D), MoST

PROJECT TEAM

Engr. Farid Bakhtiar,

Project Director

Mr. Faisal Baig

Project Coordinator

Ms. Sahrish Saleem, RO

Mr. Roohhullah, DD, PCST

Special Thanks to

Engr. Farhad Khattak, SRO, PCST

Dr. Muhammad Shahid, RO, PCSt

EDB: Engineering Development Board, MoST: Ministry of Science & Technology, JSA: Joint Scientific Adviser, AEA: Assistant Electronic Advisor, RO: Research Officer, DD: Deputy Director

Pakistan Council for Science and Technology
Ministry of Science and Technology
Government of Pakistan